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CHAPTER ONE

Introduction

David Hollander and Timothy Howe

In 1970, introducing his *Roman Farming*, K.D. White justly lamented the lack of attention being paid to Greco-Roman agriculture. Nearly fifty years later, he would presumably be quite pleased with how the field has developed. Beginning in the 1970s (and no doubt in part due to White's own work), there has been steady growth in the number of monographs and articles on aspects of Greek and Roman agriculture as well as new commentaries on, and translations of, the most important ancient texts. Furthermore, instead of a largely text-driven approach, ancient agricultural history now employs an array of archaeological evidence (e.g. botanical and faunal remains) and methodologies (e.g. field survey, isotopic analysis). Students of the agricultural history of ancient Italy, to cite one regional example, now have new editions, translations, and commentaries on the fundamental literary texts (e.g. Goujard 1975 for Cato's *De agricultura* and Heurgon 1978 for Varro's *Res rusticae*), monographs, edited volumes, and articles putting those writers' works and lives into the broader context of Republican history (e.g. Reay 2005 and many of the chapters in Becker and Terrenato 2012) and literature (e.g. Kronenberg 2009). Archaeologists have published the results of fields surveys, new excavations of rural sites (including exciting recent work on small, non-elite sites by the Roman Peasant Project, Ghisleni et al. 2011), a synthesis of the survey data (Launaro 2011), a catalog of the villas in central Italy (Marzano 2007), and important overviews (e.g. Forni and Marcone 2002). In the Greek world, archaeological survey in particular has spawned a generation of multidisciplinary studies on the interactions between landscape and people, between rural and urban (Halstead and Frederick 2000; Adam-Veleni, Poulaki, and Tzanavari 2003; Alcock and Cherry 2004; Bresson 2016).

What accounts for this astonishing development in what many outsiders probably regard as a fairly dry subject? Undoubtedly one cause is the increased interest in the ancient economy. Since ancient economies were overwhelmingly agricultural, the farming sector demands serious attention. Environmental and demographic research as well as growing interest in foodways have also prompted more work on rural life in antiquity. Efforts to better estimate the population of Roman Italy have led, for example, to interest in the land's carrying capacity and thus more attention to issues of agricultural yields (on modeling Roman production, see Goodchild 2013; for Seleukid Mesopotamia, see Jursa 2010). The need to take stock of all

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

these developments inspired us to develop this Companion, which we hope offers an entrée into a field now so rich in research as to be perhaps somewhat intimidating.

Structure of the Volume

The chapters in Part I of this volume examine fundamental aspects of the study of ancient agriculture: the roles of paleoethnobotany, zooarchaeology, and isotopic analysis as well as the plants and animals themselves. The chapters in Parts II through IV show some of the ways in which agriculture developed over the course of about four thousand years from the Neolithic to the Roman period. We asked the authors of these chapters to discuss their regions' sources (archaeological and textual); geography, climate, crops, and livestock as well as the agricultural calendar, tools and technology of cultivation, any major political, social and economic aspects of agriculture, and changes in the practice of farming during the period. (The reader will also find guides to further reading at the end of each chapter.) The greater attention paid to regional developments in the Ancient Near East and classical Mediterranean betray, of course, our training but also reflect our desire to help Classicists, Biblical scholars, and other students of the ancient world (broadly construed) understand the agricultural context of early Mediterranean societies. However, knowing the importance of comparative approaches, we have included chapters on ancient India and China. The concluding chapter, by an agricultural historian of the modern United States, is also offered in the hope of greater engagement with the broader field. As its author, Pamela Riney-Kehrberg, notes, "the agricultural world has not changed as much as we might think." Of course, we have not been able to include chapters on every period or region even of Greco-Roman antiquity (nor indeed every useful analytical approach). While we regret the omissions, they also made the project feasible.

The Trajectory of Ancient Agricultural History

We asked our contributors to note important ongoing debates and suggest avenues for future investigation in their areas. While different regions have different stories – both in terms of ancient agricultural developments and modern research trajectories (driven as much by warfare and politics as by academic trends) – similar comments appear across many chapters. In antiquity, changes in ancient agricultural practice often happened slowly, but, as Christophe Chandezon (this volume) puts it, "nothing was ever static." The biggest challenge to understanding this flux is now probably the mountains of data available to researchers, from literary, epigraphical and papyrological texts, and the results of field survey, to faunal and botanical evidence, as well as the insights offered by palynology, paleopathology, paleoclimatology, dendrochronology, and geology. Integrating all this material is no simple task, and we expect large, collaborative projects to become even more common in the future. There are also, of course, many specialized topics on which further research is needed. In certain areas, more study of particular tools, crops, art, or texts will improve our knowledge of local developments and practices. More excavations of smaller rural sites would be extremely helpful in most regions, and indeed this has been a common refrain throughout the studies collected here.

Six key developments are central to the recent and future development of ancient agricultural history. First, there is the continuing reevaluation of the fundamental ancient texts, particularly the agricultural writers. For the Roman world, one might note the work of Thibodeau (2011) on Virgil or Henderson (2002) on Columella; for Greece that of Edwards (2004) on Hesiod and his world and Pomeroy (1994) on Xenophon; and for the Ancient Near East that of Wunsch (1999; 2000; 2003) on the archives of the Egibi family of Babylon and that of Pearce and Wunsch (2014) on the archives of the Judeans in Mesopotamia. Second, the field survey, vastly expanded in use since the 1970s and considerably refined in terms of methodology (though problems remain), is greatly enhancing our knowledge of the ancient countryside. Third, the scientific analysis of biological remains from excavations has enriched our understanding of both arable farming and animal husbandry though, as several of our contributors note, we need more systematic collection of a wider range of botanical, faunal, and environmental evidence. Fourth, the study of ancient forests and forest management holds great promise (see, e.g. discussion of Mediterranean deforestation in Harris 2013). As Robyn Veal notes (2017, 388), "[wood] … was substantially part of the agricultural economy" and the remains of charred wood, if properly collected and analyzed, can tell us much. Fifth, agricultural historians of antiquity can profit from adopting a range of approaches from other fields of history. A number of our contributors suggest that we will profit by considering agriculture from an economic, religious, social, or gender perspective. Comparative history is also providing new insights into old problems. For example, Halstead's *Two Oxen Ahead*, drawing on "first-hand observation of and interviews with residents of the Mediterranean countryside" (2014, x), has much to offer the historian of the premodern Mediterranean on a variety of agricultural topics. Haug (this volume) notes the value of Alan Mikhail's environmental history of Ottoman Egypt "for historians of Egypt in any period." Environmental histories with a *longue durée* approach also tend to foreground interesting continuities. Horden and Purcell's *The Corrupting Sea* (2000) stands out in this regard, brimming as it is with important observations on ancient agriculture. Sixth, and finally, paleoclimatology is perhaps the most exciting new direction in the study of ancient agriculture. The reconstruction of ancient climates is beginning to clarify the conditions in which ancient farmers operated (for the Roman period see, e.g. Manning 2013). These avenues of research suggest that the field of ancient agricultural history has the potential to yield many more exciting developments in the near future.

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PART I

PLANTS & ANIMALS

CHAPTER TWO

Paleoethnobotany and Ancient Agriculture

Alan Farahani

Introduction

The archaeological study of ancient agriculture, like the topic itself, is a multidisciplinary enterprise that requires different natural and social scientific techniques to build a more complete picture of it. Like the proverbial blind wise men who touch different parts of an elephant and hence come to different conclusions about the shape of the organism, so too do the various techniques offered by archaeological science present complementary but distinct insights into the same phenomenon of "agriculture" in the human past (Reitz and Shackley 2012, pp. 1–6). As the contributions in this volume invariably show, agriculture is not, echoing agroecologist John Vandermeer (2011, p. 26), "planting a seed and harvesting a crop. Agriculture is making a contract among people to provide for one another, using seeds and harvests to do so." In short, agriculture is as much of a social endeavor, in that people need to coordinate their labor and create new artifacts to assist in almost every stage of the planting, harvesting, and storage of desired plants (e.g. Asouti and Fuller 2013, pp. 318–321; Fuller et al. 2014b), as it is one that is embedded in and dependent on local environments and ecologies (Ingold 2000a). Archaeological investigations of ancient agriculture, therefore, must juggle both the biophysical (seeds, soils, climate, water) and social (cuisine, economy, gender) factors that are attendant to any understanding of how people in the past came together to plant seeds in the ground, or coppice trees, or use plants to clothe, shelter, and provide medicine for the human and nonhuman animals in their communities (Ingold 2000b) (Figure 2.1).

A distinction can therefore be made between the two major, interrelated archaeological approaches used to investigate and interpret the physical residues of ancient agriculture. Typically, the subdiscipline of archaeology concerned with "the *recovery* and *identification* of plants by specialists regardless of discipline" (Ford 1979, p. 299, italics in original) is referred to as "archaeobotany." At times, another term for the analysis of the same material is "paleoethnobotany," and for many practitioners the two words can be used interchangeably (VanDerwarker et al. 2016, p. 126). Alternatively, paleoethnobotany can be envisioned specifically as "the study of past cultures by an examination of human populations' interactions with the plant world" (Popper and Hastorf 1988, p. 1). The emphasis in the latter is on past cultures, that is the

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

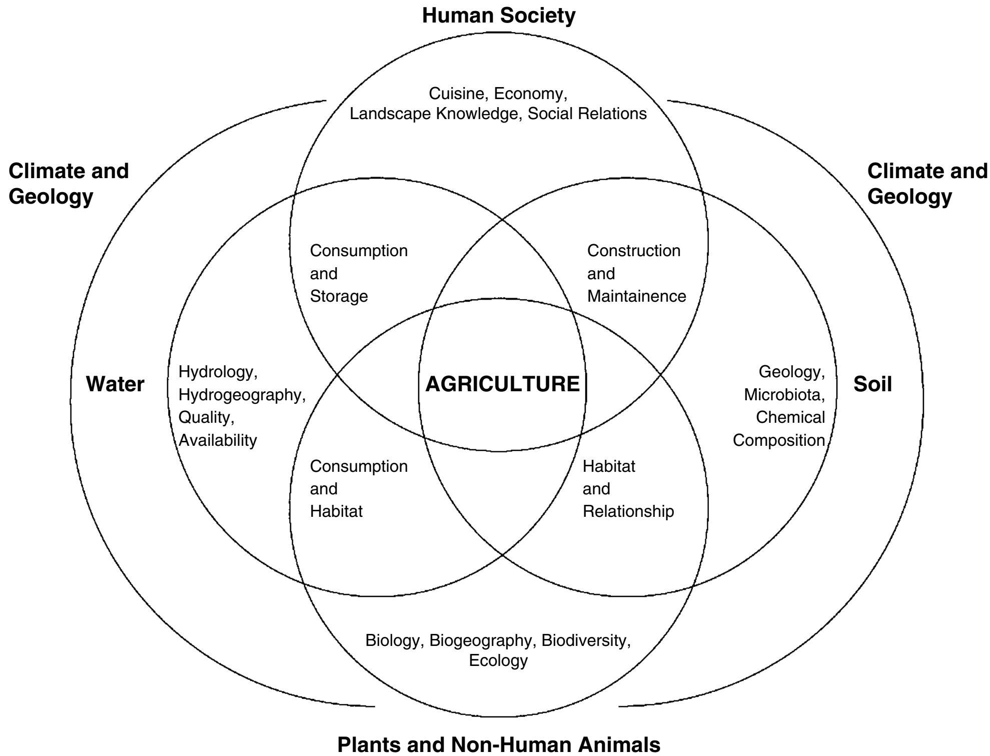

Figure 2.1 Model of the intersecting biophysical and social factors that constitute agriculture, and which thus form an essential component of establishing a research motivation for the interpretation of paleoethnobotanical data (Farahani 2018: Fig. 1). Source: Illustration by Alan Farahani.

ethno-, or the human factor. In this case, archaeological plant remains are a *means* to understand those phenomena that directly touch upon the human experience, rather than the final object of analysis themselves. The approach is thus anthropological in origin and orientation (Ford 1979, pp. 286–287; Ford 1985a), and draws from anthropological traditions that are concerned explicitly with the ecological (Kottak 1999; Scoones 1999; Orr et al. 2015).

The questions that motivate this research range from explorations of ritual to the political economy (Morehart and Morell-Hart 2015, pp. 485–487). In contrast, archaeobotany can, though may not necessarily, adopt a "plant-based" perspective in which research is aimed specifically at the archaeological plant remains themselves (cf. Dennell 1976, pp. 229–230), such as morphological changes to seeds and other plant parts, as well as vegetation history (e.g. Behre and Jacomet 1991). Paleobotany (another frequently encountered term), on the other hand, is concerned with plant remains typically *before* the emergence of anatomically modern humans or up to the end of the Pleistocene, often using fossil evidence and the methods of paleontology. These data more often address plant evolution, systematics, paleoenvironment, and paleoecology, independent of humans (Taylor et al. 2009, pp. 1–9). Paleoethnobotany and paleobotany are therefore quite distinct when seen through the lens of these operating definitions.

This chapter leans more toward the paleoethnobotanical rather than the strictly archaeobotanical since it emphasizes how archaeological plant remains can answer fundamental anthropological, historical, economic, and ecological questions regarding ancient agriculture, and the ways in which archaeological science can contribute to and enhance this knowledge.

Nonetheless, basic archaeobotanical research is still fundamental to this enterprise, as it provides the plant-focused methodological foundation upon which the analysis and interpretations of these remains are made (e.g. Fuller and Harvey 2006).

The foregoing discussion will also concentrate primarily on the kinds of agriculture that are and were practiced across Eurasia, albeit with some inclusion of other areas of the world. Despite this more restricted geographic focus, paleoethnobotany is very much an international, cooperative enterprise that utilizes methods and interpretive frameworks developed in nearly all times and places (e.g. VanDerwarker et al. 2016, p.126). Techniques used to identify root crops in the Pacific c. 1000 CE (Hather 1992) may serve as an inspiration for those seeking to explore the very same issue in the communities of southwest Asia and Europe c. 1000 BCE (Hather 1994). One of the aspects that unites paleoethnobotanical practice across the world, then, and in particular those studying ancient agriculture, is this specific variety of methods needed to explore and identify past human plant use (Hastorf 1999; Marston et al. 2014; VanDerwarker et al. 2016).

So what does paleoethnobotany entail? In brief, paleoethnobotanists seek the physical residues of past human–plant interactions to make empirically informed inferences about them. Researchers design strategies to recover from archaeological sites the preserved plant parts (seeds, wood, fruits, etc.) and microscopic components of these plant parts (starch grains, phytoliths, etc.) that serve as indicators, or proxies, of a plant's prior presence. By carefully sampling for these remains, analyzing them in laboratories purpose-made for their investigation, and then quantifying them, it is possible to address the many research questions that one might ask of past agricultural practices.

Many paleoethnobotanical pursuits of ancient agriculture can be placed into two broad conceptual categories: *synchronic*, that is, the analysis of agricultural practice within a given period of time, or *diachronic*, that is, an analysis of change through time. For example, synchronic questions may include, "are certain parts of an archaeological site dating to a specific period used for particular plant processing activities, and not others?" Diachronic questions include, "how does long-term plant-food access change at a particular site with known shifts in human sociopolitical organization?" Many of these questions are virtually unanswerable without the data generated by paleoethnobotanical methods.

Paleoethnobotany has blossomed as a subdiscipline of archaeology, and has made major contributions to our knowledge of agriculture across the world (Hather 1992; Hastorf 1999; Marshall and Hildebrand 2002; Marston et al. 2014; VanDerwarker et al. 2016). It has made particularly important contributions to our understandings of plant domestication, the origins of agricultural production, and the movement of plants by human hands over vast distances (Boivin et al. 2012; Miller et al. 2016; Stevens et al. 2016). The theoretical refinement that comes with new methodological advances, such as from molecular, isotopic, and microscopic paleoethnobotanical methods, has also opened new vistas in the study of ancient agriculture (see Chapter 4). All of these data have complicated unilineal narratives of agricultural development and attempts to portray agriculture, particularly in Eurasia, as stagnant, reactive, and unchanging over millennia, in a word, "timeless" (Knapp and Blake 2005; for a perspective from the Maya world, see Robin 2006).

A Brief History of the Paleoethnobotanical Investigation of Ancient Agriculture

The use of plant remains to reconstruct ancient environments, foodways, or economies has a history that stretches back to at least the period of "antiquarian" archaeology, c. 1600–1800 CE, within European intellectual history (Trigger 1989 pp. 80–118). Much of the research of these early antiquarians, and indeed some research well into the late 20th century, was characterized by "serendipitous finds" of plant remains preserved in or near archaeological sites (Miller, 1991, p. 133). The conditions of preservation at the sites of many of these early discoveries were usually highly amenable to the recovery of fragile remains susceptible to decomposition. For instance, in the 19th century the German botanist Carl Kunth (1826) examined extremely well-preserved plant remains, such as entire fig fruits, found inside the moisture-free Egyptian tombs of the Necropolis at Thebes, excavated by Egyptologist Giuseppe Passalacqua (Tedesco 2009). Likewise the Swiss botanist Oswald Heer (1866) identified various perfectly preserved seeds of barley, whole apples, cherry stones, and many other specimens, in early excavations of waterlogged prehistoric lake villages around Switzerland. In the Americas, the French doctor and botanist Charles Saffray (1876, p. 402) found plant remains within a Peruvian mummy bundle, made possible by the exceptional circumstances of preservation of the arid Peruvian coast.

The study of ancient plant remains followed this pattern of relatively unsystematic collection by professionally trained botanists in more favorable contexts of preservation well into the early half of the twentieth century. At that point, a series of intellectual developments occurred that laid the foundation for the systematic acquisition of plant remains at archaeological sites. One of the most important of these developments was the pioneering research of Australian archaeologist Vere Gordon Childe, who in a series of publications, notably his revision of Raphael Pumpelley's "Oasis Theory" (Childe 1929) alongside his coining of the term "Neolithic Revolution" (Childe 1936), argued that the development of agriculture counted as one of the most transformational events in human social and economic history. Childe's explanations, however, were light on their use of data; yet the explicit nature of his hypothesis permitted testability, and methods were thus sought in order to verify them (Trigger 1989, pp. 322–326).

Somewhat contemporaneously, the ethnobotanist Volney Jones began to argue for careful attention to the diverse uses of plants by then-contemporary nonindustrial communities, such as for medicine, for utilitarian ends such as food, clothing, and shelter, and to consider their role in music, literature, and oral history. He noted that "as man [sic] and plants are co-existent there is necessarily ecological interaction between them," which meant that a new field of ethnobotany, which "infring[es] on the domain of some of the more established disciplines" was needed in order to understand "the interrelation of primitive man [sic] and plants" (Jones 1941, p. 220).

The intellectual conjunction of these two developments in an archaeological project in Eurasia was perhaps represented most clearly by Robert Braidwood and Bruce Howe's excavation of the site of Jarmo, located in Iraqi Kurdistan on the hilly flanks of the Zagros mountain range. There the archaeological team sought to test the hypotheses of V.G. Childe with "field evidence" that "would need not only archaeological excavation oriented directly toward the problem, but also on-the-spot assistance of natural scientists" (Braidwood and Howe 1960, p. 2–4).

The Danish botanist Hans Helbaek was one such participant, and in turn he would establish the term paleoethnobotany as the subdiscipline of archaeology that "unravel[s] the complicated history of the plants upon which even modern civilization is ultimately dependent" (Helbaek 1959, p. 372). The results of Braidwood and Howe's research thus cemented the importance of the collection and analysis of archaeological plant and animal remains at archaeological sites (Matthews 2003, p. 25). During this time, there was a proliferation of paleoethnobotanical research around the world, with many projects aimed specifically at the investigation of early agriculture, such as Richard MacNeish (1965) at

Teotihuacan (Central Mexico), Margaret Towle (1961) in Peru, and Kent Flannery and Frank Hole et al. (1969) in Iran.

The subsequent 1960s and 1970s were extremely important in the development of paleoethnobotany. One of the most critical developments was the gradual expansion of the use of the "flotation" method for collecting archaeological plant remains, discussed in detail below (see section below titled "Obtaining Macrobotanical Remains"). Literature appeared that provided explicit instructions as to how to build a device to systematically extract carbonized plant remains from their sedimentary matrix using water immersion and capture (Struever, 1968). The latter was transformational, as Hans Helbaek (1969, p. 24) explains for his work at Ali Kosh, Iran, worth quoting in full:

> The reader will note that our preliminary report on the 1961 season states confidently that 'plant remains were scarce at [the Neolithic-period archaeological site of] Ali Kosh'. Nothing could be farther from the truth. The mound is filled with seeds from top to bottom; all that was 'scarce' in 1961 was our ability to find them, and when we added the 'flotation' technique in 1963 we recovered a stratified series of samples totalling 40,000 seeds.

The use of the "flotation" method expanded and was refined in Eurasia (Williams 1973) and in the Americas (Watson 1976). Nonetheless, many of the investigators were still botanists in training and research orientation (Renfrew 1973, p. 1–7; Miller 1991, p. 133; Warnock 1998). As Richard Ford (1985b) avers, during this time "precise botanical descriptions were expected and far more time was devoted to taxonomic exactness than to cultural interpretation." Currently, one's perspective on the ultimate objective of paleoethnobotanical research is influenced by one's training, whether in a department of botany, anthropology, or other affiliated field (Miller 1991). Yet despite the varied orientations of many in the discipline both past and present, paleoethnobotany has emerged as an integrated approach.

Major Varieties of Paleoethnobotanical Data Related to Agriculture

The varieties of paleoethnobotanical evidence of agriculture that archaeologists can encounter in the course of their field and laboratory research are not homogeneous. Depending on the context of preservation, paleoethnobotanists may recover remains as different as microscopic silicates and entire dried fruits. The conventional division of the major kinds of archaeological plant remains is between *macroscopic* and *microscopic* varieties, which are discussed below.

Macrobotanical Remains

Perhaps the most widely utilized and studied form of archaeological plant remains used to reconstruct past agricultural systems are macrobotanical remains, or "those remains visible by means of the naked eye or with a low-power microscope" (Wright 2010, p. 38). Theoretically any part of a plant may survive in the archaeological record, but in practice what survives is influenced by a combination of the preservation environment and the circumstances of the deposition of the plant parts themselves (Miksicek 1987; see the section below titled "Filtering of the Archaeobotanical Record and Preservation Conditions"). In general, the most commonly encountered macrobotanical remains are of carbonized plant seeds and wood charcoal,

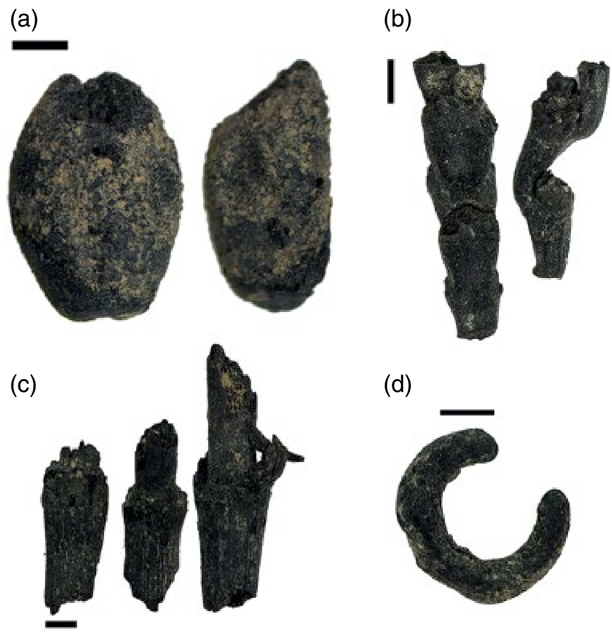

Figure 2.2 Commonly encountered archaeological plant remains used as evidence of ancient agriculture. (a) is a carbonized bread or macaroni wheat seed (*Triticum aestivum/durum*), (b) is the chaff, or the *rachis*, of wheat, (c) are grass (family: Poaceae) stems, likely of a domesticated grass such as wheat or barley, and (d) is a weed of the legume family (Genus: Hippocrepis). All of these remains are from the archaeological site of Dhiban, Jordan, and date between 600 CE and 1400 CE (scale 1 mm). Source: Photographs by Alan Farahani.

but can also include stems, roots, and parts of the fruit inflorescence (Gallagher 2014). Across archaeological sites in Eurasia where people once practiced agriculture, the most common kinds of macrobotanical remains recovered are the carbonized seeds of economic crops (rice, barley, fig, etc.), the by-products of cereal crop processing (chaff, i.e. rachises and culms), the seeds of "weeds," or agriculturally undesirable plants, and wood charcoal (Van der Veen 2007; Figure 2.2). More infrequent, and yet still within the realm of possibility, are whole fruits, leaves, and subterranean storage organs such as roots, tubers, and corms.

Wood charcoal can be especially abundant on archaeological sites (Braadbaart et al. 2009) and is essential for environmental reconstruction as many tree species are sensitive to changes in elevation, precipitation, and soil type (cf. Asouti and Kabukcu 2014; see the section below titled "Documenting Deforestation and Wood Choice"). The identification of these macrobotanical remains requires collection of modern specimens to compare against those preserved archaeologically, as well as knowledge of contemporary botany and living plants (Nesbitt 1991; see Irwin, this volume). For example, wood charcoal can be identified using microanatomical features in freshly broken pieces of charcoal, especially the number of rays, cell alignment, and vessel frequency, among other attributes, in different break planes of the specimen (cross-sectional, tangential, and radial) (Leney and Casteel 1975; Cartwright 2015, Figure 2.3). Digital resources are beginning to grow in prominence and facilitate the identification of different preserved plant parts worldwide (e.g. Neef et al. 2012).

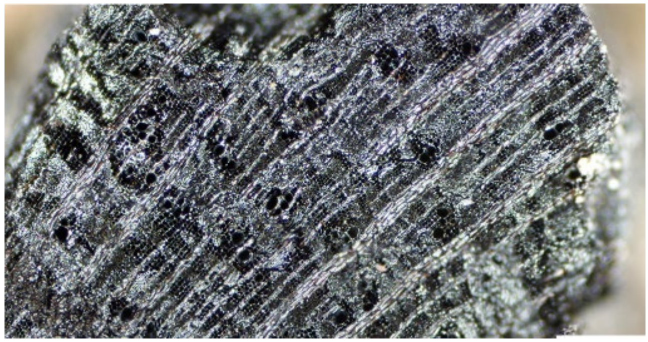

Figure 2.3 Cross section of an unidentified specimen of archaeological wood charcoal showing anatomical features used in identification, including rays and vessels (viewing window is 2 mm in width). Source: photograph by Alan Farahani.

Microbotanical Remains

Microbotanical remains require a high-power, transmitted-light microscope to view them, and therefore are invisible to the unaided human eye (Pearsall 2015, pp. 185–384). These remains are playing an increasingly important role in the archaeological reconstruction of agriculture in all aspects, but especially in documenting plant domestication and studies of cooking and diet (Ball et al., 2016). The three most commonly analyzed microbotanical remains are phytoliths, starches, and pollen grains.

Phytoliths (classical Greek for "plant rock") are microscopic bodies of amorphous opaline silica that form in the intra- and extracellular spaces of epidermal plant cell walls during the process of plant water absorption (Piperno, 2006). The shapes of these silicate bodies are often diagnostic to particular plants – for example, domesticated rice phytoliths look quite different from domesticated wheat phytoliths (see the review in Ball et al. 2016; Figure 2.4). Moreover, phytoliths are extremely durable as they are inorganic silicates and can be preserved in environments that would otherwise degrade macrobotanical remains (Madella and Lancelotti 2012). In addition, some economically important crops do not produce seeds, such as domesticated bananas (*Musa* sp., Perrier et al. 2011, pp. 11312–11313), and phytoliths may be the only form of surviving physical evidence of their presence or use. Nevertheless there are limitations and caveats related to their interpretation, especially with the potential susceptibility of phytoliths to be dissolved in water (Cabanes et al. 2011), and the possibility that the mixing of stratigraphically ordered deposits may skew the interpretation of phytoliths that represent particular crops (Bremond et al. 2004; Shillito 2013, p. 79).

Starches are a form of plant energy that are synthesized and stored in specialized plant organelles called amyloplasts. Starches are especially abundant in underground storage organs such as root tubers, corms, and rhizomes (Gott et al. 2006, p. 36), all of which have been valued by people for their high nutritive content relative to other plant parts. Starch grains from these organs importantly have shapes that can be specific to certain plants (Torrence 2006a). Starches also have unique chemical properties that aid in their identification; in particular starch granules are birefringent under polarizing light (Henry 2014, p. 39). Unlike phytoliths, however, starches are organic remains, and adverse conditions such as intense burning may rupture starches or cause morphological change (Henry 2014). Even the shape and size of a starch grain may affect its preservation (Haslam 2004). Important for the study of agriculture is that starches can be recovered from areas that directly bear on food

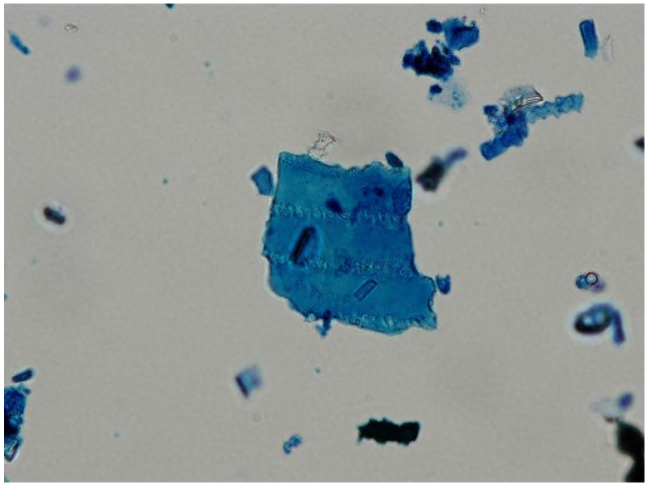

Figure 2.4 Image of a grass (family: Poaceae) phytolith cell sheet, likely of a domesticated cereal, stained blue to aid visibility and dating to c. 800 BCE from central Jordan. The magnification is 50×, and the width of the cell sheet is 100 μm. Source: photograph by Alan Farahani.

consumption, such as from the dental calculus of ancient teeth (e.g. early Neolithic teeth from Syria; Henry and Piperno 2008) and from the interior of ceramic vessels (Saul et al. 2012, see also Barton and Torrence 2015).

Pollen grains are microscopic reproductive elements found in the anther of the "male" organ of seed-bearing (angiosperm) plants and conifers (gymnosperms). The term "grain" is not a botanical designation, as pollen itself is more strictly a fusion of the male gamete and nonreproductive cells (Traverse 2008, pp. 77–85). Pollen is covered by an outer sheet made of sporopollenin called an exine, which substantially aids in the survivability of pollen in archaeological contexts due to its resistance to enzymatic action and physical stress. These exines are also often diagnostic to a plant genus or family, thereby making identification of different plant types possible (for overviews, see Dincauze 2000, pp. 343–362; Traverse 2008; Reitz and Shackley 2012, p.p. 264–283). Pollen dispersed by plants that settles in places where successive water activity can create laminations, such as lakes, ponds, and alluvial fans, "records" stratigraphically the relative frequencies of different kinds of pollen (Fall 1987; Campbell 1999). Palynologists can then collect these remains by using some form of coring equipment, preserving both the stratigraphic relation of pollen as well as the pollen itself (Canti and Meddens 2013). Through the careful identification of the pollen remains in these strata, along with dating organic material through AMS radiocarbon dating, it is possible to construct curves of the relative frequency of pollen, which are used as proxies for the relative abundance of particular kinds of plants (Gordon and Birks 1972). Palynology has been a cornerstone of environmental reconstruction of past vegetative landscapes and has been critical to the understanding of the development and history of agriculture (especially arboriculture) across Eurasia and the world (Delcourt, 1987; Odgaard, 1999).

aDNA and Stable Isotopes

In addition to the microbotanical remains discussed above, the study of ancient DNA (aDNA) and analysis of stable isotopes such as carbon (C), nitrogen (N), and oxygen (O) are offering promising new insights into ancient agriculture (Schlumbaum et al. 2008) through both direct and indirect methods. DNA, in some circumstances, can be collected directly from organic archaeological remains using amplification methods (Wales et al. 2014). Nonetheless, there are issues with acquiring a sufficient amount of DNA for robust analysis, the quality of the biomolecules due to preservation factors, as well as general problems of non-target DNA contamination, although next- generation sequencing is proving to remedy at least part of these problems (Giles and Brown 2008; Bunning et al. 2012; Brown et al. 2015).

In contrast to collecting DNA from archaeological specimens, it is possible to sequence the "races" of contemporary plant genomes often by using chloroplast DNA (cpDNA), and reconstructing their phylogenetic histories through statistical comparison with other specimens by using SNPs, or single-nucleotide polymorphisms (Zohary et al. 2012, pp. 9–19). DNA evidence, when combined with archaeobotanical data, has been a great asset in determining the origins and dispersal of several economically important crops such as rice (Fuller et al. 2010b), wheat, and barley (Brown et al. 2008), as well as maize (van Heerwaarden et al. 2011). The latter has also been instrumental in understanding the genetic diversity of cultivars in contemporary crops.

On the other hand, the paleoethnobotanical investigation of stable isotopes uses mass-spectrometry methods to detect differences in the frequencies of the variants of isotopes such as carbon and nitrogen in human and nonhuman animal remains. The latter are detectable as plants have different photosynthetic pathways (C_3, C_4, and CAM) that differentially affect the isotopes of carbon as they are separated in the process of photosynthesis (called fractionation; Ehleringer and Monson 1993). Extensive experimental research on contemporary populations of plants, animals, and sometimes humans can identify specific fractionation values in particular species (Tieszen, 1991; Szpak, 2014) which, when measured in archaeological skeletal remains, can be used to reconstruct the nutrient input of specific kinds of plants as well as the contribution of animal protein (Warinner, 2014). Archaeological plant remains can also be analyzed to some extent using these methods, and recent approaches have used stable isotopes from carbonized plant remains to reconstruct irrigation regimes (Araus et al., 1997) and identify manuring (Fraser et al., 2011). For a more detailed discussion, see Chapter 4.

Ethnoarchaeology

The observation of past and contemporary agricultural practices is an essential part of paleoethnobotanical research. In many cases this research provides useful analogues to help understand better the patterning of botanical remains observed in the archaeological record (Hillman, 1973b), as well as more situated understandings of the meanings of agricultural practices to specific communities (Lyons and D'andrea, 2003). The pace of change in agricultural practices worldwide in the past one hundred years has been rapid, especially since the gradual global diffusion of mechanized agriculture, and then again with the "Green Revolution", replaced many indigenous cultivars with varieties more conducive to global market economies (Vandermeer 2011, pp. 263–269). Technologies and methods once used throughout Eurasia, such as ard plowing, manual winnowing, and threshing by animal, are now being, or have been, replaced by tractors and machines (Palmer, 1998).

Fortunately, researchers have documented at least some of these practices before their disappearance, and there are some who continue to chronicle these transformations. Especially important for paleoethnobotanical research into ancient agriculture were the ethnoarchaeological efforts of Gordon Hillman (1973a, b) in Aşvan, Turkey, who documented how each stage of cereal crop processing produced discrete associations of different kinds of crops, weeds, and chaff remains, and that the application of these associations to paleoethnobotanical data could in part be used to reconstruct ancient agricultural activities. Glynis Jones (1987; Jones and Halstead 1995) built upon this research through an ethnographic investigation, and statistical analysis of, crop processing and crop-processing by-products in agricultural communities in Amorgos, Greece. Finally, Naomi Miller (1984; Miller and Smart 1984) conducted critical archaeobotanical and ethnographic work in Iran that detailed how seeds and other plant parts could enter the archaeological record via animal dung burned as fuel.

There is also research that incorporates data about agricultural practices from the evidence of written language, such as from historical documents and inscriptions (see Part III, esp. Chapter 9, and Part IV of this volume), literary texts (e.g. Decker 2009), ethnohistoric sources such as accounts of the practices of the indigenous communities of Central and South America (Sayre 2009) or the US Southwest (Ford, 1985a), and contemporary ethnobotanical work, such as the investigation of the intensive rice terrace *subak* systems of Bali (Lansing 1987, 2012). Ethnoarchaeological research does have interpretive limits, however. For instance, it has been argued that too many archaeologists in southwest Asia reliant on contemporary ethnographic research assume "the apparently unchanging appearance of the … landscape" which, critically, "mask[s] substantial changes in agriculture and diet over the last 3000 years" (Riehl and Nesbitt, 2003, p. 301). Therefore, while communities around the world have retained some degree of continuity with past agricultural practices, there has also been change and innovation with varying degrees of intensity.

The Collection of Archaeological Plant Remains

In the past, plant remains were often recovered serendipitously from archaeological sites, and as a result, they tended to be those remains that were large and well-preserved enough for field researchers to notice in the course of excavation. Thus, most of these incidental finds were macrobotanical in nature. Unfortunately, there are still projects that only incidentally collect macrobotanical remains (if at all), and most of this material is usually wood charcoal collected by hand, known as "grab" sampling. Nevertheless, the recovery of archaeological plant remains is one of the most important aspects of paleoethnobotanical research. There are numerous publications that deal with specific methodological issues related to sample collection, and which should be consulted in order to appreciate the full breadth of techniques available (see *Further Reading* below).

Obtaining Macrobotanical Remains

The kind of sampling strategy used to acquire macrobotanical remains is critically important in making larger inferences about ancient agriculture, whether in a particular site or through time. Grandiose claims about past agricultural societies made from a handful of small-volume and highly selective sediment samples should be held in suspicion. Ideally, all of the deposits found on archaeological sites would be sampled in full, a technique known as "blanket" sampling (Pearsall 2015). The latter is typically impossible on logistical and financial grounds. Nonetheless, many paleoethnobotanists recommend that a comprehensive and systematic, albeit partial, sampling technique be used to recover archaeobotanical remains (Jones 1991). The two most common approaches are "bulk" and "scatter" sampling strategies; in the former, samples are collected from discrete physical locations and processed and analyzed independently, while in the latter, small samples are collected throughout a deposit and then aggregated, providing a generalized image of the deposit (Figure 2.5). Each approach has its

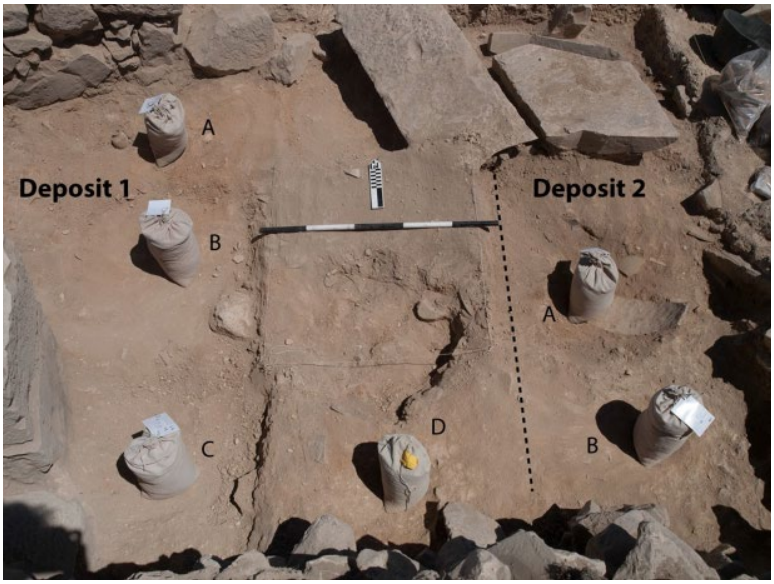

Figure 2.5 Schematization of sampling for macrobotanical remains, with two deposits, one and two, separated by a dashed line. In a bulk sampling strategy, each sample, represented by a letter, in each deposit would be processed and analyzed separately. In a scatter sampling strategy, all of the samples would be processed, and hence analyzed, simultaneously, although sampled from discrete areas. See also Guedes and Spengler 2014. Source: Photograph by Alan Farahani.

advantages and disadvantages with respect to how representative the recovered remains are of past agricultural practices (Lennstrom and Hastorf 1992; Guedes and Spengler 2014, pp. 79–82). Paleoethnobotanists must also adjust their sampling strategies depending on the preservation conditions encountered, such as whether remains are likely to be waterlogged or desiccated (e.g. Tolar et al. 2010; Chiou et al. 2013).

Once collected, the most widespread method for processing archaeological sediments, used virtually worldwide, is flotation. Flotation is the process whereby archaeological plant remains are freed from their surrounding sediment matrix by submerging them in water and then lightly agitating them through mechanical or other means (Pearsall 2015, pp. 113–115). Specialized devices are created for this purpose, and there is a history associated with each style of device (for a discussion of the different flotation machines, see Warnock 1998, pp. 240–242). A mesh is fixed inside of a barrel, and archaeological sediment is poured into the mesh. Those remains that float to the top are typically carbonized archaeological plant remains (known as the “light fraction” or “light residue”; Struever 1968), and those remains that do not float, which typically include artifacts, heavier botanical items (such as nuts; see Wright 2005), and animal bones, are often designated the “heavy fraction.” Some devices require manual removal of the floating items by skimming them off the top using a separate hand-held mesh; this is typically referred to as “bucket flotation” (Watson 1976). Another, and increasingly common, type of device uses an electric, gas, or hand-powered water pump to recycle water between two or more barrels. Those remains that float then travel out of a spout and are captured in a very fine mesh (Williams 1973; Shelton and White 2010, Figure 2.6). There are advantages and disadvantages to using each of these devices, although

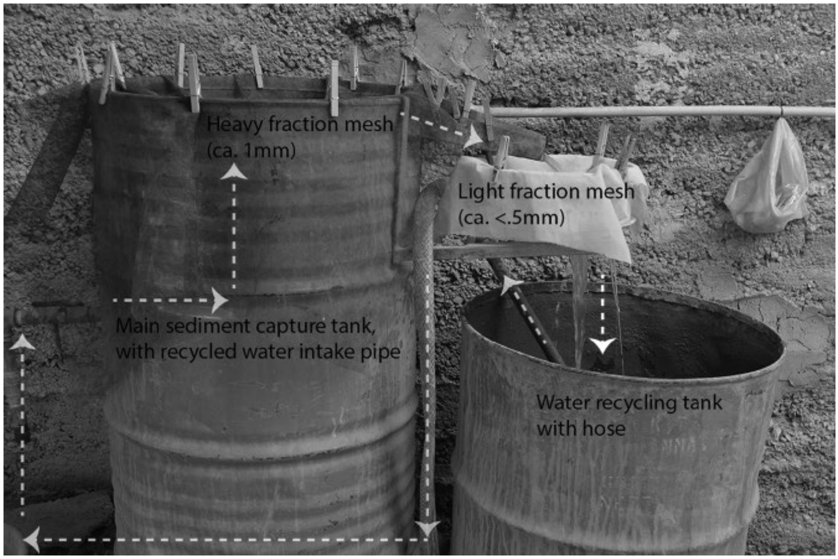

Figure 2.6 Highly modified flotation machine that cycles water with an electric pump. Water is drawn out of the secondary recycling tank, filtered, and then passed back into the main sediment capture tank. Note the spout that pours directly into the light fraction mesh, which catches any archaeological plant remains that float. Arrows indicate movement of water throughout the system. Source: photograph by Alan Farahani.

experimental research has shown that "mechanized" flotation has a greater recovery rate of macrobotanical remains, usually between 84% and 98% of purposely introduced material (Wagner 1982, p. 129).

Once these remains are dried, they are then transported to a laboratory where they undergo further processing, usually by passing them through a set of nested geologic sieves, and these subfractions are then analyzed under a stereo microscope to count the number of remains per sample (Fritz and Nesbitt 2014). The end result is typically a table of counts associated with the number of specimens identified to some taxonomic level, typically to family, genus, or species.

Obtaining Microbotanical Remains

There are several methods that can be used to obtain microbotanical remains at archaeological sites, and the importance of sampling for their interpretation also applies. What differs, however, is the method of on-site retrieval, as well as the laboratory procedures needed for their extraction. For instance, the acquisition of phytoliths requires ten to fifty grams of archaeological sediment be placed into a clean, breathable bag and brought directly to a laboratory. Phytoliths are then extracted through the use of deflocculants (chemicals used to release the electrostatic bonds holding together particles in the soil or sediment), heavy acids (such as HCL and HF) for the digestion of organic remains, and often some form of heavy liquid used for flotation (e.g. sodium polytungstate) (Piperno 2006; Horrocks 2005; Barton and Torrence 2015). The resulting supernatant can then be mounted on slides, and phytoliths are then identified and counted using a high-power transmitted-light microscope. Starch remains can also be extracted through similar on-site sampling strategies, although they can also be recovered directly from artifacts and from bone and dental calculus (Hardy et al. 2009; Hart 2011). Unlike phytoliths, organic digestion methods are not employed to extract starches since the remains themselves are organic. Nevertheless, they still require a sequence of chemical treatments, including flotation using a heavy liquid (Torrence 2006b). The resulting supernatant is then also placed upon a slide and analyzed under a high-power, transmitted-light microscope.

Pollen grains are typically obtained through the coring methods described previously, that is, by using a gas-powered cylindrical device several meters long that projects a coring device at high velocity (Glew 1991). Palynologists generally attempt to sample alluvial environments, as successive waves of sedimentation caused by water transport create highly stratified sequences amenable to temporal analysis (Fall 1987). The sediment cores that preserve these stratigraphic relations are then cut into sections using specialized machinery (Glew et al. 2002). Each slice of sediment, which is usually of uniform thickness, is then processed using chemical treatment methods to isolate the pollen exines (Heusser and Stock 1984). The resulting product is then analyzed under a microscope to identify and count the pollen remains per section, and these data are graphed using specialized software to indicate relative pollen frequencies through the core.

Filtering of the Archaeobotanical Record and Preservation Conditions

Paleoethnobotanists do not uncover all of the plants that were once in existence or in use at an archaeological site. Two factors largely influence what plant remains survive in the archaeological record. The first is those processes that are human mediated, such as plant processing or cooking, which determine what plants are brought on to and then deposited at archaeological sites. The second is biophysical factors, such as the effect of the environmental "matrix," which influences what plant parts survive after deposition (Lee 2012). The simple, yet challenging, question that paleoethnobotanists must first answer when undertaking any analysis is: why are archaeological plant remains found in the state they are in (Minnis 1981; Miksicek 1987; Fuller and Weber 2005; Van der Veen 2007)? If they are carbonized, how did they become burned? If they are desiccated, how were they kept free of moisture? In that respect, the main forms of preservation of macrobotanical archaeological plant remains are desiccated (completely dried), waterlogged, carbonized, and mineralized.

Of these routes, carbonized remains are the most commonly encountered at archaeological sites worldwide, and particularly among people who practiced agriculture (Fuller and Stevens 2009). Most archaeological plant remains are carbonized due to direct human action, namely, anthropogenic fires, rather than due to environmental factors, such as wildfires or lightning strikes (Minnis 1981). Accidental conflagrations, food preparation, or dung-fuel burning (with plant remains embedded) are the most common reasons for encountering charred archaeological plant remains.

Yet the very act of burning predisposes some parts of the plant to survive, while others do not. A comparison of dessicated versus carbonized archaeological plant remains from several archaeological sites in Roman and pre-Roman North Africa revealed that the seeds of cereals and their chaff survived the carbonization process best, and fruits, condiments, vegetables, and oil-rich seeds the worst (Van der Veen 2007, pp. 977–979). Carbonization can also alter the morphology, or shape, of seeds to the point where they might be unrecognizable to later analysts (Braadbaart 2008, pp. 161–163), and other experiments have shown that more sensitive elements of domesticated cereals, such as straw and chaff, disintegrate near 300 degrees Celsius (Boardman and Jones 1990). Therefore many paleoethnobotanists have cautioned that the absence of evidence in carbonized assemblages is not necessarily the evidence of absence, especially for oil crops, fruits, and the leafy parts of plants.

In contrast to carbonized remains, dessicated and waterlogged conditions preserve a richer number of plants and plant parts independent of human action, which is essential for understanding the full range of past cultigens available in agricultural systems. For instance, immersion in water, whether intentional or accidental, fosters anaerobic conditions that prevent bacteria from digesting plant material (Jacomet 2013). The latter is especially common in central and northern Europe, where such conditions are prevalent in bogs, wells, and peats, but can also be found in shipwreck sites around the Mediterranean. Entire pomegranates (*Punica granatum* L.) have been preserved at some Roman-period lake sites in Switzerland (Jacomet et al. 2002), while the excavation of Roman-period shipwrecks in Pisa, Italy produced entire beech (*Fagus sylvatica* L.) leaves, and a Roman shipwreck in Naples, Italy, contained whole stone pine (*Pinus pinea*) cones (Sadori et al. 2015).

Desiccation, by contrast, relies on hyper-arid conditions to suppress microbial action, often with the same result. In areas such as those encompassed by the contemporary states of Egypt and Peru, entire fruits and whole plants can be found intact. For example, at the Roman quarry site of Mons Claudianus in Egypt near the Red Sea, the remains of dill, celery, cabbage, and garlic were preserved (van der Veen and Hamilton-Dyer 1998). The volume of material produced by desiccation and waterlogging can also be substantial: one five-liter sample from a waterlogged channel excavated at the harbor of Punic-period Carthage yielded over four thousand fig (*Ficus carica* L.) seeds and over a hundred pomegranate and grape seeds each, not to mention other non-economic plant seeds (van Zeist et al., 2001). In fact, this does not approach the limits of how rich waterlogged samples can be (cf. Brombacher and Hecker 2015), and many carbonized assemblages with hundreds of liters of processed archaeological sediment do not often approach the density and richness of assemblages derived from waterlogged or desiccated preservation environments.

The second question regarding archaeological plant preservation is: how did the remains in question become deposited in the area in which they are encountered (i.e. sampled)? The latter is fundamentally connected to the specific historical conditions and cultural practices attendant to the individuals populating the communities whose plant remains are under analysis. As mentioned above, numerous ethnographies have revealed that practices such as cereal crop processing filter the kinds of remains that are ultimately found at archaeological sites (Dennell 1974; Jones 1987; Fuller et al. 2014b), although these processing activities need not be restricted solely to cereals, as seen in studies of Hellenistic-period grapes in Greece and Neolithic-period legumes in India (Margaritis and Jones 2006; Fuller and Harvey 2006; Capparelli et al. 2011).

In addition, practices such as dung-fuel burning, specific modes of cooking (boiling, frying, etc.), and even cultural taboos related to what kinds of plants are permissible to be in and near human habitations, affect plant presence. To this can be added cultural notions of where processed or consumed plants should be deposited as "rubbish," and indeed what constitutes "rubbish" (Miksicek, 1987). Thus, archaeological deposits sampled by paleoethnobotanists are not static repositories of inert environmental (or other) data altered by human action after the fact, but are the by-products of continuous interaction of past communities with the site, through the cultural practices of processing, cooking, digging, burning, dumping, and countless other routine activities.

Putting Paleoethnobotanical Data to Work

It should be apparent that the scientific recovery of the remains of seeds, stems, fruits, and other plant parts deriving from past agricultural practices is superior to conjecture about what "ought" to be present at any given site, or during any particular period. This was already recognized by Helbaek (1960, p. 188) when he claimed that "a handful of remains of the actual plants … surpasses pages of … theorizing." Since the adoption of flotation for the systematic recovery of macrobotanical remains, and the increased use of various recovery methods for microbotanical remains, there has been a veritable explosion of research into ancient agriculture with hundreds of published studies now available for many areas of the world (Fuller 2012, pp. 111–112). The impact of this has been felt especially in the investigation of agricultural origins and plant domestication (e.g. Fuller et al. 2014a; Langlie et al. 2014; Larson et al. 2014). Apart from documenting large-scale shifts in human food production, paleoethnobotanical remains have also provided unparalleled insight into what crops were available, and when, how they were grown and harvested, their storage, the relationship of sociopolitical factors or climate on agricultural production, the symbolic, ritual, and medicinal importance of major crops, and spatially bound practices related to food preparation and consumption. Indeed, even in time periods and places in which there are other lines of evidence available, such as written language, archaeobotanical remains can shed light on agricultural practices and plants that were present in communities but otherwise omitted by those with knowledge of writing.

Plants on the Move

One area of inquiry that has largely benefited from intensified paleoethnobotanical analysis is the investigation of the origins and dispersal of domesticated plants by human hands (Zohary et al. 2012; Langlie et al. 2014; Larson et al. 2014). Paleoethnobotanical data have challenged assumptions of the linear diffusion of domesticated plants from "primary" centers to "secondary" locales (Fuller, 2010). For example, previous explanations of agricultural origins in southwest Asia emphasized a single center of domestication in the "Fertile Crescent," whose Neolithic agricultural package then radiated outward (cf. Lev-Yadun et al. 2000). More consistent use of flotation and increasingly refined knowledge of the differences between wild and domesticated cereal rachis and seed shapes have revealed that many areas of southwest Asia were independently experimenting with the domestication of grasses (Fuller et al. 2012; Asouti and Fuller 2013). One such example is Riehl et al. (2013), who recovered the carbonized seeds and rachises of domesticated einkorn wheat (*Triticum monococcum* L.) in the lower Zagros of Iran that display evidence of morphological domestication roughly contemporaneous with the domesticated cereals of the Levant ca. 10 ky cal BP.

Even the number of areas of the world which have been found to be independent centers of domestication has increased to nearly twenty-four (Larson et al. 2014). In this respect, microbotanical work is of critical importance as plant phytoliths can be diagnostic to wild and domesticated varieties (Pearsall et al. 1995) and are often present in environments not conducive to macrobotanical preservation. For instance, maize (*Zea mays* L.) domestication has been pushed back to the 9th millennium BP in the Rio Balsas region of contemporary Mexico on the basis of intertwined phytolith, stratigraphic, and radiocarbon evidence (Piperno et al. 2009). Further research worldwide will continue to build upon and likely supersede these results. Paleoethnobotanical data have also documented the arrival and emergence of different crop types representing new food varieties through both time and space. Apart from the introductions of plants indigenous to the Americas into Eurasia and beyond (such as chili pepper [*Capsicum* spp.], potatoes [*Solanum tuberosum* L.], and tomatoes [*Solanum lycopersicum* L.]) due to the "Columbian exchange" (Crosby 1972), paleoethnobotanical data have revealed much earlier long-distance movements of food and plants within the Americas and Eurasia (Boivin et al. 2012; Spengler 2019). Large-scale syntheses of paleoethnobotanical reports have now provided chronological insight into the spread of wheat and barley into

China and Tibet (Flad et al. 2010; Guedes et al. 2014), the wide-scale movement of Eurasian cotton (*Gossypium arboreum* L. and *Gossypium herbaceum* L., Brite and Marston 2013), the dispersal of foxtail and broomcorn millet (*Setaria italica L.* and *Panicum miliaceum* L.) from east Asia into west Asia and Europe (Frachetti et al. 2010; Miller et al. 2016, perhaps alongside domesticated chickens, Peters et al. 2016), the movement of plants from south Asia into Africa (Fuller et al. 2011), of bananas from their probable center in and around New Guinea into Africa (Perrier et al. 2011), and even the arrival of Austronesian-speaking peoples in Madagascar based on the evidence of carbonized seeds (Crowther et al. 2016). The latter joins traditional research in tracing the spread of southwest Asian crops westward into continental Europe and its surrounding islands (Zeder 2008). In the Americas, this research has identified the domestication and spread of plants such as manioc (*Manihot esculenta* Crantz., Isendahl 2011) and chili peppers throughout both continents (Chiou and Hastorf 2014).

Toward Reconstructing Agricultural "Economies"

Previous approaches to agricultural economies, for the moment leaving aside the potentially problematic use of that term, using paleoethnobotanical data were limited to catalogs or lists of the counts of archaeological plant parts identified to some taxonomic level (e.g. *Vitis vinifera* (grape) seed: 3), often found in the appendices of excavation volumes (cf. Hastorf 1999, p. 57). Nonetheless, as was stressed at the beginning of this chapter, agriculture requires a host of practices dependent on coordinated, routine human labor, each of which leaves different physical residual signals or patterns within the archaeobotanical record (Fuller and Stevens, 2009; Fuller et al. 2010a). Concordantly there has been a desire among some paleoethnobotanists to "shift[ing] attention from the numerical frequency with which a plant is represented to the type of activity represented [by it]" (Dennell 1976, p. 243).

One of the ways that paleoethnobotanists have attempted to reconstruct these activities has been through the use of aforementioned crop processing and other ethnographically informed models (Capparelli et al. 2011). Many paleoethnobotanical studies based in the cereal-agriculture dominant parts of Eurasia have used these models to identify or argue for different economic relationships and modes of exchange between and within agricultural communities. For instance, these remains have been used in a debate over the extent to which grain-rich paleoethnobotanical samples found at dozens of archaeological sites in Iron Age Britain are indicative of "consumer" or "producer" sites, implying particular kinds of exchange relationships between them (Stevens 2003), or instead reveal the scale of harvesting and processing operations, and thus say more about internal labor organization (Van der Veen and Jones 2006).

In a similar vein, archaeological plant remains from two large bins recovered in excavations of an early Iron Age period site in central Jordan were used to argue that while both contained barley (*Hordeum vulgare*), the degree of chaff and weed remains (i.e. crop-processing residues) in each indicated that one bin was meant for human consumption, and the other for nonhuman animal consumption. Based on the location of each bin, it was also argued that the distribution and processing-as-food of barley was likely centrally controlled by an influential household, either by consensus or coercion (Porter et al. 2014; Farahani et al. 2016).

A study of long-term agricultural production in Gordion, central Anatolia, likewise identified risk factors in local agricultural decision making (Marston 2011), using the ratios of the recovered remains of wheat to barley, and bitter vetch to lentil, to argue for an expansion of irrigation that supported more intensive wheat agriculture during the Phrygian and Roman periods of Gordion's inhabitation, while the later medieval community utilized a more diverse agro-pastoral strategy (Marston 2012). Built infrastructure upon which agriculture depends, such as irrigation, and which is critical to the maintenance of agricultural economies, are also potentially identifiable through the specific morphological features of cereal phytoliths, such as of wheat and barley (Miller Rosen and Weiner 1994). Some studies have been able to use the concordance of contemporary botanical growth patterns and weed ecology, alongside the biological characteristics of weed seeds recovered from archaeological sites in Europe, to identify in-field agricultural practices such as soil tillage plowing, and even crop rotation (Charles et al. 1997; Bogaard et al. 1999, 2001). Paleoethnobotanical data have also been combined with zooarchaeological data, that is, the data derived from the study of archaeological animal remains, to create a more holistic picture of past agricultural economies. One study used the associations of plant and animal remains recovered at numerous Early Bronze Age and Iron Age sites in the Levant, identified through a statistical method called correspondence analysis (Smith and Munro 2009), to find that "[s]amples dating to different phases from the same site cluster together, as do geographically proximate sites." The latter is likely due to environmental factors, as those archaeological sites in bioclimatic zones with the greatest contemporary precipitation were also most associated with the possible dry-farming of einkorn and emmer (*Triticum dicoccum* Schrank) wheat in the past. A study from the same region and time period using similar aggregates of multi-site paleoethnobotanical data found that while local climates affected which crops were grown, the abandonment of certain crops through time, such as emmer wheat, seems to have been motivated more by social and economic factors (Riehl 2008, 2009).

High-resolution paleoethnobotanical analyses of archaeological sites have also yielded insight into the communal operation and labor arrangements of local agricultural economies. Graham and Smith (2013) analyzed samples collected in multiple Ubaid-period structures at the site of Kenan Tepe in Turkey, which revealed that some structures were kept "clean" of plant remains, others contained processed emmer wheat, and yet another room potentially held dung cakes intended for fuel. These results revealed coordinated activities between structures, and potentially between groups, toward crop processing and storage. Similarly Hald and Charles (2008) utilized spatial analyses of third millennium BCE structures at Tell Brak in Syria and identified different crops in storage structures in different household compounds, implying intra-household but not supra-household organization, and moreover evidence of crop specialization through time.

Other paleoethnobotanists have used the concordance of considerable textual, ethnohistoric, and natural science resources to triangulate ancient agricultural economies. Logan (2012) utilized just such an approach using macrobotanical and microbotanical remains to illustrate how non-indigenous plants, such as maize from the Americas, came to be "indigenized" in west-central Ghana, alongside ethnography and written sources. Finally, paleoethnobotanical research at the Roman-period site of Mons Claudianus (van der Veen and Hamilton-Dyer 1998), illustrated how paleoethnobotanical data can complement documentary sources. Ostraca recovered from the site indicated that wheat was a major imported staple crop, but the archaeobotanical assemblage was dominated by barley "with clear evidence that it formed a major food for human consumption." These same ostraca made reference to unspecified "vegetables," yet the analysis of these samples revealed what those vegetables were: basil, rue, and mint – all of which imply garden-plot cultivation among the residents of the community.

Fodder, Fuel, and Feces

Paleoethnobotanical research has also refocused questions of agriculture to consider the full spectrum of plant–animal–human relationships, in particular, on the many domesticated animals that formed an essential part of agricultural systems worldwide (Miller et al. 2009).

In this respect, apart from the integrative studies noted above that also include animal remains in their statistical analyses, research from Peru (Hastorf and Wright 1998), India (Reddy 1998), and Turkey (Anderson and Ertug-Yaras 2013) all underscore the importance of the burning of animal dung as fuel for cooking, warmth, or industrial purposes (such as ceramic firing). As stated previously, much of this research was inspired by the recognition of Miller (1984) that dung fuel could have served as a potential route of entry for carbonized seeds in archaeological samples. As a result, many interpretations of paleoethnobotanical data now identify dung as a likely pathway for the presence of carbonized remains in semi-arid areas of the world where woody plants may be scarce.

Consequently, samples formed as a result of dung-fuel burning indicate how domesticated animals were foddered (Charles 1996; Valamoti and Charles 2005; Jones 1998), or alternatively the environmental/vegetal conditions of the areas in which they grazed. The latter have been used to argue, for instance, for fluctuating changes in the degree of pastoralism versus sedentary agriculture in 3rd millennium BCE Anatolia (Miller and Marston 2012; Miller 2013). While the burning of dung-fuel is typically associated with semi-arid environments, research at the late Roman site of Le Marais de Dourges in northern France (Derreumaux 2005) found carbonized germinating wheat seeds and chaff indicating that at least one (very rich) sample was evidence of the dung of, and litter for, horses, "about which not very much was known until now" in temperate Roman Europe. Designing techniques to ascertain whether a sample was the result of dung fuel burning, and therefore evidence of animal food and foddering has become a major issue in paleoethnobotanical research in Eurasia (Lancelotti and Madella 2012).

Food and Foodways

It is sometimes claimed that paleoethnobotanical data reveal the menu, not the meal (Warinner, 2014, p. 276). Nevertheless, one productive research pathway investigated through paleoethnobotanical data has been food and foodways. The core of this research orientation is the recognition that "people eat food, not species" (Sherratt 1991), and that analyses should move "beyond subsistence," that is, to incorporate the symbolic and social importance of food, not just identify the minimum nutritional level needed to maintain human physiological function (Jones 1985). Thus, there is increased interest in the culturally specific practices of food – *what* is considered food, *how* it is prepared, and *why* it is consumed (Palmer and Van der Veen 2002). For example, Cox and Van der Veen (2008) documented changes in the sizes of watermelon (*Citrullus lanatus*) seeds recovered from Roman to middle and late Islamic Quseir al-Qadim in Egypt. They noted that Islamic-period watermelon seeds were not only much larger than the Roman varieties, but that experimental evidence matched breakage patterns in the archaeologically recovered seeds consistent with seed consumption – thus, a change not necessarily in what was eaten, but what was considered food and how it was eaten.

In a similar vein, a synthesis of many archaeobotanical reports from sites in Roman-period Britain documents the arrival of over fifty new kinds of domesticated plants at the same time as the emergence of new culinary equipment brought by the Romans, representing Britain's largest foodway shift since the Neolithic (Van der Veen 2008; Van der Veen et al. 2008). Similar studies on sites in central Europe have noted the gradual dispersion of "luxury foods" such as pomegranates, outward from Roman military encampments (Bakels and Jacomet 2003), indicating new relationships between military and civilian non-Roman communities. Gender identities and food have also been explored using paleoethnobotanical data, especially in the Americas (Hastorf 1991; Fritz 1999; Morehart and Helmke 2008). Other studies investigate the long-term mutually constitutive changes across Eurasia of techniques of ingestion and the technologies of food production that maintained them (Fuller and Rowlands 2011).

Documenting Deforestation and Wood Choice

The study of archaeological wood charcoal, known as anthracology, has a history of research independent of paleoethnobotany (Scott and Damblon 2010). Some of the main questions that wood charcoal evidence has answered in paleoethnobotanical research primarily relate to vegetation cover and deforestation, although there are now an increasing number of studies that focus on arboriculture and the use of charcoal to identify activity areas on archaeological sites. To begin with the latter first, some archaeologists have used spatial analyses to identify areas of archaeological sites with greater densities of charcoal or increased fragmentation (Balme and Beck 2002). High rates of charcoal fragmentation may indicate areas that were once heavily trafficked by people, while middens, or ancient trash dumps, will more likely have larger and more intact pieces as they are removed directly from hearths and fire pits and deposited whole (Théry-Parisot et al. 2010). The analysis of wood charcoal on-site also may indicate where hearths or other cooking installations were located, where industrial activities such as metal smelting or ceramic firing were taking place (Engel, 1993), homes were heated, or charcoal was swept out as rubbish.

The identification of wood charcoal to some taxonomic level provides some of the most robust data available on local changes in past vegetation, with the recognition that wood charcoal recovered at archaeological sites represents a composite image of woody vegetation communities of many decades, if not centuries (Asouti and Austin 2005, p. 5). By examining the varying proportions of the identified fragments of wood charcoal, whether by weight or count of a species, genus, or family, studies across Eurasia have identified episodes of deforestation and wide-scale vegetation changes that accompany the expansion of agriculture, especially the diminution of old-growth oak and pine forests. Research has documented these changes from Roman Portugal (Figueiral 1995) to early Neolithic northern Syria (McCorriston 2007), to the Levant (Asouti et al. 2015; Fall et al. 2015), Anatolia (Willcox 1974), and China (Fuller and Qin 2013). In fact, numerous studies advocate that both pollen and charcoal evidence be combined to understand these phenomena more fully, as a regional pollen signature may not precisely represent local vegetation realities (Nelle et al. 2010).

Wood charcoal can also be used to understand the culturally specific practices of wood selection, or wood acquisition strategies, that can range from least effort (i.e. the nearest and most conveniently accessible wood), to wood that has favorable burning or construction properties, or that has major symbolic or ritual importance (Marston 2009). Arboriculture can also be investigated using wood charcoal evidence as many domesticated trees require specific forms of management, such as coppicing or cutting, to encourage fruit or nut growth (Asouti and Kabukcu 2014). Other studies have used wood charcoal evidence to identify the presence of domesticated grape (Miller 2008) and olive (Terral 2000; Salavert 2008) trees in local arboriculture.

Conclusions and Future Directions

Paleoethnobotanical data offer rich insights into past agriculture unobtainable by other methods, archaeological or historical. Even when written language is available as a resource, as has been shown above, these data can complement or reveal aspects of agricultural practice that may have been elided or overlooked in the written or art-historical record.

The methods offered by paleoethnobotany will continue to be of importance to many disciplines, especially considering that one of the major "grand challenges" for archaeology includes the need to generate high-resolution data regarding human–environment interactions

(Kintigh et al. 2014), which paleoethnobotanical data are well poised to offer. Some archaeologists (and ecologists) have found that due to its high-quality, temporally sequenced data, ecology "needs" archaeology, and vice versa (Briggs et al. 2006).

While paleoethnobotany offers much by itself, future and continuing work will continue to emphasize that these data should not be interpreted in isolation. By combining plant remains with other lines of archaeological evidence, such as artifacts, animal bones, and the physical spaces in which they are found, or with historical or ethnographic evidence such as texts or images if at all possible, and alongside data derived from natural science techniques, such as genetics and botany, this multidisciplinary complementarity will facilitate a more informed and empirically guided view of ancient agricultural practice. In this sense, it becomes more meaningful to consider not only the carbonized grains recovered at an archaeological site, but the tools used to process them, and the bioarchaeological signatures of the skeletal impact of routine practices and dietary regimes.

In addition to a greater integration of data, there is a continual need for intensive sampling of archaeological sites using systematic strategies informed by fully articulated research designs. High-resolution investigations of archaeological sites continue to improve knowledge of agriculture at the scale of local practice and overturn previous hypotheses regarding major social and natural phenomena and events. Failing to collect these remains would be a missed opportunity to answer essential questions about ancient agriculture due to the inherently destructive nature of excavation. Likewise, regional and inter-regional analyses of paleoethnobotanical data will continue to provide evidence of not only long-distance transfers of plants and agricultural knowledge, but also how, and if, communities came to specialize in and become known for the agriculture of specific crops and varieties. As it stands, paleoethnobotany has offered much to archaeology, ecology, history, and even linguistics, and it is fully expected that this archaeological subdiscipline will continue to bear much fruit.

FURTHER READING

For broad surveys of environmental archaeology, of which paleoethnobotany forms a part, see Dincauze (2000) and Reitz and Shackley (2012). The authoritative textbook on paleoethnobotany is Pearsall (2015), while a shorter overview is available in Wright (2010). Surveys of more recent issues are available in Hastorf and Popper (1988), Hastorf (1999), Sayre and Bruno (2017), and Pearsall (2019), but see especially Marston et al. (2014) for a comprehensive overview of many facets of paleoethnobotanical research. Thorough discussions of phytolith methodology can be found in Piperno (2006), and starches are detailed in Torrence and Barton (2006). Integration of archaeobotanical remains with zooarchaeological evidence is surveyed in VanDerwarker and Peres (2010). For a classic overview of the paleoethnobotany of Europe and southwest Asia, see Renfrew (1973), and for an overview of plant domestication in this area, see Zohary et al. (2012). For histories of the development of paleoethnobotany, see Watson (1997) and for southwest Asia specifically, (Warnock 1998), as well as *passim* in references above. For a complementary perspective from the Americas, see Morehart and Morell-Hart (2015) and VanDerwarker et al. (2016).

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CHAPTER THREE

Zooarchaeology

Valasia Isaakidou

Introduction

Zooarchaeologists analyze and interpret animal remains, especially their durable teeth and bones, from archaeological contexts. Although written and iconographic sources may shed valuable light on past husbandry, animal bones and teeth are far more widely available. This chapter discusses the traditional macroscopic methods of zooarchaeology and their complementary relationship with more recent microscopic, biochemical, and biomolecular techniques. It begins with an overview of the main analytical tools and then illustrates their application in various combinations to some key problems in past animal husbandry, including its role in crop husbandry, but largely excluding the consumption of animal products. While the focus is common Old World domesticates (especially sheep, goats, pigs, and cattle), the approaches discussed are more broadly relevant.

Zooarchaeological Methods

The analytical methods and interpretive models of zooarchaeology draw extensively on other animal-focused disciplines (zoology, paleontology, biogeography, ecology, biology) and also ethnography. Much of its methodological toolkit, however, was gradually developed and refined, to create a distinct subdiscipline, in response to changing paradigms and research questions within archaeology as a whole. The following sections briefly review current methods for the recovery, identification, quantification, and taphonomic evaluation of animal remains and for their interpretation as evidence for past human behavior.

Systematic *recovery* during excavation is a vital prerequisite for most zooarchaeological analysis. Hand collection in the trench, previously the norm, has been progressively replaced by dry-sieving and flotation of soil samples, as experimental studies have highlighted the potentially severe biases against smaller bones and fragments and hence against smaller-bodied and younger animals (Payne 1972). Losses in hand collection vary with soil conditions, time pressure, and excavator experience. To reduce the effects of variably incomplete

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

Figure 3.1 Example of a group of bones and teeth recovered from the dry sieve (Neolithic Knossos, Crete); includes loose deciduous and permanent mandibular teeth (top row), sheep and goat astragali and various foetal/newborn postcranial elements (middle row) and unfused (young) epiphyses of sheep and goat (bottom row). Source: Photograph by Valasia Isaakidou.

recovery, this method is currently widely replaced, or (for reasons of labor efficiency) selectively supplemented by dry and wet sieving (the latter commonly combined with retrieval of plant remains) through standard-sized meshes. By providing a less incomplete and more controlled sample of surviving faunal remains, sieving helps filter out the effects of partial archaeological recovery before interpreting recorded datasets as evidence of ancient human behavior. Assemblages resulting from uncontrolled (or unspecified) recovery pose greater problems of interpretation, although the direction of any losses is predictable. Accordingly, since the composition of a complete skeleton is known, *under*representation of small body parts may be due to recovery bias, but their *over*representation should be due to ancient human activity (Figure 3.1).

Routine macroscopic *identification* of animal bones and teeth determines, with varying precision (e.g. mandible > of small ruminant > of sheep/goat > of sheep > of elderly ewe) and in descending order of the proportion of the assemblage that is so identifiable, their anatomical, taxonomic and demographic (sex, age at death) status. In general, taxon is most precisely and reliably distinguished from morphological and metrical traits of teeth and limb bones. Age at death is determined most precisely from tooth eruption and to a lesser extent wear (affected by dietary abrasiveness as well as age) and more coarsely from fusion of bone epiphyses to bone shafts (also affected by factors such as nutritional plane and castration). Age at death is thus determinable quite *accurately* until adulthood is reached and dental eruption completed, but increasingly *approximately* thereafter, as the effects of variable wear accumulate (Jones 2006). Sex is variously inferred from secondary characteristics (e.g. tusk shape in pigs and pelvis morphology in ruminants), and biometric differences in absolute size and, in some ruminant limb bones, relative build (females being smaller and slenderer than males) (Higham 1969; Payne and Bull 1988). Both morphological and biometric sexual differences develop with age, so young animals cannot be sexed. Males and females are generally born in similar numbers, however, so an uneven adult sex ratio probably reflects sexually selective slaughter of infants or juveniles.

Tooth and bone dimensions also differ between breeds/populations, while bone dimensions are affected by life history (e.g. diet, exercise, weight), as well as sex, so biometric analysis can explore several variables, including breed and quality of husbandry – especially if taxon, age, and sex are determined independently. Life history may also be illuminated by macroscopic "pathological" traces, including developmental checks due to disease, poor nutrition, or extreme weather (Dobney et al. 2007), remodeling due to activity patterns (Mainland, Schutkowski, and Thomson 2007), and healed fractures suggesting care of vulnerable animals. Potentially informative on crop as well as animal husbandry are the mechanical stress-related pathologies (e.g. eburnation and grooving) and remodeling (extension) often (but not exclusively) observed in the hip and foot joints of modern draft cattle and horses (Baker and Brothwell 1980; Bartosiewicz, van Neer, and Lentacker 1997). While joint pathologies might be of congenital or age-related origin, their anatomical distribution and the age of the animals affected may preclude such natural causes of joint degradation, and the articular extensions are more plausibly attributed to draft use (Isaakidou 2006; Figure 3.2). Macroscopic morphological and metrical criteria, from study of modern skeletons of known species, age, sex and (ideally) life history, remain the most common and cost-effective basis of identification, but are now supplemented by more costly but potentially more precise and objective microscopic and biomolecular analyses, again based on analysis of modern animals of known status (e.g. Makarewicz 2014). They have been applied to such diverse variables as species identification using ZooMS analysis of collagen peptides (Buckley et al. 2010); season of birth and death, using sequential tooth enamel oxygen isotope values (Balasse et al. 2012); region of birth, based on sequential tooth enamel strontium isotope ratios (Viner et al. 2010); lifetime movement, using a combination of strontium, oxygen and carbon isotopic analysis (Balasse et al. 2002; Isaakidou et al. 2019); and diet in both the long term, using carbon and nitrogen isotopes (Nitsch et al. 2017), and the weeks or days before death, using dental microwear (Mainland and Halstead 2005).

These newer methods have extended the range of "identification" and enhanced its precision and reliability, but zooarchaeologists mostly address questions that require identification of thousands of specimens, for which macroscopic methods are sufficiently reliable and the most cost-effective. Particularly critical in the Near East or Mediterranean is the distinction between the domestic sheep and goat which, although similar skeletally, are quite different ecologically, ethologically, and economically, but macroscopic distinction between these species is now possible for much of the skeleton (Halstead et al. 2002; Zeder and Lapham 2010). As in this case, macroscopic identification protocols have steadily advanced, so early reports must be evaluated against the criteria then available. Accordingly, one hallmark of a good zooarchaeological report is sufficient presentation of the laboratory and data analysis methods used to enable the reader to evaluate results and assess their comparability with other published data.

The most common method of zooarchaeological *quantification* is a simple count of the numbers of identified specimens (often referred to as NISP), but as a measure of the relative abundance of different body parts, species, or age/sex groups, this has weaknesses. First, animals of different species, age, and sex may not have identical numbers of skeletal parts. Secondly, identifiability varies between complete body parts (e.g. teeth and limb bones are more identifiable than ribs), species (close relatives are hardest to distinguish), and age/sex

Figure 3.2 Effects of traction: anterior view of a "remodeled" (extended) distal articulation of a cattle metacarpal with additional pathological modifications (Late Neolithic Knossos, John D. Evans excavations, 1969–1970) (right) compared with a modern specimen with natural conformation (left). Source: Photograph by Valasia Isaakidou.

groups (adults are generally more identifiable than juveniles). Third, breakage by butchery, trampling, and so on, may vary between body parts, species, and age/sex groups, with increasing fragmentation inflating numbers of specimens but reducing their identifiability. Fourth, identification skills and counting protocols vary between zooarchaeologists. It is questionable, therefore, whether NISP counts can reliably be compared between animal categories, analysts, assemblages, or even contexts. An early proposed solution to these weaknesses was to measure relative abundance of species or age/sex groups by estimating minimum numbers of individuals (MNI) represented, but protocols for doing so again vary between analysts and, in assemblages comprising commingled incomplete skeletons (especially if subject to taphonomic attrition), all protocols exaggerate the abundance of rare species or age/sex groups. Increasingly, therefore, analysts estimate minimum numbers of body parts as the basis of quantification, thus avoiding multiple counting of fragmented parts and improving comparability between animal categories and assemblages.

However bones are quantified, zooarchaeologists work with "deadstock" assemblages, derived mainly from the discard of animals slaughtered for food and carcass by-products (bone, horn, hides), so their data may (with caution) serve to assess the relative proportions in which different species were slaughtered. Such deadstock proportions only resemble livestock proportions, however, if all species had similar mortality profiles, whereas a *deadstock* assemblage dominated by infant (short-lived) piglets with a minority of elderly (long-lived) sheep might represent *livestock* in which sheep outnumbered pigs. Thus, calculation of probable livestock proportions from zooarchaeological data is far from straightforward, although sometimes necessary, for example, to compare with textual livestock records or to explore the relationship between livestock and habitat (e.g. between pig:sheep and woodland:field ratios). Moreover, particular parts of the live population may, through exchange or seasonal movement, have been preferentially consumed and discarded in different contexts (e.g. summer vs. winter; urban vs. rural; domestic vs. public); such complexity can only be explored by contextualized analysis on a regional scale.

Taphonomy, a term borrowed from paleontology, is the study of the anthropogenic and natural processes that modify faunal assemblages from the death or discard of an animal up to archaeological excavation (Lyman 1994). Processes before burial (trampling, gnawing by dogs, weathering) or a hostile burial environment (e.g. acidic soil) may fragment bones/teeth, erode their surfaces (obscuring evidence of taxon, age, butchery, etc.), or destroy them altogether. As with recovery losses, therefore, before interpreting datasets as evidence of human behavior, the effects of subsequent taphonomic modification must be filtered out. Fortunately, present-day experimental and ethnoarchaeological observations, for example, of attrition by dogs (Brain 1981; Binford 1981), have identified diagnostic surface markers for different processes (e.g. canid vs. rodent tooth marks) and shown that they modify faunal assemblages selectively causing most damage to less robust specimens (e.g. of younger animals). The taphonomic processes that have affected an assemblage can thus be identified, together with the likely direction, if not severity, of alteration of its composition. In general, remains buried rapidly in a benign soil environment are best preserved, yield most information (because attrition has not obscured variables of interest), and pose fewest problems of disentangling the imprint of ancient human behavior from subsequent taphonomic distortion. Even degraded assemblages may provide reliable information, however, if the observed assemblage composition is the opposite of that expected from documented taphonomic processes (e.g. high proportion of young animals in a heavily scavenged assemblage). Moreover, taphonomic pathways may be important not only as sources of identifying potentially misleading assemblage modification, but more "positively" as evidence for discard practices, often related to consumption contexts (e.g. rapid burial after sacrifice or formal feasting) that may in turn have involved animals with distinctive management histories (King 2005).

Interpretation of the zooarchaeological record in terms of *past* human husbandry again relies heavily on present-day studies of animal biology, ecology, and ethology and especially on ethnographic or ethnoarchaeological studies of "traditional" (pre-mechanized, pre-industrialized) herding and cultivation. Studies of traditional animal husbandry have highlighted the diverse goals, methods, and scales of recent regimes and the varied natural (e.g. climate, terrain) and cultural (e.g. agricultural land use, market involvement) environments within which they have developed. Anthropologists and ethnographers have focused on "exotic" specialized pastoralism rather than smaller-scale household herding and, with notable exceptions (Dahl and Hjort 1976), have provided limited quantified or practical data that would aid interpretation of zooarchaeological evidence. Increasingly, however, (zoo)archaeologists have collected ethnographic data on alternative pasturing and feeding regimes (Halstead 1998a; Halstead and Isaakidou 2011a) or on herd demography in the context of different production goals and pasture or labor constraints (Payne 1973; Redding 1981; Halstead 1998b).

Studies of herd demography underpin alternative mortality models that zooarchaeologists widely use to explore the production goals and constraints of past animal husbandry. Adult female cattle, sheep, and goats produce young and the milk that the latter consume in their first weeks or months. Most males are not needed for breeding and, if castrated, grow bigger than intact males and make more docile and powerful draft animals (cattle), or produce more and better wool (sheep) or hair (goats). While most females are retained to adulthood for breeding (/milking), therefore, slaughtering males as infants (sparing milk for humans), juveniles/subadults (as their growth rate slows), and castrated adults should maximize availability of milk, meat, and wool/hair or traction, respectively (Payne 1973; Legge 1981a). These biologically based models assume that millennia of human management have not altered livestock performance (Noddle 1990). Critics argue that primitive-breed females (perhaps cows more than sheep or goats) do not let down milk after removal of offspring (Balasse 2003), but recent herders used various stratagems for stimulating let-down, of which the most dramatic ("cow blowing," i.e. blowing air with a tube into the cow's vagina in order to induce milk let-down) appears in Near Eastern iconography from the 3rd millennium BCE. A broader issue is that these models assume optimization by herders, and for a single goal, and so can only be used heuristically, as a measure of potential rather than actual production (Halstead 1998b).

Ethnography has helped not only to identify potential zooarchaeological proxies for different husbandry strategies, but also to elucidate likely wider economic contexts for the latter. Of heuristic importance below is the balance between production for household self-sufficiency and for exchange in recent Mediterranean farming (Isaakidou 2011; Halstead 2014). The former tended to be small-scale, perforce using scarce available land intensively (e.g. rotating crops, manuring, and weeding instead of fallowing). To satisfy diverse household needs, make year-round use of available labor, and avoid total failure from bad weather or disease, it also tended to diversified husbandry of several crop and livestock species. Crop husbandry might thus resemble "gardening" more than "agriculture," with manual tillage supplementing plowing with multi-purpose cows (also supplying calves and perhaps milk) or perhaps donkeys (also pack animals) rather than oxen (useful only for draft). Any sheep or goats were reared for a mixture of milk, meat, and fiber; Christian households typically fattened a piglet to slaughter in winter for fat and preserved meat (Rousounelos 2006), and crop by-products (stubble, straw, weeds, prunings, kitchen waste) provided much of livestock diet (Halstead and Isaakidou field notes; Jouannes Papadopoulos memoirs of pre-Ottoman conquest Crete in Vincent's critical edition of *L'Occio*, 2008).

Farming for exchange tended to be larger-scale (enabling surplus) and specialized on particular crop or livestock species (for economies of scale). Large landowners often specialized in growing cereals with extensive methods, using regular fallowing and oxen to minimize human labor and thus costs (Halstead 1995). They perhaps kept a few cows (to breed oxen) and horses or mules for transport. Some also sold meat and/or milk from cattle, goats, or sheep that mainly grazed fallow fields in winter, crop stubble in summer, and rough pasture otherwise. Others rented their fallow fields to the large and often single-species herds of independent pastoralists, who mostly moved in summer to distant highland pastures (Figure 3.3). While extensive arable farming is familiar to academics, mobile specialized pastoralism perhaps seems seductively primitive, but both were geared to production for sale in urban markets, and the latter acquired staple grains in exchange for the produce and services of their livestock. "Traditional" large-scale and specialized arable or pastoral farming in the Near East and Mediterranean may not, therefore, be relevant analogues for early farming without large towns, sharply inegalitarian landownership, and large polities enabling safe long-distance movement by herds and traders (Halstead 1987). Nonetheless, Mediterranean and Near Eastern ethnography is central to discussion of ancient stock husbandry in these regions because local traditional land use is ecologically more relevant than that of, say, highland New Guinea.

Figure 3.3 Flock of transhumant sheep grazing fallow fields on the Lasithi Plateau (850 masl), east-central Crete (late May 2018). Source: Photograph by Valasia Isaakidou.

Zooarchaeological Applications

The rest of this chapter explores how different zooarchaeological tools and approaches have been applied, usually in combination, to some key problems in past animal management. For clarity, these problems are addressed in approximate chronological order.

The Beginnings of Animal Husbandry in the Near East

Perhaps the most challenging problem of identification for zooarchaeologists is the distinction between domesticates and their wild relatives (Vigne 2015). Early research into domestication of the main "farmyard" animals (henceforth "MFA") and crops of western Eurasia targeted the hilly flanks of the Near Eastern "Fertile Crescent," where the wild relatives of these species overlap today. Zooarchaeologists initially looked for the smaller bodies, brains, and horns/tusks that zoologists considered characteristic of domesticates. Such *biologically* domestic forms of all MFA (and likewise cereal and pulse crops) have now been documented by about the mid-9th millennium BCE (Vigne 2011). Already in 1969, however, Higgs and Jarman highlighted the difficulty of reducing the global continuum of human–animal/plant relationships to either "wild" or "domestic" and of matching the conventional skeletal distinction between these categories to any point on this continuum. Claims that selective culling of juvenile males (mostly superfluous to herd reproduction) indicated domestication in the zoological sense of human control over breeding were also questionable because zooarchaeologists encountered similar mortality in several conventionally "wild" species. It is now widely accepted, however, that documented selective culling of juvenile males will have reduced reproductive competition between males and thus selective pressure in males for large size and big horns or tusks (Helmer et al. 2005). The conventional biometric/morphological markers of domestication in the early postglacial Near East were thus perhaps unintended consequences of selective culling that, by sparing females, prioritized future reproductive capacity over immediate meat yields. A plausible context for such sustainable management is that those exercising restraint expected to benefit in future, recalling Ingold's argument (1986, p. 113) that a domesticate differs from a wild animal in belonging to someone.

The island of Cyprus separated from mainland southwest Asia by a 70–100 km sea crossing and lacking indigenous ancestors of all four MFA, provides an ideal laboratory to explore the chronology of domestication. Between the 10th and 8th millennia BCE, humans introduced wild pigs, then goats, cattle, sheep, and pigs at varying stages of skeletal "domestication," and also the cat, fox, mouse (presumably unintentionally), and fallow deer (Vigne et al. 2011). By the 9th millennium BCE, *selective anatomical representation* of deer and more even representation of cattle, goats, sheep, and pigs at settlements suggests that deer were killed at a distance and so hunted, while the MFA were slaughtered nearby and so herded (Vigne et al. 2011; 2015).

Animal domestication thus poses problems of both definition and zooarchaeological recognition, but by the 7th millennium BCE, skeletally domestic MFA widely dominated faunal assemblages and were associated with morphologically domesticated cereals and pulses across southwest Asia. This Neolithic "package" of domesticates reached Greece before the mid-7th millennium BCE and northwest Europe by 4000 BCE. Pre-Neolithic sheep, goats, and domestic (i.e. small) cattle and pigs have been claimed in support of domestication by indigenous European hunter-gatherers, but morphological and biometric re-analysis and direct ^{14}C dating of bones have shown that supposedly Mesolithic MFA were variously misidentified, wrongly dated, or fall within the size range of wild relatives (Rowley-Conwy 2013). The decreasing size of European domesticates (e.g. for Greece, von den Driesch 1987) through the Neolithic suggests that cattle and pigs were largely isolated from large wild males, in turn implying close and thus small-scale herding of domestic females. The cattle and pigs introduced to Neolithic Europe were thus probably "domestic" in both the zoological sense of breeding under human control and Ingold's definition (above). Analyses of modern and ancient DNA have now confirmed modern European "wild" sheep and goats as descendants of escaped domesticates (Luikart et al. 2001) and Early Neolithic European "domestic" pigs and cattle as descendants of southwest Asian rather than local boar (Larson et al. 2007) and aurochs in the latter case from very few female founder individuals, suggesting a "discrete and rather localized origin" (Scheu et al. 2015, p. 7).

Early Farming in Europe – the Role of Livestock

Introduced MFA widely co-occur across Neolithic Europe, but in varying proportions for which both cultural and environmental rationales have been offered. Available faunal data, showing increasing proportions of cattle from southeast to northwest Europe as precipitation rises and temperatures decline, perhaps favor environmental constraints (Manning et al. 2013). The variable zooarchaeological protocols underpinning these data have probably blurred rather than exaggerated the observed trend, but environmental constraints should influence livestock rather than deadstock proportions, and the reported deadstock trend is not necessarily incompatible with uniform livestock proportions (e.g. if cattle were slaughtered younger from southeast to northwest). In practice, the MFA have broad tolerances, so direct influence of precipitation or temperature on livestock proportions seems unlikely, especially if the four species were not functionally interchangeable but managed for different goals.

Macroscopic, microscopic, and biomolecular techniques together illuminate how each species was exploited. Butchery traces show that deadstock of all four MFA were routinely exploited for food (meat, fat, marrow) and raw materials (hides, horns, bones/teeth). Lipid residues from ceramic vessels confirm cooking of both ruminant and non-ruminant fat and reveal widespread heating of ruminant milk from early in the Neolithic (e.g. Evershed et al.

2008). Cattle hip and foot bones, with deformations common in draft animals, are widespread in small numbers (e.g. Halstead and Isaakidou 2011b) and relatively abundant, from early in the Neolithic and in cows rather than oxen, at Knossos on Crete (Isaakidou 2006). To some extent, therefore, the four MFA were exploited for different purposes. Integration with crop husbandry is indicated not only by tillage with cattle, but also by $\delta^{15}N$ values in charred cereals, showing intensive manuring widely across Neolithic Europe (Bogaard et al. 2013). Dental microwear indicates a very abrasive diet in the days before death for most sheep and goats at LN Makriyalos in northern Greece (Mainland and Halstead 2005), indicating that they grazed on land cleared for crops rather than browsing in surrounding woodland and suggesting that livestock proportions were shaped by embedding in crop husbandry more than directly by precipitation or temperature.

Zooarchaeological evidence cannot directly reveal the relative contributions of livestock and crops to human diet, but ruminants managed for milk production potentially contribute much more than those managed for meat (Dahl and Hjort 1976; Legge 1981a). Although lipid residues confirm early Neolithic milking of livestock, most cattle, sheep, and goat mortality data across Europe approximate to the "meat" model (selective slaughter of juvenile/sub-adult males) and, unless the ratio of livestock to people was very high, favor a minor role for domestic animals in human diet. "Milk" mortality is encountered, however, in Early Neolithic cattle, sheep, or goats in the northwest Mediterranean (Vigne and Helmer 2007), Alpine Foreland (Legge 1981a), and perhaps southern England (Legge 1981b). In these cases, the potential intensity of dairy production was high, and livestock perhaps played a greater dietary role – possibly because crop production was initially less dependable as it spread west and north into alien environments (Halstead 1989). Thus, lipid residues can confirm milking and mortality data reveal the potential intensity of milking, but the dietary importance of dairy produce can only be understood in its broader ecological and economic context.

Livestock, Hierarchy, and the "Urban Revolution"

The accumulation of zooarchaeological life history and mortality data for early MFA and recent analyses of lipid residues in ceramics have revolutionized understanding of Neolithic animal husbandry by demonstrating exploitation of livestock for traction (Helmer and Gourichon 2008, pp. 138–139) and milk (Evershed et al. 2008) much earlier than envisaged in Sherratt's (1981) model of a 4th–3rd millennium BCE "secondary products revolution." Drawing on iconography (zooarchaeological evidence was scarce), Sherratt concluded that animals were domesticated for "primary" carcass products and much later exploited for "secondary" products of milk, traction, and wool, for which the prerequisite know-how (e.g. constructing an ard), technology (e.g. yoking pairs of cattle), and breeds (e.g. woolly rather than hairy sheep) developed in and diffused from early urban centers in the Near East.

The part of Sherratt's model most compatible with the wealth of new evidence is the widespread Bronze Age adoption, in addition to the original MFA, of domestic animals used primarily for transport. The DNA of extant North African wild asses confirms them as ancestral to modern domestic donkeys, while biometric evidence suggests domestication before size decreases in 5th millennium BCE Egypt (Kimura et al. 2013). Use as a pack animal at Egyptian Abydos around 3000 BCE, implied by the "Libyan palette" depicting a train of donkeys, is confirmed osteologically by burials of morphologically wild adult male donkeys with spinal pathologies suggesting stress from load carrying (Rossel et al. 2008). In recent pre-mechanized farming, donkeys facilitated nucleated rural settlement, carrying personnel, tools, manure, and produce to and from distant fields, especially for smallholders and in hilly terrain where cattle-drawn carts were impracticable. Whether they played this role in antiquity, in addition to documented use in long-distance transport, depends on how socially inclusive was their ownership, but discard practices complicate zooarchaeological investigation of this. For example, in later Bronze Age Greece, some donkeys (and horses) were butchered and their bones discarded with other food waste, but others were accorded apparently high-status burial (Pappi and Isaakidou 2015), and yet others perhaps discarded off-site never to be retrieved by archaeologists.

Wild horses were widely distributed, but modern and ancient DNA suggests domestication in the west Eurasian steppes, involving a narrow genetic bottleneck with changes in physiology, cognitive functions, and coat color/patterning (Librado et al. 2016). Domestication by the mid-4th millennium BCE in Kazakhstan has been proposed on several grounds (Outram et al. 2009). Biometrically, the Kazak horses resemble individuals from LBA southern England (outside the natural wild range and so presumed domestic) more than earlier wild horses from Siberia, while their mortality profile was considered characteristic of a managed rather than natural population. Additionally, some teeth displayed wear attributed to bridling, while ceramic residue analysis revealed fatty acids compatible with equine milk. Each of these arguments has been disputed (Levine 2012), but by the 3rd and 2nd millennium BCE horses had spread beyond their natural range, to the western and eastern margins of Eurasia (Bendrey 2012), and have been widely found as intact paired burials, often with remains of wheeled vehicles. Of the "transport domesticates," the horse especially had elite connotations, evident textually, iconographically, and in the mortuary record. Draft cattle also have elite associations in Bronze Age texts from both Mesopotamia (administrative and literary) and Greece (administrative), where recorded working cattle were apparently oxen, rather than cows as at Neolithic Knossos. As Sherratt argued in a later reconsideration of his model (Sherratt 2006), therefore, Bronze Age urbanism was associated with elite reliance on specialized draft oxen rather than the initial yoking of cattle for labor.

Sherratt was also probably right in highlighting the association between wool and hierarchical urban societies in the Near East. Wild sheep are hairy with a woolly undercoat, from which a fleece developed – probably gradually – under domestication. In Bronze Age Mesopotamia, written sources document state-controlled weaving of woolen textiles, while both texts and iconography imply breeds with wool of different quality. Such breeds are perhaps reflected in the variable biometric record of Bronze Age Near Eastern sheep. Management for wool may be reflected osteologically also in relatively balanced proportions of adult males (including gracile specimens of probable castrates) and females (clearly predominant in most Neolithic assemblages) at 4th–2nd millennium BCE sites in the eastern Mediterranean (Isaakidou 2006; Arbuckle, Öztan and Gülçür 2009).

Zooarchaeological data from these early urban societies are also invaluable in clarifying the reach of contemporary texts dealing with domestic animals. For example, texts in Linear B script from LBA southern Greece principally document close "palatial" monitoring of large flocks of male sheep, together with the wool they produced, and of smaller numbers of working oxen. Zooarchaeological remains, however, even from elite sites and allowing for the difference between faunal deadstock and textual livestock data, offer a very different picture in which goats and pigs were also well represented, most adult sheep were female, and draft cattle were frequently cows rather than oxen. Zooarchaeological data thus demonstrate that textual coverage was highly selective, while the two sources combined highlight the limits of palatial and non-palatial resource control and thus advance understanding of Bronze Age political economy (Halstead 1998–1999).

Greco-Roman to Early Modern Europe and the Improvement of Livestock

Over the last three millennia, Europe witnessed two principal and rather different revolutions in animal husbandry: first, expansion of the range of common domesticates to include chicken, goose, duck, and rabbit; and, secondly, systematic breeding of improved forms of long-established domesticates, together with important associated changes in agricultural practice.

Of the additional domesticates, the chicken and turkey were introduced to Europe after long periods under human management in southeast Asia and central America, respectively, where genetic study of modern populations has identified their wild ancestors (Miao et al. 2013). On grounds of biogeography and evolutionary history, therefore, their spread across Europe from the mid-first millennium BCE (chicken) and 16th c. CE (turkey) involved domesticates. The rabbit too may reasonably be regarded as domestic when found outside its Iberian natural range, for example, its breeding becoming widespread in Britain from the late 12th c. CE (Sykes and Curl 2010). Conversely, the wild ancestors of domestic European goose and duck, recognized on the basis of modern DNA analyses (Wang et al. 2010), are widespread across the continent. Zooarchaeological identification of the domestic forms is therefore not straightforward, but zooarchaeological and documentary evidence suggests systematic human management from the Medieval period onward (Albarella 2005). In early modern times, domesticated fowl have been of considerable nutritional and economic significance in supplying eggs and small carcasses for the table of individual households to a degree that the original "farmyard animals" could not (Redding 2015), other than by sacrificing very young lambs, kids, or piglets that could alternatively have been raised to a greater age and substantially larger weight. Their widespread adoption may thus hint at increasing independence through the historical era of small household units, although textual evidence points to the importance of the chicken as a Greco-Roman sacrificial victim and medium for divination.

Deliberate improvement of livestock is famously associated with elite landowners in 18th c. CE Britain, who adorned the walls of their country houses with paintings of large and improbably proportioned livestock. Increased size was due to selective breeding coupled with improved nutrition, enabled by intensive rotation schemes including fodder crops. Zooarchaeological data, however, show that size increments began centuries earlier, were regionally variable, and often accompanied significant changes in husbandry goals (Davis and Beckett 1999; Albarella, Johnstone, and Vickers 2008).

Biometry documents a long-term trend through the European Neolithic and Bronze Age toward smaller livestock, perhaps mainly as an unintended consequence of selectively culling most males before breeding age, as outlined above. Elite interest in selective breeding, however, especially of cattle, is also evident in Greco-Roman literature, while biometry confirms increases, albeit regionally variable, in the size of cattle, pigs, and sheep, perhaps in pre-Roman Iron Age Greece and certainly in Roman Italy and the northern Roman provinces. Sustained increases in size presuppose improvements in livestock diet and/or housing (large individuals are less resilient to harsh conditions), and archaeobotanical evidence from temperate Europe suggests increasing use of hay from at least the pre-Roman Iron Age. That imported breeding stock also played a part is suggested by a biometric study spanning the late pre-Roman Iron Age to late Romano-British periods in eastern England, where locally variable size increases were observed not only in bones (more affected by the quality of husbandry), but also in more conservative teeth (Albarella, Johnstone and Vickers 2008). Whatever the balance between local improvements in animal welfare and inter-regional movement of improved stock, the raising of larger-bodied livestock was not merely an elite vanity project, but also a response to economic incentives including growing urban markets probably supplied by more specialized animal producers and larger-scale agricultural estates. Zooarchaeological contributions to elucidating these incentives include macroscopic evidence (anatomical representation and butchery traces) for specialist urban butchers (Lepetz 2007), strontium isotope evidence for long-distance movement of cattle in later Iron Age and Roman southern England (Minniti et al. 2014), and macroscopic (age/sex and "pathological") identification of increasing Roman use of draft cattle in presumably larger-scale agriculture (de Cupere et al. 2000).

One important problem in the (pre)history of Old World animal husbandry, largely avoided in the preceding sections, is the antiquity of specialized pastoralism and pastoralists. Intra-site contextualized faunal analysis suggests some subsistence specialization even within Neolithic villages, for example, in the contributions of cattle, sheep, and game to meat consumption in different households at Cuiry-les-Chaudardes in northern France (Hachem 2000). In many mixed farming villages today, a few households make a living by herding their own and/or their neighbors' livestock, but this is very different from the whole communities of specialized pastoralists of recent centuries that attracted scholarly attention for the long-distance seasonal migrations of their herds and, in many cases, also their families and worldly goods. Seasonal mobility was long regarded as an archaic trait, preceding sedentism and has widely been proposed for later prehistory. Most recent pastoralists survived by exchanging animal produce for cultivated grain, however, so it is questionable whether such specialized pastoralism can have developed before the formation of large urban centers offering a dependable "market" for pastoral products. Such a market possibly existed in the Near East from the 3rd or even 4th millennium BCE, but was perhaps lacking in Europe (with the possible exception of Classical Athens), until Roman Imperial times or later. There is epigraphic and literary evidence for cross-border and even long-distance movements of livestock in Classical Greece and Republican and Imperial Italy, but most Greek examples involved modest numbers, and the owners were large landowners rather than specialized pastoralists. Osteological evidence for high proportions of adult sheep is consistent with management for exchangeable wool or dairy produce, but mobile herding, if dominated by sheep as in the recent past, was not on a sufficient scale to affect meat consumption in Roman towns, which display no consistent increase over time to consuming more mutton (MacKinnon 2004). The degree of mobility of early historical livestock will probably be clarified in future by analysis of oxygen and strontium isotopes in animal teeth. Inferring pastoral specialization rather than seasonal movement, however, will be challenging.

Conclusions

The potential and limitations of different zooarchaeological approaches are best understood in their application to particular questions and so have been explored here in the context of some key periods and issues in past animal management in the Near East and Europe. It is important to acknowledge that addressing similar issues with a different geographical focus would have entailed different sets of sources and methods. For example, in northern China, early domestic pigs and dogs can be identified because they consumed locally domesticated millet. Millet, a C_4 plant, displays carbon isotope values distinct from natural temperate vegetation, which consists mostly of C_3 plants (Barton et al. 2009). In the case of South American camelids, thanks to favorable preservation conditions, dung deposits within enclosures are among the most convincing early indications of domestication (Mengoni Goñalons and Yacobaccio 2006).

As noted above, the variety of analytical methods now available to zooarchaeologists share certain key characteristics. First, they are all based on analogies drawn from present-day observations, some in a natural sciences context and others in a humanities context. The former provide data that are generally more secure and involve less risk of circular reasoning, but the latter are integral to answering questions about past human management, as, for example, in debates over the meaning (as opposed to zooarchaeological recognition) of "domestication". Second, all these methods are subject to development or dispute, such that comparison of ostensibly similar datasets (e.g. mortality data from different assemblages) requires careful consideration of the protocols applied in each case – which in turn presupposes that reports present the procedures followed in sufficient detail. Third, interpretation of data from all these analytical methods demands prior consideration of the archaeological formation processes to which samples have been subject, and perhaps especially so, if rare well-preserved specimens are selected for analysis – for example, if good preservation was due to deliberately rapid burial, which in turn reflected an animal's unusual life history or death.

The "case studies" reviewed above highlight the complementarity of different zooarchaeological methods – macroscopic, microscopic, and biomolecular – and the need to mobilize multiple methods and sources to address major questions in the (pre)history of animal management. Different and apparently contradictory methods may shed light on different aspects of a question, as in the complementary contributions of lipid residues in ceramics and ruminant mortality profiles to understanding early dairying in Europe. Equally, "traditional" macroscopic data (e.g. on age, sex, context of consumption) should inform sampling for more costly and destructive biomolecular analysis. The "case studies" also highlight the complementarity between zooarchaeological evidence of actual exploitation and iconographic or written clues to cultural ideals regarding, or elite interests in, animals.

FURTHER READING

Zooarchaeology is a continuously evolving field and has been slowly but consistently gaining ground in the archaeology of the historical period. Broad introductions to the scope and methods of the field include Davis (1987), O'Connor (2000), and Reitz and Wing (2008). The weighty *Oxford Handbook of Zooarchaeology* (Albarella et al. eds., 2017) presents applications of zooarchaeology in a chronologically and geographically rich array of case studies, many of which make use of the rapidly expanding isotopic and (archaeo)genetic methods of analysis. For the application of zooarchaeological approaches to historic period faunal assemblages, and the light these shed on farming practices and on the distribution and consumption of animal products, the reader is referred to works by Albarella, Davis, King, Lepetz, MacKinnon, O'Connor, and Sykes, mentioned in this chapter; to several contributions in the *Oxford Handbook*; and to the recent special issue of the *European Journal of Archaeology* (2017, volume 20, 3) devoted to "Animal husbandry in the Western Roman empire: a zooarchaeological perspective" An extensive synthesis of ethnographic work on recent agricultural practices in the Mediterranean, and their relevance to exploring past farming (albeit with an arable rather than pastoral focus), can be found in Halstead (2014), which may also be consulted for further reading. Finally, the recent volume by Outram and Bogaard 2019 presents a concise review of the history of economic archaeology and a critical assessment of the potential of integrating 'traditional' and novel approaches in zooarchaeology and archaeobotany to shed light on ancient subsistence and economy.

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CHAPTER FOUR

Stable Isotopes in Ancient Agriculture

Simone Riehl

Introduction

Although most stable isotope studies on bioarchaeological remains focus on ancient diet, there are also works that address more or less directly ancient agriculture (e.g. Araus et al. 1999, 2007, 2014; Alagich, R. et al. 2018; Bogaard et al. 2007; Ferrio et al. 2005; Fiorentino et al. 2012; Mueller-Bieniek, A. et al. 2019; Riehl et al. 2014; Styring. A. K. et al. 2017; Vignola, C. et al. 2017). By studying stable isotope ratios in archaeological organic remains, we can, however, learn about ancient environmental conditions (e.g. climate and moisture availability) as well as anthropogenic factors that determined the development of ancient agriculture (e.g. the position of crop fields in the landscape). Furthermore, specific aspects of human behavior that reflect the modalities of agricultural practice become apparent, such as diet, herding strategies, technologies of crop production, and crop trade. However, stable isotope analysis on archaeobotanical remains still requires considerable methodological refinement to generate knowledge on local agricultural practice, as well as large-scale accumulation of data to enable conclusions on long-term, supra-regional agricultural development (Fiorentino et al. 2015).

For interpreting stable isotope values measured on archaeological remains and for evaluating their meaning in studying ancient agriculture, an understanding of isotopic fractionation during primary production, i.e. changes in the ratios of light to heavy isotopes, mostly due to changes in physical processes, as well as of the sources and cycling of organic matter in natural systems, including ancient food webs, is crucial. These basics cannot be outlined in detail in this chapter. Instead, the reader is advised to consult the fundamental textbooks and articles (e.g. Hoefs 1997; Fry 2006; White 2015; DeNiro and Epstein 1979; Vogel 1980; Farquhar 1983; Schoeninger and DeNiro 1984; Ehleringer, Hall, and Farquhar 1993).

Analyzing stable isotope values in archaeological remains is basically the interpretation of variation in the data. Besides a probable causality of environmental change or human activity, there can be a number of different factors responsible for data variation, including sampling of material from a single context that represents in fact a longer-term (up to decades) accumulation or a limited sample size. Variation in isotopic composition usually also increases with increasing complexity of the life system; e.g. in the food chain (Figure 4.1), small animals

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

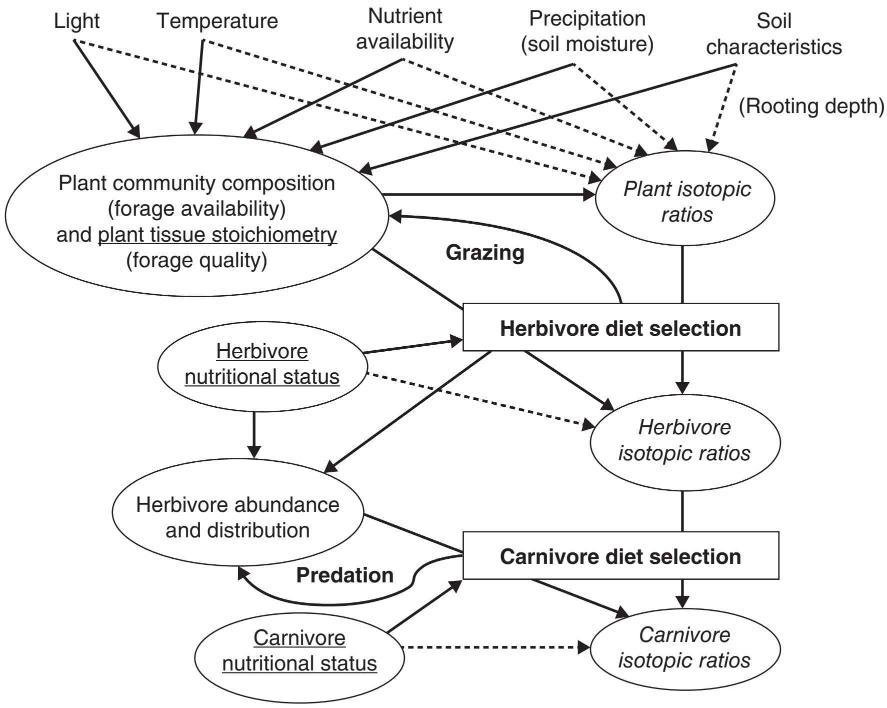

Figure 4.1 Interactions between processes that influence stable isotope ratios of herbivores and carnivores, showing biochemical, physiological (underlined), and behavioral processes (in rectangles). Solid lines represent ecological interactions, and dotted lines represent factors affecting diffusion rates and enzymatic reactions (i.e. photosynthesis, nutrient routing, and nutrient recycling). Source: Ben-David, M. and Flaherty, E.A. (2012). Stable isotopes in mammalian research: A beginner's guide. *Journal of Mammalogy* 93(2):312–328.

raised on diets of known isotopic compositions show $\delta^{13}C$ values that differ from that of the diet by up to 3‰, whereas large ruminants with estimated $\delta^{13}C$ values of their diet have values in collagen that are 5–6‰ less negative than the estimated diet (Schoeninger and Moore 1992). Aspects of variation involve deep immersion into basic stable isotope geochemistry and ecology, and can only shortly be touched upon within this chapter. The reader is therefore recommended to address the references provided to pursue these systemic aspects.

Stable Isotopes Relevant to the Investigation of Ancient Agriculture

While the diversity of stable isotopes measured in archaeological material is continuously increasing, the most frequently analyzed isotopes to address questions on ancient agriculture are those of carbon, nitrogen, oxygen, and strontium.

Carbon ($\Delta^{13}C$)

As one of the most abundant chemical elements, carbon contributes to all sorts of different processes on Earth and beyond. Biomass formation through photosynthesizing plants by using carbon dioxide is one of the most important aspects of reservoir generation within the carbon cycle. The evolution of different carbon fixation strategies in plants was closely determined by Earth's climate history through providing competitive advantages to plants using C4 carbon fixation related to increased water use efficiency under drier and warmer climate conditions. Studies to reconstruct the vegetation development and climate change through identifying C3 vs. C4 plants in natural sediments are therefore numerous (Cerling et al. 1997; Huang et al. 2001; Sage 2001; Ehleringer and Cerling 2002; Hatte and Schwartz 2003; Codron et al. 2005; Parker et al. 2006; Nordt et al. 2008).

During the 1980s, stable carbon isotopes aroused interest in archaeology in relation with studies on ancient diets, when they were measured in archaeobotanical remains to provide reference values for estimating food webs in human populations (DeNiro and Epstein 1981; DeNiro and Hastorf 1985).

Simultaneously, the relationship between the carbon isotope composition and plant-water status was investigated in plant physiology (Farquhar and Richards 1984) and agronomy (Condon, Richards, and Farquhar 1987), enabling the development of applications to answer archaeological research questions on ancient cereal yields, soil moisture availability, and irrigation (Araus and Buxó 1993; Araus et al. 1997b; Araus et al. 1999).

Determination of 13C/12C ratios (R) is conducted by mass spectrometry, referring to the PeeDee Belemnite (PDB) standard:

$$\delta \text{ in ‰} = \frac{R_{(\text{sample})} - R_{(\text{standard})}}{R_{(\text{standard})}} \times 1000$$

During photosynthesis, there is discrimination of the heavy isotope ^{13}C in favor of the light ^{12}C, which is expressed in the formula by Farquhar et al. (1982):

$$\Delta^{13}C = \frac{\delta^{13}C_{air} - \delta^{13}C_{plant}}{\left(1 + \delta^{13}C_{plant}/1000\right)}$$

Because $\delta^{13}C$ of atmospheric CO_2 ($\delta^{13}C_{air}$) changed throughout Earth's history, it is necessary to calculate past $\delta^{13}C_{air}$ before comparing $\delta^{13}C$ values in archaeological remains with modern and other archaeological data. A standard method to calibrate $\delta^{13}C$ measurements of ancient cereal grains is the application of global atmospheric changes in $\delta^{13}C_{air}$, as measured in Antarctic ice cores (Ferrio et al. 2005; Ferrio et al. 2006; ftp://aftp.cmdl.noaa.gov/ccg/co2c13/flask/readme.html).

Since in C3 plants the strongest discrimination occurs during carbon fixation by the enzyme RuBisCO, the availability of ^{12}C in the plant during this photosynthetic step is crucial. Under drought stress, the plant closes its stomata to increase water use efficiency, which leads to decreasing CO_2 concentrations through continuing photosynthesis and relative enrichment of ^{13}C or decreasing $\Delta^{13}C$ in the plant (Ehleringer, Hall, and Farquhar 1993). $\Delta^{13}C$ values thus can provide insight into the availability of soil moisture (either through precipitation or irrigation) during the grain-filling period of the crops.

Discrimination in C4 plants is weaker and has been found to strongly decrease at roughly 50 days after planting in sorghum (Williams et al. 2001), which makes application to archaeobotanical remains difficult (Tieszen and Fagre 1993).

Diagenetic alteration through carbonization has been a concern, particularly with archaeobotanical remains that preserve in most cases only through charring during the settlement period. While numerous studies suggest that stable carbon isotope composition of cereals during charring remains almost unchanged (DeNiro and Hastorf 1985; Araus et al. 1997b; Ferrio et al. 2007), some found changes in $\delta^{13}C$ of peas of up to 1.5 ‰ when charred at different temperatures (Poole et al. 2002), although it is unclear if these variations are due to the heterogeneity between different pools of grains (Fiorentino et al. 2015).

Nitrogen ($\delta^{15}N$)

As the major component of Earth's atmosphere, nitrogen is involved in a large number of different physical and biological processes and determines the basic features of the ecosystem. $\Delta^{15}N$ is calculated in accordance with the $\delta^{13}C$ formula, referring to atmospheric N_2 with a $\delta^{15}N$ value of 0‰, i.e. less than 0.366 ‰ (White 2015). Biochemical and physical processes either cause enrichment or depletion in $\delta^{15}N$ values in the food chain, resulting in considerable variations in values within and between ecosystems (Ambrose 1991; Figure 4.2). Compared to $\delta^{13}C$, the diversity of influential factors acting on $\delta^{15}N$ in the soil–plant system processes is considerable, which, when applied to archaeological materials, complicates the interpretation of nitrogen values from archaeobotanical remains (Högberg 1997; Fiorentino

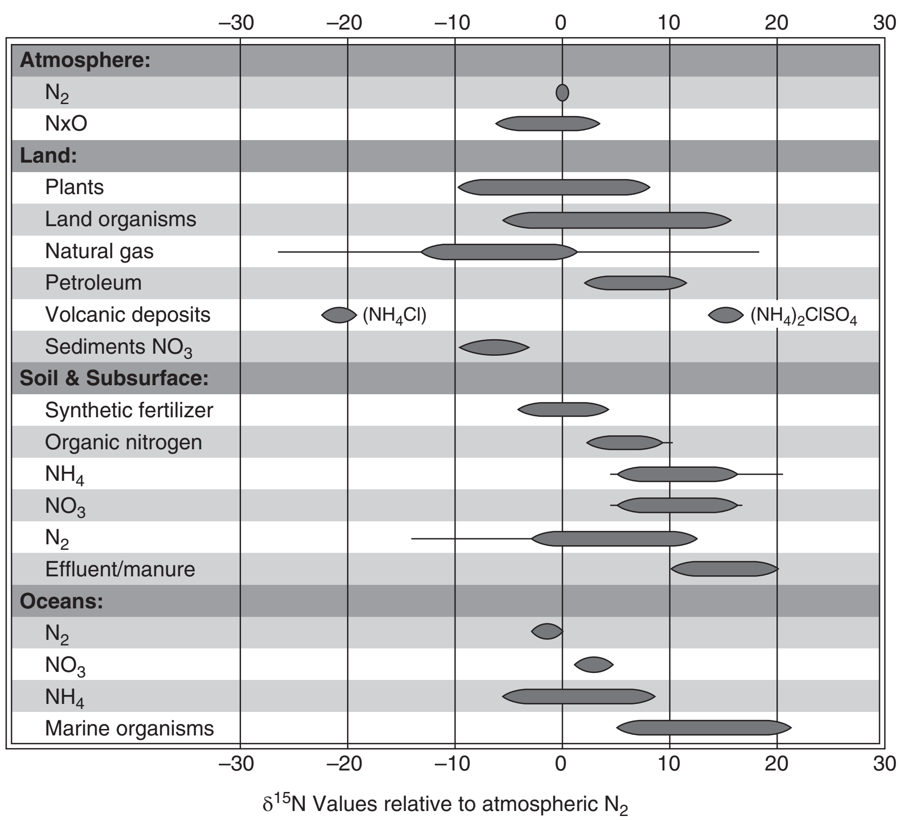

Figure 4.2 Ranges in $\delta^{15}N$ variation. Source: From http://web.sahra.arizona.edu/programs/isotopes/nitrogen.html

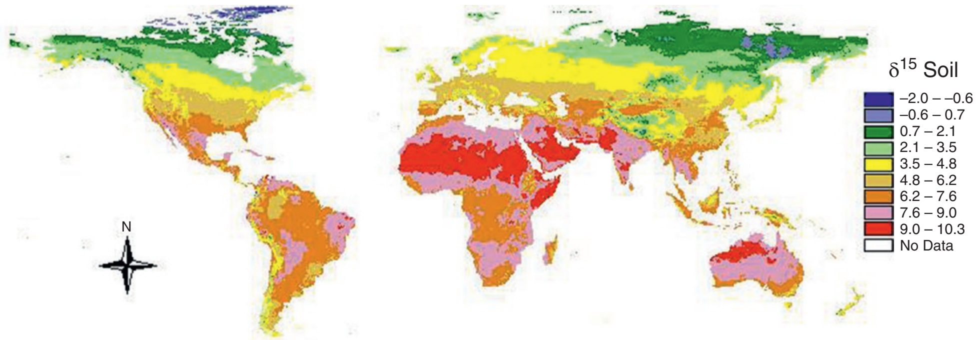

Figure 4.3 Estimated geographical distribution of soil $\delta^{15}N$ values to 50 cm. Source: From Amundson et al. (2003). Reproduced with permission of John Wiley & Sons.

et al. 2015), as well as for the following steps of the food chain (DeNiro and Schoeniger 1983; Heaton et al. 1986; Ambrose 1991; Schwarcz and Schoeninger 2012; Szpak 2014).

In relation to ancient agriculture, a considerable amount of information on the isotopic composition of plant remains and soils reveals the positive relationship between high levels of organic nitrogen in soils (Figure 4.3), either through natural preconditions or animal-derived fertilizers, and stable heavy nitrogen isotopes in plant tissues (Amundson et al. 1998, 2003; Bol et al. 2005), allowing archaeologists to answer questions on ancient soil fertility (Araus et al. 2007; Aguilera et al. 2008) and manuring practice (Bogaard et al. 2007; Fraser et al. 2011).

For the interpretation of $\delta^{15}N$ signals in plant remains, Aguilera et al. (2008) proposed a model according to which $\delta^{15}N$ in plant matter is mostly determined by a combination of three factors:. $\delta^{15}N$ of the different nitrogen sources, the relationship between nitrogen inputs and plant demand (nitrogen excess), and the amount of nitrogen derived from organic matter, all of them reflecting the nutrient status of ancient crops.

However, there are a large number of different processes in soils (Ambrose 1991) as well as interrelated mechanisms influencing the δ^{15} N of archaeobiological remains from past agricultural contexts that cannot be completely disentangled for indicating their causative nature (Szpak 2014). Particular attention should, for example, be placed on separating the effect of manuring from cultivation of original soils that are naturally fertile, particularly in arid regions, where nitrogen systems are more open and soil nitrogen fixation is inhibited by soil dryness and high temperatures. Thus, cool and moist soils by contrast show higher nitrogen fixation and mineralization rates and lower $\delta^{15}N$ values than hot, dry savanna and desert soils (Ambrose 1991). This can be particularly problematic with respect to past climatic fluctuation. In addition, nitrogen fixation is inhibited in alluvial plains, and salinity decreases $\delta^{15}N$ in cereal grains (Yousfi, Serret, and Araus 2009).

Possible alteration of $\delta^{15}N$ in plant remains through charring has been investigated experimentally by a number of authors (Bogaard et al. 2007; Aguilera et al. 2008; Fraser et al. 2013a). They all found no or only insignificant change in $\delta^{15}N$ values after charring at different temperatures, thus preserving the original environmental signal during the lifetime of the plants. Archaeological sediments, however, carry carbonate precipitates and humic/fulvic acids that may accumulate in archaeobiological material and distort stable carbon and nitrogen isotope measurements. Therefore pretreatment of the material is required. The standard pretreatment method for removing carbonate crusts and humic/fulvic acids is described by DeNiro and Hastorf (1985). Since that, the method has been systematically refined (Fraser et al. 2013a; Styring et al. 2013; Vaiglova et al. 2014b).

While diagenetic alteration is less of a problem in archaeobotanical remains, the chemical composition of bones and teeth is more prone to physical and chemical mechanisms leading to changes in the biogenic isotopic signatures after the individual's death. Collagen preservation in fossil bones and dentine depends on climatic conditions and is particularly critical in warm, humid open air environments. Similarly, oxygen signatures may be altered and need to be carefully assessed on the sample level by using a maximum of different proxies (Bocherens and Drucker 2007).

Oxygen ($\delta^{18}O$)

Stable oxygen isotope analysis of atmospheric precipitation applied to terrestrial palaeoenvironmental archives, as for example, ice cores, is a standard method for reconstructing ancient climatic dynamics (Dansgaard 1964).

Applied to the tooth enamel of an animal, $\delta^{18}O$ provides information on climatic regimes in which ancient husbandry was practiced, because $\delta^{18}O$ is determined by the body water and precipitation ingested from surface reservoirs, i.e. drinking water and plants, at the time of tooth formation (White et al. 1998; Towers et al. 2011). High-resolution intra-tooth enamel sampling even allows elaboration of seasonal climatic variation, answering agriculturally relevant questions such as birth seasonality in domesticated animals (Balasse et al. 2003; Pederzani and Britton 2019).

In charred plant remains, oxygen isotopes are of limited use, due to strong fractionation during carbonization. Exceptions are the seed coats of some species (*Celtis* spp. and *Lithospermum* spp.) that preserve biogenic carbonate, providing $\delta^{18}O$ in the carbonate fraction for palaeoenvironmental reconstructions and information on agricultural preconditions (Jahren et al. 2001; Pustovoytov et al. 2010; Quade et al. 2014). $\delta^{18}O$ in carbonate of Celtis seed coats correlates with $\delta^{18}O$ in local river waters, which has been interpreted to show that water intake from the landscape by Celtis happens without notable fractionation. Furthermore, there is a strong relationship between $\delta^{18}O$ of the biogenic carbonate and air temperature during the growing period of the plant (Jahren et al. 2001). Similarly, Lithospermum seed coats indicate relationships between their $\delta^{18}O$ values and climatic parameters, particularly for the warm season (Pustovoytov et al. 2010).

Strontium ($^{87}Sr/^{86}Sr$)

Strontium isotope analysis is based on the observation that strontium in weathering rocks and sediments transfers into biological cycles without notable changes in $^{87}Sr/^{86}Sr$ ratios (Åberg 1995).

In archaeological contexts, strontium isotopes have been analyzed in bones to determine the geographical mobility of humans and other animals (Price et al. 1994; Ezzo, Johnson, and Price 1997; Hodell et al. 2004; Arnold, Greenfield, and Creaser 2013), most frequently to elucidate Neolithic migration patterns (Grupe et al. 1997; Price, Burton, and Bentley 2002; Bentley, Price, and Stephan 2004; Knipper 2011). Only very few studies have been conducted on archaeobotanical remains for locating ancient crop fields within the landscape (Benson 2012; Bogaard et al. 2014).

The application of strontium analyses on carbonized plant remains is accompanied by some methodological problems. Several environmental factors affect the availability of minerals to plants, such as the rate and extent of weathering, soil drainage, and pH (Arnold, Greenfield, and Creaser 2013). Furthermore, plants generally contain low densities of Sr compared to animal bones, resulting in superimposition of plant-specific $^{87}Sr/^{86}Sr$ ratios by the ratios in the matrix of the cultural sediments (Heier, Evans, and Montgomery 2009).

Natural and Anthropogenic Determinants in Ancient Agriculture

Natural Factors That Affect Agricultural Production and Development, and That Are Reflected by Stable Isotopes

In principle, the full set of stable isotopes measured in palaeoclimatological archives is of some relevance to questions related to the development of ancient agriculture, because climatic aspects are relevant for most processes that are described for the emergence, establishment, or change of agriculture. Indeed, no matter whether the Younger Dryas fluctuation and its role in the emergence of agriculture or diverse Holocene climatic fluctuations such as the 5.2, 4.2, or 3.2 ky BP events are considered, $\delta^{18}O$ and $\delta^{13}C$ measurements in speleothems (Bar-Matthews and Avner 2011) and lake sediments (Parker et al. 2006; Roberts et al. 2011) play a major role in finding possible explanations of agricultural phenomena through the assessment of local and regional climate development (Araus et al. 2007; Fiorentino et al. 2008; Riehl, Bryson, and Pustovoytov 2008; Riehl et al. 2012, 2014; Riehl 2012 and 2016, in press).

During the last two decades, stable carbon isotope analysis of archaeobotanical remains developed into a tool to identify ancient environmental conditions for plant growth, particularly in the landscapes of the Mediterranean and the Near Eastern regions (Araus and Buxó 1993; Vernet et al. 1996; Ferrio, Voltas, and Araus 2003; Riehl 2008; Fiorentino et al. 2008; Aguilera et al. 2011). However, a general interpretation of such local data as proxy records for regional environmental development is difficult due to often unknown anthropogenic factors, such as the mode of irrigation practiced in arid or semi-arid landscapes. If no direct archaeological or geoarchaeological record of ancient irrigation is available, incorporation of additional archaeobotanical data and textual evidence may help solve such problems (Riehl 2010 and 2014; Riehl et al. 2012).

Temperature

In semi-arid to arid regions, temperatures have the most influence on evapotranspiration of crop plants during their growing season, and are thus directly related to crop yields. $\delta^{18}O$ values in the biogenic carbonate of fruit pericarps of the tribe Lithospermeae (Boraginaceae), which are frequently associated with crop plants in archaeobotanical samples from Near Eastern agricultural settlements, have been shown to proportionally correlate to summer mean monthly temperatures of the vegetative period and are inversely proportional to the amount of precipitation (Pustovoytov et al. 2010). Despite its potential, the study of $\delta^{18}O$ values in biogenic carbonate of archaeobotanical seeds is still in its infancy and requires further investigation, including methodological refinement through experimental data and additional methods, such as clumped isotope thermometry (Δ_{47}; Eiler 2007 and 2011). While the interpretation of $\delta^{18}O$ is not straightforward as regards its influence by precipitation, Δ_{47} values in carbonate are determined by temperature and thus can help resolve such uncertainties. Applied to seasonally built carbonate in seed plants, the measurements could serve as a highly resolved proxy for palaeotemperatures during the time of seed formation.

Water

The availability of water for crop growth is particularly critical in arid and semi-arid regions, which is why studies of stable carbon isotopes in archaeobotanical crop species are most abundantly available from archaeological sites in these climatic regions (Fiorentino et al. 2015 and references therein). Different factors relevant to water availability have been interpreted to relate to $\delta^{13}C$ values in plants, such as local rainfall (Stewart et al. 1995), humidity (Edwards et al. 2000), soil moisture (Chen et al. 2005), or in the case of archaeobotanical crop species, water availability including possible irrigation (Araus et al. 1997a). For reconstructing natural factors that directly affected agricultural production, cereals are preferred to other kinds of plant remains, because $\delta^{13}C$ values provide a signal for the amount of water that was received during the grain-filling period, allowing for seasonal fluctuations in moisture conditions that are important to agricultural and economic development in ancient societies.

Some methodological aspects need to be taken into account when considering $\delta^{13}C$ data of archaeobotanical specimens. These include environmental parameters other than water availability that may cause variation in the $\delta^{13}C$ data. Along with salinity, evapotranspiration, and crop density, soil fertility causes variation in $\delta^{13}C$, but according to Wallace et al. (2013), nitrogen stress increases $\Delta^{13}C$ for less than 0.5‰, while (Yousfi, Serret, and Araus 2009) report 0.03‰. Other methodological issues relate to the strong interannual fluctuation in precipitation in arid regions that can cause high intraspecific and intrasample variability of $\delta^{13}C$ values. Furthermore, ancient irrigation practices could hinder a straightforward recognition of water stress in plants from archaeological contexts, which additionally represent accumulations of grains from different fields and/or different years of yield. Therefore, it has to be taken into account that the more arid the climate regime and the higher the possibility that contextual accumulations have been sampled, the more samples will be needed to capture meaningful data variability (Riehl 2010; Riehl et al. 2014). Sufficiently large data amounts (i.e. 6–10 measurements on individual grains deriving from one archaeobotanical sample), however, allow assessment of local climate fluctuations despite possible irrigation (Fiorentino et al. 2015).

During the last years, a number of large $\delta^{13}C$ data sets from Near Eastern and Mediterranean archaeological sites have been published, providing overviews on the diachronic development of the role of water availability in ancient agricultural societies (Araus and Buxó 1993; Araus et al. 2014; Riehl et al. 2014; Wallace et al. 2015; Riehl 2016). Investigating cereal grain weight and stable carbon and nitrogen isotope signatures of grains and charcoal from 11 northern Mesopotamian Neolithic sites, Araus et al. (2014) could elaborate the evolution of agronomic conditions in this region at the beginnings of agriculture (Figure 4.4). The data show considerably higher water availability for crops during the Holocene than at present, with a maximum between 10 000 and 8000 cal BP. Araus et al. (2014) also found decreasing $\delta^{15}N$ values for the time sequence considered, suggesting cultivation under gradually less fertile soil conditions. On the basis of their study and including additional stable isotope and archaeobotanical data for a number of archaeological sites, Riehl (2016) refined the model of the developmental processes of emerging agriculture for the component of local human–environment interrelations. These results show that a loss of diversity in plant use from the Epipalaeolithic until the Pre-Pottery Neolithic B is coupled with the geographic region, climatic background, and flexible human subsistence. The investigated sites show a trend of higher amounts of small-seeded taxa in older sites with lower modern mean annual precipitation in contrast to large-seeded progenitor species that occur in higher amounts at younger sites with higher modern mean annual precipitation, emphasized by the $\delta^{13}C$ record that indicates a stronger stress signal in different cereal species in sites older than 10 800 cal yrs BP than in sites of younger age. In addition, samples younger than 10 300 cal yrs BP are depleted in ^{15}N but only until the end of the Middle Bronze Age.

In another study, focusing on reconstructing site-specific ancient growing conditions for crop species and drought stress variability in ancient Near Eastern agricultural systems

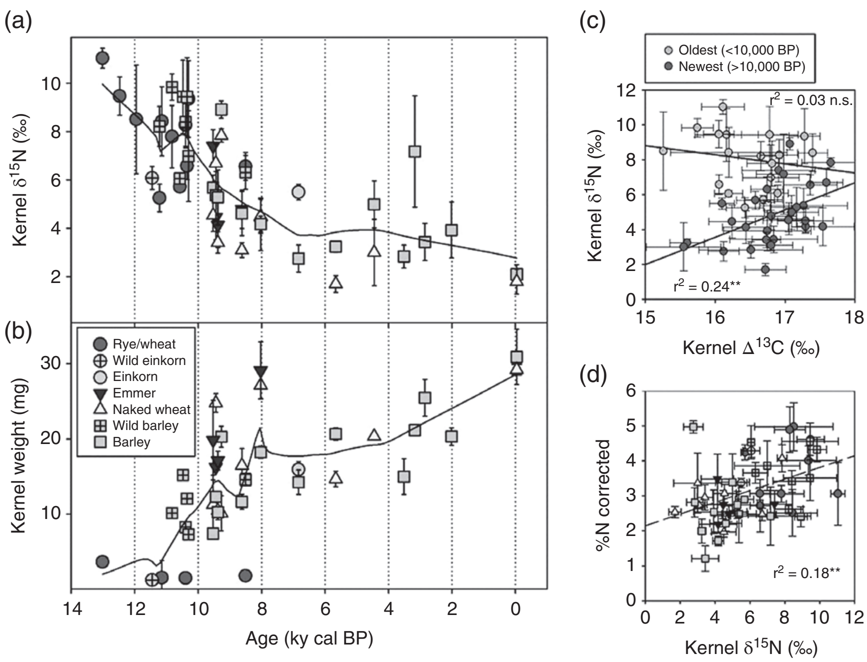

Figure 4.4 Crop grain quality and soil fertility: Evolution through time of (a) nitrogen isotope composition ($\delta^{15}N$) and (b) estimated grain (kernel) weight of cereal crops. Kernel weight was estimated from the morphometric values of the charred grains. Trend lines depict locally weighted least-squares regression curves. Each value represents the mean ±s.e. of kernels from a specific site and dating; (c) relationship between $\delta^{15}N$ and $\delta^{13}C$ average values of grains across the oldest and the more recent sites; (d) relationship between $\delta^{15}N$ and the nitrogen concentration in kernels for the set of fossil cereal kernels used in this study. Source: From Araus et al. (2014). Reproduced with permission of Springer Nature.

between the Aceramic Neolithic and the Late Iron Age (10 000–500 BCE), 1037 barley grains from 33 archaeological sites were analyzed for their $\delta^{13}C$ values (Riehl et al. 2014). The results show the regional diversity of mostly climatic effects on ancient crop species in the Near East over the Holocene sequence (Figure 4.5). Drought stress was occurring in many agricultural settlements in the ancient Near East, particularly in correlation with the major Holocene climatic fluctuations. The regional impact of these climatic fluctuations was, however, diverse and influenced by geographic factors and by human interaction with their environment. For example, while the coastal areas of the northern Levant were less affected by climatic fluctuations, regions further in land had to cope with increased water stress.

Soil

Most archaeological studies investigating nitrogen isotopes in relation to ancient soils focus on manuring (e.g. Bogaard et al. 2013; Fraser et al. 2011; Kanstrup et al. 2014), whereas the natural fertility of soils is only considered randomly (Aguilera et al. 2008; Araus et al. 2014;

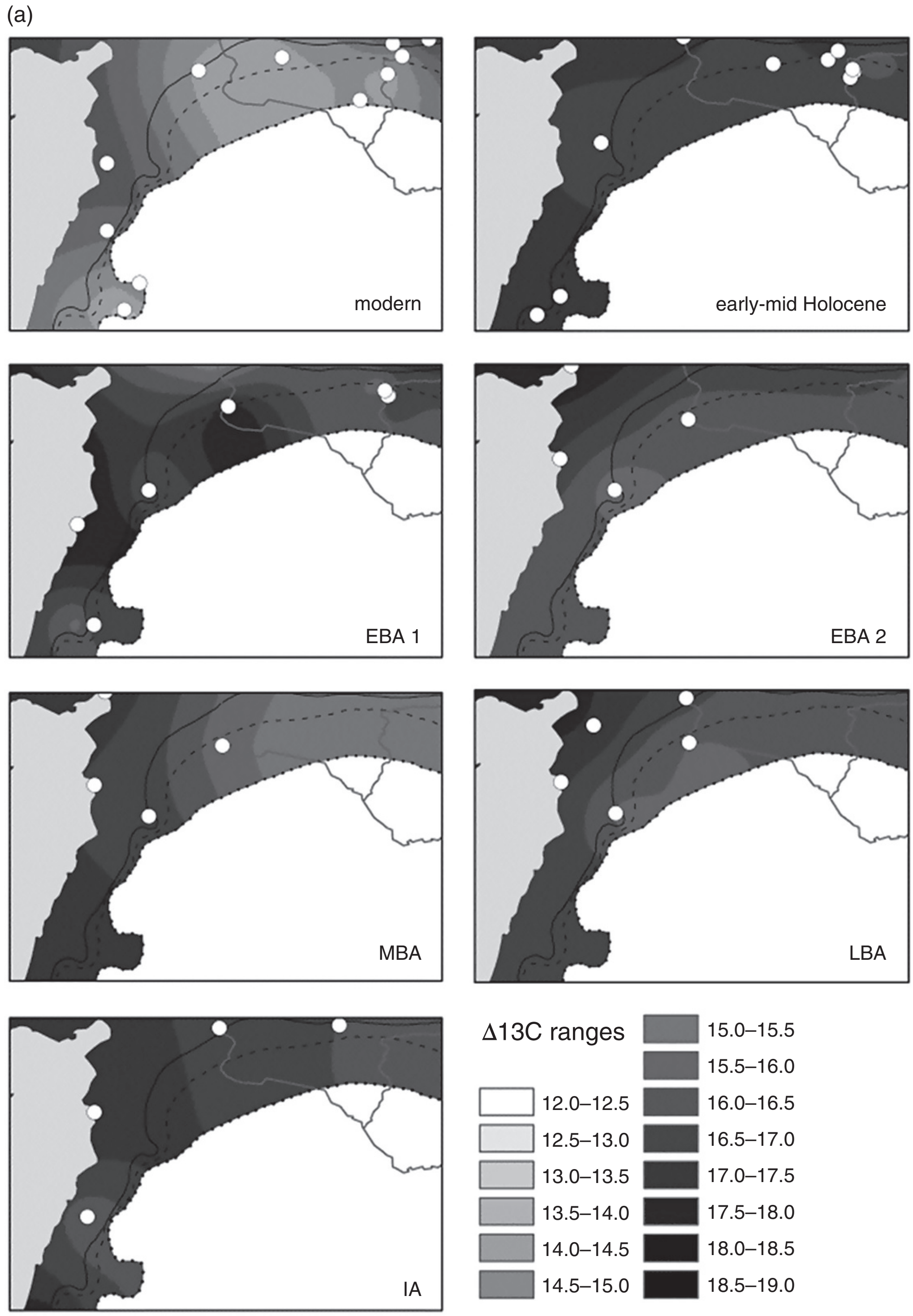

Figure 4.5 (a) Spline interpolation of mean $\Delta^{13}C$ values from barley grains for different periods in archaeological sites located in the Fertile Crescent; EBA1: earlier Early Bronze Age, EBA2: later Early Bronze Age, MBA: Middle Bronze Age, LBA: Late Bronze Age, IA: Iron Age. Source: Illustration by Simone Riehl.

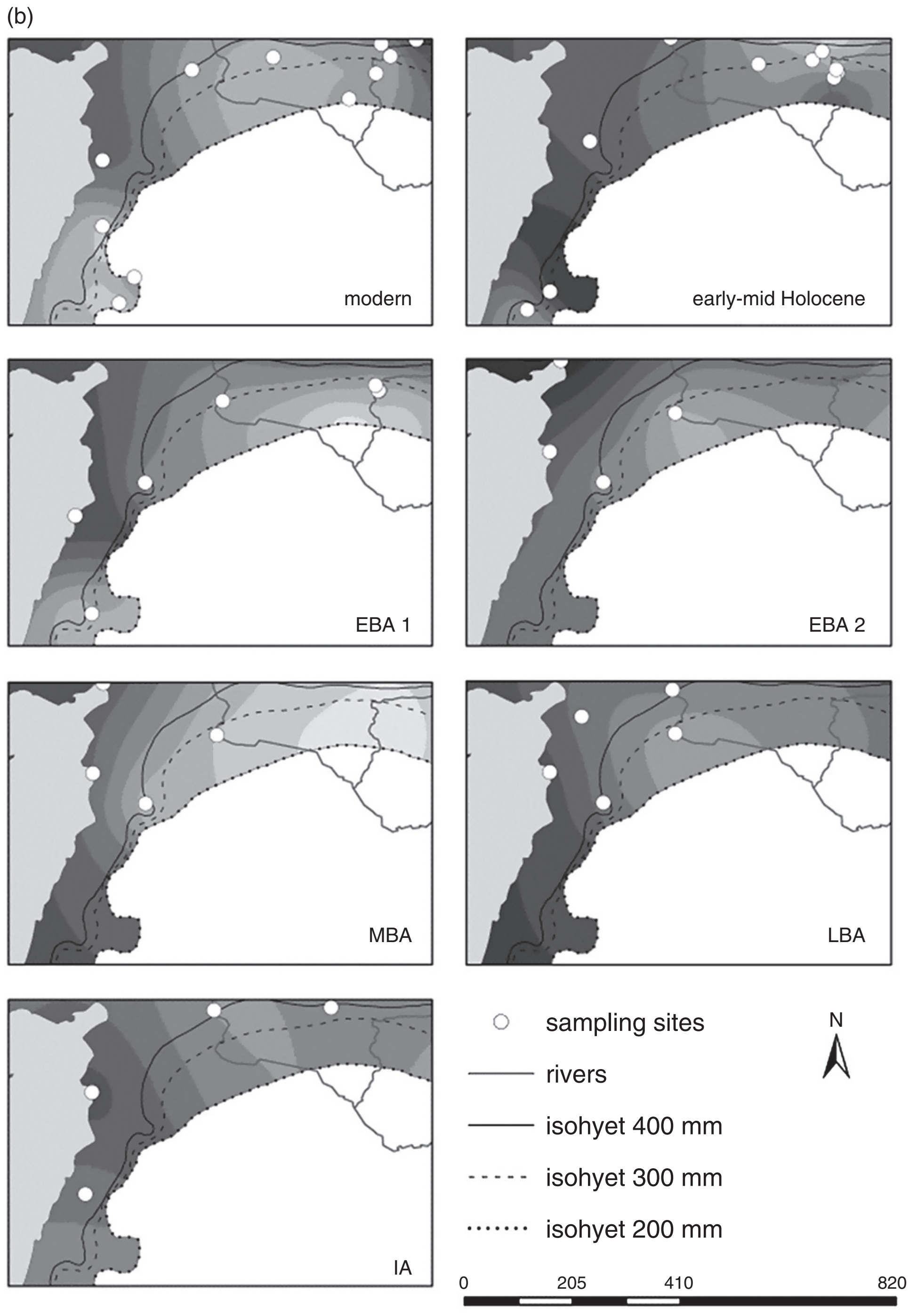

Figure 4.5 (b) Spline interpolation of minima $\Delta^{13}C$ values from barley grains for the same periods and sites. Light gray colors (values smaller than 16 ‰) represent a strong drought stress signal, whereas dark gray tones indicate no drought stress signal. Source: Illustration by Simone Riehl.

Riehl 2016). This is due to the fact that archaeological objects and ancient human activity are fused, thus showing modification rather than natural conditions. Disentangling soils naturally rich in nitrogen from manured soils in the $\delta^{15}N$ record by analyzing archaeobotanical crop remains requires large datasets derived from long chronological sequences, ideally from one location, to be compared to equally highly resolved data from other locations within and beyond the same region.

Buried soils or prehistoric topsoil relicts have mostly been studied for addressing palaeoclimatic questions and only rarely by investigating their stable isotope signatures in relation to ancient human societies. The work by Lauer et al. (2014) considers Neolithic and Bronze Age topsoil relicts in pit fillings of German archaeological sites for their nutrient status, addressing the question of targeted soil amelioration in the past. For comparison, an Early Weichselian humic zone was investigated, representing the soil status before the introduction of agriculture. A large number of relevant biomarkers were analyzed, allowing a wealth of conclusions on ancient soil status. For example, elevated $\delta^{15}N$ values and bile acids as markers for fecal input indicate manure addition to the Neolithic arable topsoils of the investigated region. An amount of up to 38% of soil organic carbon from charcoal suggests additional inputs of burned biomass. All micronutrient parameters indicate that Neolithic and Bronze Age arable soils did not show any nutrient deficiencies. Future studies of ancient soil conditions should aim at combining $\delta^{15}N$ of archaeobotanical remains with studies on buried soils.

Human Interaction with the Natural and Cultural Environment That Affects Agricultural Production and Development

Crop Choice, Dietary Preferences, and the Introduction of New Crop Species (C3 vs. C4)

Human dietary studies based on stable isotope ratios are fundamental to our understanding of ensuing systemic processes of agricultural development. While bioarchaeological remains provide a rough overview on the plant and animal species consumed by ancient human populations, their overall contribution to ancient diets remains unclear, at the same time making them better suited for investigating ancient agricultural production patterns. The only way, however, to directly address the nutritional and economic importance of food plants and animals is through stable carbon and nitrogen isotope measurements on human skeletal remains, which were initiated in the late 1970s (DeNiro and Epstein 1978; DeNiro and Epstein 1981; Van Der Merwe and Vogel 1978; Ambrose 1991; Schoeninger and Moore 1992; Hedges and Reynard 2007; Fraser et al. 2013b).

Most of the older studies, particularly on coastal sites, consider ancient diet under the question of marine vs. nonmarine food or examine signs of a shift in ancient diet with the beginnings of agriculture (Schoeninger and Moore 1992), as has been elaborated already for the Mesolithic–Neolithic transition in northern Europe on the basis of bone finds (Tauber 1981). These early studies could demonstrate a distinct difference in stable nitrogen isotope signatures in pastoralists, agriculturalists, and hunter-gatherers for various geographic regions and, in agreement with ethnographic reports, indicating on average, 4‰ less positive $\delta^{15}N$ values in groups dependent on plant foods than those reported as most dependent on animal products (e.g. Ambrose and DeNiro 1986). On the other hand, distinguishing between different amounts of protein input is difficult, because reasonable differences of 15% for protein input in modern populations produce less than 0.5‰ difference in bone collagen $\delta^{15}N$, which then would lie within the usual range of variation in a group of individuals within a population (Schoeninger and Moore 1992).

Although there is currently no particular method to calculate the accurate intake of macronutrients in an ancient human's diet or their origin from meat or dairy products from isotopic ratios, recent results of $\delta^{13}C$ and $\delta^{15}N$ analysis, from human and animal bone collagen, as well as from charred plant remains of cereal and pulse crops from the Neolithic site of Vaihingen in Germany, suggest a much higher intake of plant-derived protein than previously assumed (Fraser et al. 2013b). This supports earlier criticism of interpreting high $\delta^{15}N$ values (i.e. +9‰) in human diet from the Neolithic period onward to indicate animal-based subsistence, ignoring potentially high input of N from manured cereals (Bogaard et al. 2007).

The study of ancient dietary patterns as a characteristic of ancient agriculture may address two different spatial levels: (1) the local, mostly site level and (2) a regional level of agricultural patterns.

On the local level, differentiation of plant diets with large components of nitrogen-fixing pulse crops from diets that rely on cereals can be a difficult task. Although it has been shown that $\delta^{15}N$ values in nitrogen fixers seem to be similar to atmospheric values, i.e. around 0‰, while $\delta^{15}N$ values in non-N_2 fixers are mostly determined by soil properties, their straightforward interpretation in the palaeodietary context has not been resolved yet, due to limited knowledge of nitrogen isotope data in relevant plant species and the high variability of natural nitrogen abundances in plants (Van Klinken, Richards, and Hedges 2002). Furthermore even the study of the trophic level, i.e. the extent to which the $\delta^{15}N$ of human bone collagen lies above the $\delta^{15}N$ values of herbivore bone collagen from the same archaeological site can be confounded by uncertainty regarding the ^{15}N trophic enrichment factor in both individuals (Styring et al. 2015). Applying different models for estimating the proportion of animal protein in human diet, Styring et al. (2015) could show that large discrepancies in the estimated proportions of animal protein occur depending on whether plant $\delta^{15}N$ values are included or not. For a better understanding of the plant $\delta^{15}N$ contribution to human bone collagen, more $\delta^{15}N$ value determinations in modern and archaeological plants even on the local level are necessary to minimize discrepancies in diet reconstruction through diversity in metabolic processes associated with nutrient assimilation and tissue biosynthesis.

Regional agricultural development of later periods has often been considered with respect to the potential introduction of C4 crops. On the basis of differences in their ^{13}C signatures (C4 agriculture: –6.5‰, a mix of C3 and C4 plants: –15‰; Schoeninger and Moore 1992), the European crop spectrum, which is dominated by C3 plants has been investigated, for example, considering the beginnings of millet cultivation and consumption of this crop (Murray and Schoeninger 1988). For East Asian settlements, the study of C3 vs. C4 signals was used to regionally and locally discriminate millet domestication from rice-based economies (Hu, Ambrose, and Wang 2006), and in a New World context Alfonso-Durruty et al. (2019) could demonstrate that the terrestrial resources consumed by Arica Culture groups in northern Chile were mostly contributed by C_3/CAM plants instead of maize. However, recent studies indicate that the complex correlation of $\delta^{13}C$ values from millets with precipitation must be taken into account when interpreting human and animal diets in millet-based societies (An et al. 2015). In marine environments, interpretation of the carbon signal is even more complex due to the difference in carbon sources of terrestrial versus marine foods, particularly when C4 plants and marine foods are part of the diet, which can lead to a signal suggesting a mixed C3/C4 diet (Schoeninger and Moore 1992). Here, nitrogen values may help to differentiate, providing different $\delta^{15}N$ values for marine and terrestrial foods, thus enabling a better understanding of ancient subsistence economies.

Field and Crop Management

Various agricultural technologies, such as weeding, tillage, plowing, crop rotation, and manuring are known from archaeological records or the textual evidence as having been practiced by ancient farmers (Willcox 2012; Sherratt 1981; Hruska 1990; Hillman 1985; Postgate 1984; Brochier, Villa, and Giacomarra 1992; Charles 1998). While some techniques are archaeologically well recorded, others are less obvious, particularly for periods or cultural regions where ancient texts have not been recovered. In such cases, stable isotopes may help reveal ancient methods of field and crop management.

Most isotopic studies addressing field and crop management focus on the application of manure to ancient crops (Figure 4.6). Experimental studies indicate that soils with high nitrogen inputs from animal dung or that are naturally rich in easily available organic nitrogen produce higher $\delta^{15}N$ values in cereals, so that human diets with a major component of grain from manured fields can be misinterpreted as indicating a largely animal-based diet, thus creating a biased picture of ancient agriculture (Bogaard et al. 2007). While it appears that systematic manuring was practiced as part of the Neolithic agricultural diffusion into the west (Bogaard et al. 2013), its role is less clear for ancient Near Eastern agricultural societies and has been addressed for the Eastern Mediterranean only in experimental studies (Fraser et al. 2011).

Interpretation of crop rotation systems by applying $\delta^{15}N$ measurements has been emphasized only recently. Vaiglova et al. (2014a) investigated different crop taxa at a Neolithic site in Greece, suggesting cultivation of pulses in a high-manuring/high-watering regime, likely in garden plots in rotation with free-threshing wheat, above all indicating small-scale mixed farming with long-term use of the same plots rather than shifting cultivation (Vaiglova et al. 2014a). Manuring of pulses is identifiable, due to their N_2-fixing characteristics, allowing them to obtain most of their nitrogen from the atmosphere. Thus, they are less affected by soil ^{15}N enrichment factors than cereals are. Therefore, Vaiglova et al. (2014a) conclude that if $\delta^{15}N$ values of pulses are increased, they must have been manured under a high-intensity regime. In consequence, this kind of investment would, according to the authors, exclude shifting cultivation, but indicate crop rotation. As such interleaving of arguments involves a number of untestable assumptions, more studies are needed to address crop rotation systems.

A recent investigation combines functional weed ecology and crop stable carbon and nitrogen isotope analysis for identifying crop growing conditions and husbandry practices with the main goal of assessing the intensity of past cereal production systems on the base of archaeobotanical assemblages (Bogaard et al. 2016). This study revealed that modern floristic variation primarily reflects geographical differences, an aspect that is also reflected in ecological characteristics of taxa in archaeobotanical assemblages (Riehl 2015). Furthermore, crop stable nitrogen isotope values interpreted to distinguish between intensive manuring and long-term cultivation with minimal manuring suggest that early farming in central Europe was intensive, and likely incorporated manuring (Bogaard et al. 2016).

Irrigation of Crop Species

While Bronze Age irrigation is well documented for southern Mesopotamia from ancient texts, its application in northern Mesopotamia and the Levant is less clear (Jas 2000; Bagg 2000; Reculeau 2011; Wilkinson 2003). Stable isotope analysis potentially can help address the question of ancient irrigation.

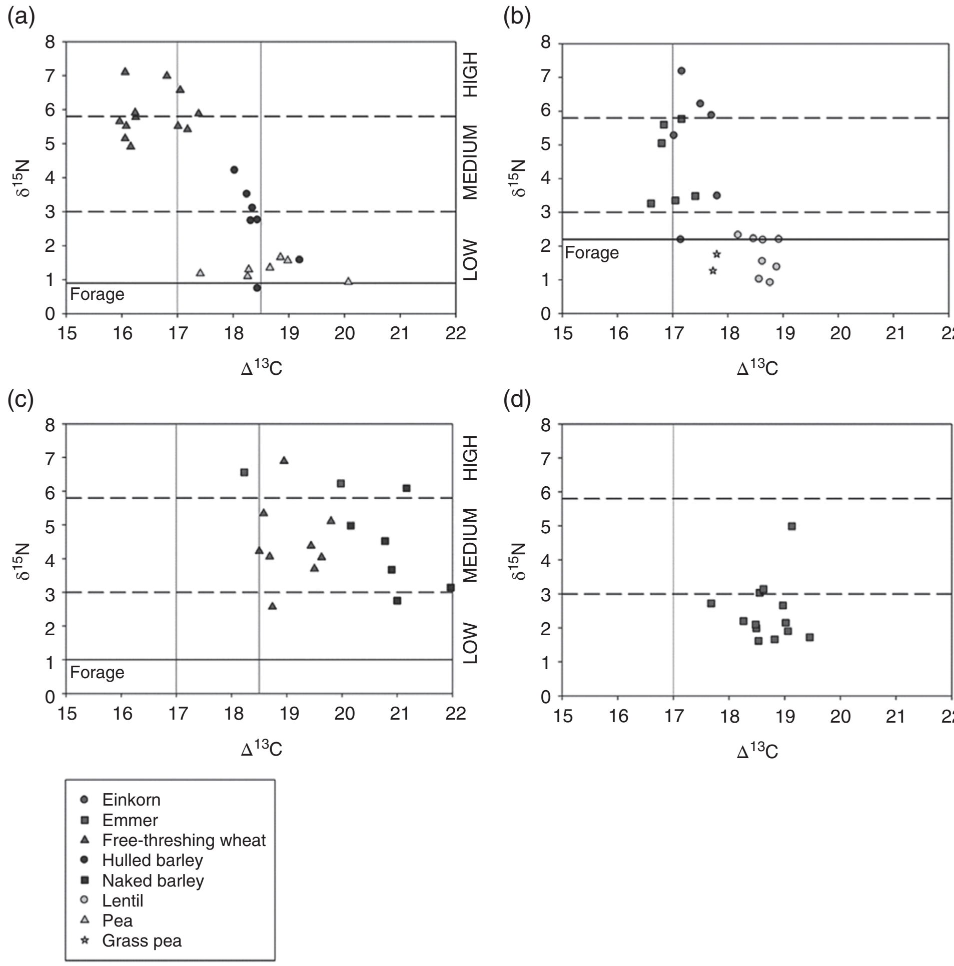

Figure 4.6 $\Delta^{13}C$ and $\delta^{15}N$ values of cereal and pulse samples at four Neolithic sites: (a) Koufovouno, Greece; (b) Slatina, Bulgaria; (c) Hornstaad, Germany; and (d) Sarup, Denmark. Solid horizontal lines represent estimate of large herbivore forage $\delta^{15}N$ value (by subtracting 4‰ from the mean value for herbivore bone collagen to account for trophic shift). Dashed horizontal lines represent thresholds of low, medium, and high manuring rates inferred from modern experiments. Red vertical lines represent well-watered wheat and pulse thresholds; dark blue lines represent the well-watered barley threshold. Source: From Bogaard et al. (2013). Reproduced with permission of Proceedings of the National Academy of Sciences.

While $\delta^{13}C$ values in archaeobotanical crop species generally give information on soil moisture availability during the grain-filling period of the plants, Ferrio et al. (2005) combined $\Delta^{13}C$ data from different crop species to differentiate between precipitation and irrigation in ancient crops. It also has been suggested that a large standard deviation of stable carbon measurements in cereal grains of one species within an individual sample may indicate high variability of moisture conditions, thus potentially reflecting irrigation agriculture (Riehl,

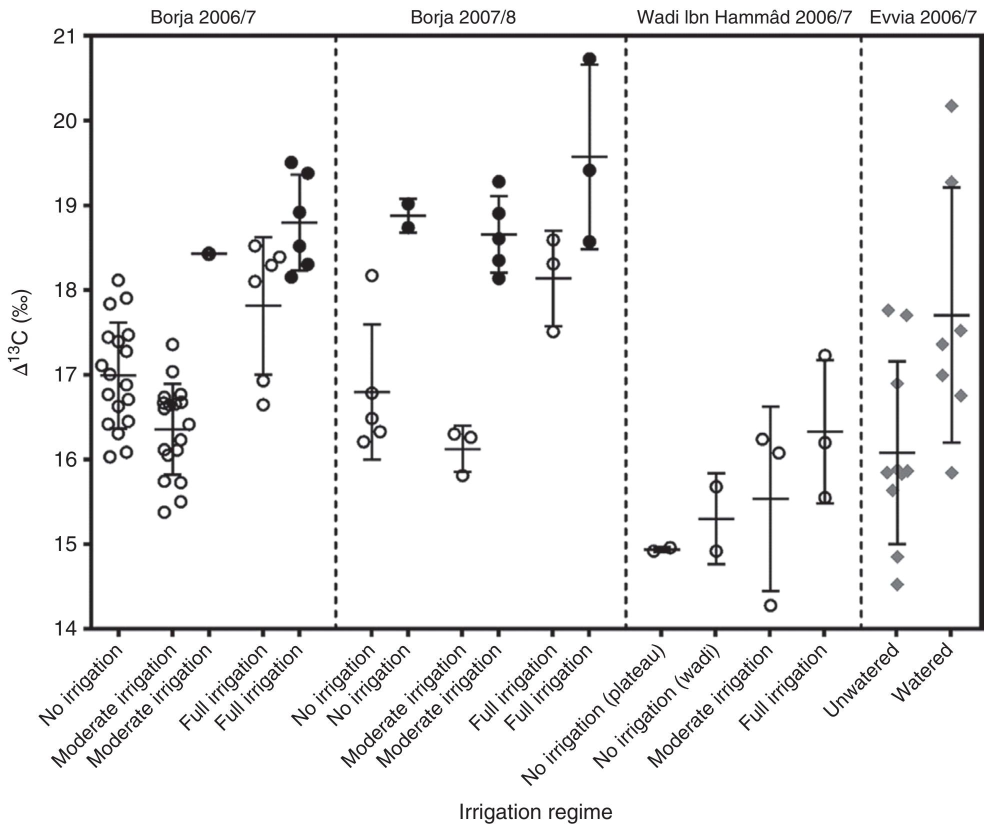

Figure 4.7 Plot of $\Delta^{13}C$ values of wheat grain (○), barley grain (●), and broad beans (◆) from the farm collections; bars and whiskers denote means and standard deviations, respectively. Source: From Wallace et al. (2013). Reproduced with permission of Taylor and Francis.

Bryson, and Pustovoytov 2008), which is supported for moderate irrigation by experimental work (Wallace et al. 2013; Figure 4.7). Combined stable C and N isotope analysis has also been used for specifying the water sources, i.e. irrigation versus elevated precipitation.

In another study, Wallace et al. (2015) investigated early crop water management through stable carbon isotope analysis for archaeobotanical grains from nine Eastern Mediterranean and Near Eastern archaeological sites, dating to the Neolithic and Bronze Age. Their results indicate preferential irrigation of wheat and opportunistic watering practices for some pulse crops (*Lens culinaris*, *Pisum sativum*, and *Vicia ervilia*). Irrigation was particularly ascertainable for wheat grains from the Iraqi site of Abu Salabikh, which produced the highest $\Delta^{13}C$ values in comparison with other sites, thus indicating the wettest growing conditions in this arid site (Wallace et al. 2015).

Combining ecological data for archaeobotanical wild taxa and stable carbon isotope analysis on cereal grains from the same samples also allows the investigation of ancient irrigation, as has been done for some Bronze Age sites in Syria (Riehl 2010 and 2012). In the case of Emar, drought-susceptible crops such as free-threshing wheat and grape were abandoned during the Middle Bronze Age, and irrigation of at least some crops was practiced (Riehl 2010). Combining $\delta^{13}C$ measurements on archaeobotanical crop species and phytolith studies on archaeological sediments (Miller Rosen 1992; Madella et al. 2009) may further increase our ability to distinguish between natural water availability and irrigation practice in the past.

A straightforward interpretation of high $\Delta^{13}C$ values as either signalizing increased precipitation or irrigation is, however, impossible, and additional stable isotope methods are required to resolve this issue. A possible method could be clumped isotope thermometry (Δ_{47}), which clearly identifies palaeotemperatures (see the section titled "Temperature"). Combining $\delta^{18}O$-Δ_{47} ratios in fruit carbonate of Lithospermum species with $\delta^{13}C$ values in charred cereals from the same archaeological samples could help resolve the question by identifying the role of water availability in $\delta^{18}O$ values of the biogenic carbonate, which will then be comparable to $\delta^{13}C$ values from cereals. In case the fruit carbonate shows more negative $\delta^{18}O$ values but equal Δ_{47} values for some samples, which also show a lack of water stress in the $\delta^{13}C$ values of the cereals, this could then be a sign of additional water supply through irrigation.

Import of Crop Species and Localization of Crop Fields

Combined $\delta^{13}C$ and $\delta^{15}N$ in archaeobotanical remains can potentially also be used to detect the possible locations of crop fields in closer proximity to a settlement (Fiorentino et al. 2012), whereas cultivation of crops at farther distances might be recognized by strontium isotopes (Bogaard et al. 2014).

Provenance studies based on C and N have only recently been started and require comprehensive basic research. The assumption for using combined stable carbon and nitrogen analysis to recognize different locations of crop fields is that the natural (climatic and edaphic) and anthropogenic (agricultural practices) conditions at a site are reflected in the grain size and highly variable $\delta^{13}C$ and $\delta^{15}N$ values of a particular crop species within a site. For addressing the question of crop provenance, Fiorentino et al. (2012) investigated estimated cereal grain volumes, based on thickness, length, and width of grains from a silo at Middle Bronze Age Ebla in Syria by combining these with $\delta^{13}C$ and $\delta^{15}N$ values from the grains. Textual evidence from Ebla indicates that taxation included grain tributes from satellite sites, which would suggest that cereal fields were located in different regions. Statistical analysis of the barley grains stored in the silo revealed different groups of specific morphometric grain types, and specific carbon and nitrogen values, supporting the hypothesis of an origin from different locations, thus providing insight into agricultural management and redistribution at the site.

Strontium isotopes have been more frequently used on bones and teeth, especially to investigate migration patterns of ancient humans and animals (Bentley et al. 2002; Price et al. 2002), but only a few results have so far been obtained for plant remains (Benson 2012; Rich et al. 2012; Bogaard et al. 2014), which not least relates to methodological problems (see the section titled "Strontium ($^{87}Sr/^{86}Sr$)"). Extensive acquisition of comparative samples based on multiple depth-integrated sediment samples and vegetation samples, however, allowed the reconstruction of the origin of maize at different archaeological sites in the semi-arid environments of the southwestern United States (Benson 2012).

For evaluating local versus distant land use Bogaard et al. (2014) investigated tooth enamel of small ruminants and archaeobotanical remains from the Neolithic site of Çatalhöyük. By analyzing strontium isotope data in modern plants, they found contrasting values in modern plants from the plain versus the terraces. While the strontium isotope measurements on the Neolithic animal teeth from Çatalhöyük provide information on animal herding practices (see the section titled "Herd Management and Animal Foddering"), strontium isotope data for archaeobotanical remains suggest that the terraces were not used for plant gathering and cultivation, but diverse habitats on the plain were exploited with different land-use practices. However, potential diagenetic alteration and the fact that alluvial sediment may have covered the investigation area later than the Neolithic requires extension of the analyses through sampling of geoarchaeological cores on substrates around the site that could be relevant to Neolithic growing conditions (Bogaard et al. 2014).

Herd Management and Animal Foddering

Addressing herd management in the past involves diverse issues that have been studied by stable isotope analysis, such as managing birth rates, preferred modes of animal nutrition, and choice of landscape zones for browsing.

The question of birth seasonality of small ruminants has been addressed at a number of archaeological sites. Balasse et al. (2003) investigated high-resolution intra-tooth analysis of enamel oxygen isotope ratios at a Late Stone Age site in South Africa with the goal of contributing to food availability throughout the year and the residential mobility strategy of the human community, both of which would affect ancient agricultural patterns. They found two birth seasons separated by approximately six months, which can be explained either by females lambing more than once a year within a herd system where rams and ewes mate more or less freely, or by a planned reproduction cycle with subdivision of the flock into two groups, each giving birth once a year in different seasons. Two lambing seasons would have resulted in an extension of the period of milk availability, suggesting that sheep may have played an important role in the subsistence economy of these communities, and would have resulted in limitations on the degree of mobility of prehistoric herders.

Henton (2012) combined $\delta^{18}O$ values and microwear in sheep teeth to contribute to the question of seasonal management of domestic herds at Çatalhöyük (Figure 4.8). She found a

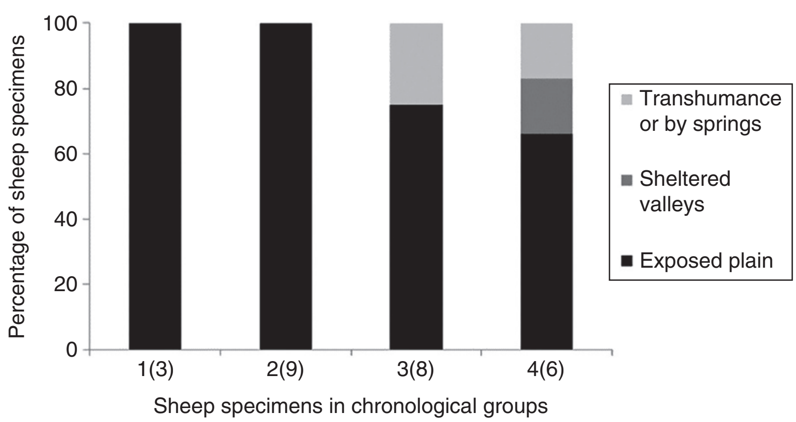

Figure 4.8 Temporal trends in the first year movement of Çatalhöyük sheep, based on modeled oxygen isotope evidence; Group 1: Pre-ceramic Neolithic (7400–6900 cal. BC.), Group 2: Early Ceramic Neolithic (6900–6500 cal. BC.), Group 3: Late Ceramic Neolithic (6400–6200), Group 4: Late Ceramic Neolithic (6300–6000 cal. BC.). Source: From Henton (2012). Reproduced with permission of Elsevier.

settlement-wide preference for keeping herds within a day's distance of the settlement, suggesting maintenance of the synchrony of the breeding cycle. She also argues for herding on the arable fringes rather than in closer proximity to the plant cultivation plots, due to the lack of evidence for field-edge weed diets in the teeth microwear samples.

Herd management issues have also been addressed by analyzing $\delta^{13}C$ and $\delta^{15}N$ ratios (Stevens et al. 2013). Stevens et al. (2013) concluded from their studies that highly variable isotopic values within animal populations are related to differences in the isotopic signatures of different plant communities colonizing different parts of a landscape. Such spatially and ecologically determined differences in the isotopic signatures of the landscape have also been used to investigate different feeding terrains (Madgwick et al. 2013) or alternatively to differentiate between natural browsing and human feeding of animals (Hammond and O'Connor 2013).

Animal foddering has also been studied by combining stable isotope measurements in archaeobotanical and associated faunal remains at the Neolithic site of Vaihingen in Germany. Although focusing on ancient human diet (see the section titled "Crop Choice, Dietary Preferences and the Introduction of New Crop Species (C3 vs. C4)"), Fraser et al. (2013b) also provide information on animal forage. Inferred domestic herbivore forage $\delta^{15}N$ values are higher than expected if livestock consumed only the chaff of einkorn and emmer wheat crops, or their isotopic equivalents. Estimated herbivore forage $\delta^{15}N$ values suggest a high input of local vegetation, rather than feeding on crop species. Sheep and goat samples differ distinctly in their carbon $\delta^{13}C$ values, suggesting that sheep and goats were kept in more open areas.

Analysis of d13C in deer molars and sequential d13C and d18O analysis in tooth enamel of different domesticated ruminants from the Xinzhai site in China (ca.1800–1705 cal. BC) led Dai, L. et al. (2016) to far-reaching conclusions on social and cultural life of the ancient settlers. A strong C4 signal in cattle supported the hypothesis of cattle feeding with millet, which they connect with a privileged status of cattle in the Xinzhai society. In another study on Neolithic farming in southern Greece, Vaiglova et al. (2014a) (see also the section titled "Field and Crop Management") support a model of small-scale mixed farming, where crop cultivation and animal husbandry are closely integrated. They conclude that the ancient farmers intensively grew free-threshing wheat for human consumption, while hulled barley was also cultivated for fodder. They also found a diachronic development from the early to the Late Neolithic, which they interpret as indicating that sheep and goats were kept in smaller numbers during the Late Neolithic. The study also showed that a combined analysis of stable isotopes of archaeological crop and animal remains has important implications for understanding the relationship between humans, plants, and animals in an archaeological context.

With respect to herd management that includes mobility patterns, $^{87}Sr/^{86}Sr$ ratios have been used much more frequently (e.g. Knipper 2011; Arnold, Greenfield, and Creaser 2013). In a recent study, Bogaard et al. (2014) compared strontium isotope data in the teeth of small ruminants at the Neolithic site of Çatalhöyük to strontium values in modern plants from different landscape zones. The results suggest predominant herding on the alluvial plain, whereas the limestone terraces were used only occasionally. They also support the view that diversity in stable carbon and nitrogen isotope values may not equal distance per se but, rather, diversity in habitats used for herd management.

Conclusions

Although stable isotope applications in archaeology have become a standard method throughout the last decades, their use for answering questions on the history of ancient agriculture has only started recently.

So far, research has been addressed to the environmental preconditions, such as water availability, as an important factor for the emergence and the development of ancient agriculture, but also to human agency in agricultural management, e.g., decision making on the location and layout of crop fields, irrigation practice, manuring, and activities related to animal herding.

A number of methodological limitations are still awaiting resolution, to enable clarification for some of the major questions. For example, while the interpretation of $\delta^{13}C$ values in archaeobotanical cereals in the case of a stress signal is straightforward (see the section titled "Water"), the lack of a stress signal may either be due to irrigation or elevated precipitation. Experimental work to disentangle natural from anthropogenic water input (see also the section titled "Irrigation of Crop Species") produces skewed comparative dataset for modern $\delta^{13}C$ values, because modern plants are genetically optimized products of recent agronomic aims, and are characterized by a lower stomatal limitation of photosynthesis; i.e. they show a much higher stress tolerance than that found in traditional landraces. Additionally environmental factors influencing $\delta^{13}C$ other than water input (e.g. salinization) are still under-investigated in archaeobotanical assemblages. Similar methodological issues exist for other stable isotopes, as outlined in particular in the sections titled "Nitrogen ($\delta^{15}N$)," "Temperature," "Soil," and "Human Interaction with the Natural and Cultural Environment That Affects Agricultural Production and Development."

While most stable isotope studies addressing questions of ancient agricultural development have been conducted on domesticated species, the interpretation of ambiguous data can benefit from stable isotope measurements on wild species that may better reflect general environmental trends than taxa that were heavily modified by ancient humans.

To obtain more accurate interpretations of the archaeological data, uncertainties in current models need to be resolved by extending experimental work according to historically known settings and by introducing new taxa into the set of study objects.

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Ehleringer, J.R., Hall, A.E., and Farquhar, G.D. (1993). *Stable Isotopes and Plant Carbon-Water Relations.* San Diego: Academic Press Inc. This edited book presents a broad range of key contributions in stable isotope research for understanding plant metabolic processes, including the concept of water loss with respect to photosynthesis, and provides a set of terms relating to plant-water use.

Fiorentino, G., Ferrio, J.P., Bogaard, A. et al. (2015). Stable isotopes in archaeobotanical research. *Vegetation History and Archaeobotany* 24(1):215–227. DOI:10.1007/s00334-014-0492-9. This contribution provides an overview on the current state of the art of stable isotope research in archaeobotany.

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CHAPTER FIVE

Agricultural Plants in the Ancient Mediterranean

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This chapter discusses agricultural plants in the ancient Greek and Roman world, using authors who wrote on agriculture in Greek and Latin; agricultural plants grown in Mesopotamia, China, India, and other geographical areas are discussed in other chapters in this book.

The Importance of Agricultural Plants to the Greeks and Romans

Agricultural plants provided the basic diet for Greeks and Romans, their slaves, and their farm animals: food, oil, and wine along with fruit and vegetables for human consumption; and fodder for farm animals. In addition, plants were the source of fiber for making ropes and cloth, oil for ointment, cooking and illumination, material for making needed containers and tools, and wood for warmth and cooking. Plants provided a pharmacy for the treatment of ailments and yielded dyes for wool and linen. Wine was poured out in libation to gods and goddesses, and flowering plants and leaves were made into wreaths to wear or place on statues.

A landowner who produced these food crops could store them for use all year long, and for variety could supplement this diet with fresh fruit and vegetables in season. Plants were particularly important for food because, although meat was served in the houses of the wealthy and at festivals, it was not served every day for ordinary people (Garnsey 1999, pp. 16–17; Wilkins and Hill 2006, p. 133). Plants surplus to the needs of the family and their animals were traded or sold and so provided the wherewithal to acquire other products (Varro *Rust.* 1.1–1.2; Thibodeau 2011, p. 38).

Sources of Information and Related Questions

An important source of information about agricultural plants in the Greek and Roman world is found in authors who wrote in Greek and Latin. For each author, I indicate the purpose of

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the work and their practical farming experience. The following section will consider the times and seasons of agricultural tasks in the ancient world. In the third section, I will suggest the difficulties we encounter in identifying plants in Greek and Roman authors and in the fourth section a brief discussion of what we are learning from archaeology.

Greek Authors

The earliest Greek author who dealt with agriculture was the poet Hesiod, who was born in Boeotia about 750 BCE. His poem *Works and Days* addressed his brother Perses, who had cheated him of his patrimony, and instructed him on planting and harvesting grain and caring for grape vines, marking the time for each task by the stars (*Op.* 381–617). For an analysis of the composition of the poem and its connection with farming, see West (1978, pp. 41–59) and Edwards (2004, pp. 141–147).

The next Greek author, Xenophon (430–354 BCE), was an Athenian, who as a young man spent time with Socrates. His experience as a landowner in Attica formed the background for his *Oeconomicus* (11–21), in which he discussed how to grow grain, olives, and grapes successfully, the key being good management of the slaves and workers. He served as a mercenary in Persia in the army of Cyrus the Younger, whom he greatly admired. After his return to Greece, he was granted property near Olympia in the Peloponnese, where he dedicated a farm to Artemis. For a further study of Xenophon and the *Oeconomicus*, see Pomeroy (1994, pp. 1–20).

The third Greek, Theophrastus (371–287 BCE), was born on the island of Lesbos, where he first showed an interest in plants, followed Aristotle to Macedonia, and succeeded him in the Lyceum in Athens. His *Enquiry into Plants* and *Causes of Plants* show more interest in plants and less in farming than Hesiod and Xenophon. He developed terminology to describe the parts of plants and the way they grew and, in the process, suggested reasons for agricultural practices. He grouped plants depending on the way they were propagated: trees and vines propagated from cuttings (*Hist. pl.* 2), plants primarily grown from seed like vegetables (*Hist. pl.* 7), and grains and pulse (*Hist. pl.* 8). He considered the aims of agriculture and how they were accomplished for trees in general (*Caus. pl.* 3.2.6–3.18.3), adding information about measures needed for the vine (*Caus. pl.* 3.11.1–3.16.4), for the date palm and a few other trees with special needs (*Caus. pl.* 3.17.1–3.18.3), for undershrubs and vegetables (*Caus.pl.* 3.19.1–3.19.3) and for seed crops (*Caus. pl.* 3.20–1-4.16.4). For an appreciation of the difference between Theophrastus and later Roman writers, see Rihll (1999, pp. 116–118).

Roman Authors

The oldest of the Roman authors, Cato (234–149 BCE), was notable for working side by side on his farm with his slaves after a hard morning in the city (Plutarch, *Cat. Mai.* 3). He preserved information about religious practices connected to farming and many recipes using plants he grew on his farm in *De agri cultura*. For an introduction to Cato's work, see Brehaut (1933, pp. xiii–xlv), Dalby (2010, pp. 13–24), and White (1970, pp. 19–20, 44–45).

The second Roman author, Varro (116–27 BCE), ostensibly was giving advice in his *Res Rusticae* to his wife Fundania, who had just purchased a farm. His first book dealt with agriculture, the second with cattle, and the third with other domestic animals and birds. He raised cattle and sheep in Apulia and horses in Reate (*Rust.* 2 preface 6). His style and his fascination with etymology make his *Res Rusticae* a challenge at times. For a discussion of the complexity of this work, see Nelsestuen (2015, pp. 1–11); see also White (1970, pp. 22–24).

Vergil (70–19 BCE) was born in Mantua in northern Italy. His farming experience was acquired in his youth on his father's farm, which, according to Probus, *Life of Vergil*, was expropriated to settle 60 veterans and therefore must have been a fairly large property (Spurr 1986, p. 175; p. 186, n. 43). The relevance of Vergil's poem *Georgics* is shown by the fact that he was cited by Columella and Pliny more often than they cited Cato or Varro (Spurr 1986, p. 182; see further White 1970, pp. 39–41).

Columella (c. 40–70 CE) was born in Cadiz in southern Spain. He owned farms at Carseoli, Ardea, and Albanum in Latium (*Rust.* 3.9.2) and perhaps at Caere in Etruria (*Rust.* 3.3.3) and observed agricultural practices when he visited Syria and Cilicia (*Rust.* 2.10.18). The relevant books of his work on agriculture are Book 2 on plowing, fertilizing, and care of crops, and books 3–5 on fruit trees, vines, and olives. The 11th book has information on the timing of agricultural tasks. An appreciation of Columella's work can be found in Forster (1950) and Reitz (2013); see also White (1970, pp. 26–30).

Pliny the Elder (23–79 CE) had a military career in Germany, Spain, and Gaul. He was stationed at Misenum on the Bay of Naples when Vesuvius erupted in 79 CE and lost his life attempting to rescue people threatened by the volcano. He collected material from Greek and Latin authors to incorporate into his work, which was organized by types of plants rather than by the tasks of the year. Books 12 to 19 of his *Natural History* are concerned with agriculture and horticulture. Books 20 to 27 contain information on the medical uses of plants. For Pliny's use of his predecessors, especially Theophrastus, see Morton (1986) and White (1970, pp. 28–29).

Other Authors

These were by no means the only authors to write on agricultural plants. Varro (*Rust.* 1.1.8–1.1.11) listed more than 50 authors with which he was familiar, most of whose work has survived, if at all, in fragments. Columella (*Rust.* 1.1.1–1.1.15) acknowledged the work of his many predecessors, both Greek and Roman. Pliny similarly read widely – or had read to him – and appended a list of authorities at the end of each book. They all singled out for praise the work of Mago of Carthage, written in Phoenician. Varro (*Rust.* 1.1.10) says that after the destruction of Carthage in 149 BCE, Cassius Dionysius "turned" (*vertit*) eight books of Mago into a 20-book work in Greek, adding considerable material from Greek writers. Columella (*Rust.* 1.1.13) notes a 28-book translation of Mago into Latin *ex senatus consulto*. For a general discussion of the sources for Roman farming including authors whose work has not survived, see White (1970, pp. 14–43).

Times and Seasons in Greek and Roman Authors

Knowing when to plant and harvest was essential for success in farming. Before there were reliable calendars, the timing of planting and harvesting was set by observing the rising and setting of constellations or bright stars, the migration of birds, and the leafing out of plants as Hesiod did in *Works and Days* (West 1978, pp. 376–381). Theophrastus used the equinoxes and solstices as markers along with bright stars and constellations, the blowing of the south and west winds, and the arrival of the swallow as well as, occasionally, Athenian months (Einarson and Link, v. 1. 1976, xlvi–lix).

Varro (*Rust.* 1.28) took the solstice as the midpoint of summer and winter and the equinox as the midpoint of spring and autumn and divided the year into eight sections with agricultural tasks for each.

Columella is less rigid about the timing of agricultural tasks, warning against waiting for a specific day (*Rust.* 11.2.2) while providing an orderly description of the tasks during the year. He divided each month in half and listed tasks to be undertaken within this period.

Identifying Plants in Greek and Latin Authors

When plant names appear in Greek and Latin texts, it can be difficult to know how to translate them for two reasons. First, it is necessary to determine, if possible, the scientific identification of the plant. Then we need to find the name by which the plant would be known to readers. We are helped in the case of Theophrastus by the index supplied by Thiselton-Dyer (Hort 1926, pp. 437–485), who was Director of the Royal Botanic Gardens at Kew and took as his retirement project identification of Greek plant names for Liddell-Scott-Jones, ninth edition (Irwin 2004, pp. 960–961). For plant names in Pliny, an index (Jones 1980, v. 7, pp. 485–549) was provided by A.C. Andrews, who published many articles on Latin agricultural plants (1942–1943, 1948, 1949a,b, 1951, 1956, 1958). Dioscorides, who wrote on the medical uses of plants, describes some of the less familiar ones in detail; illustrations in manuscripts, the most famous of which is the Vienna codex, are also useful (Riddle 1985, 181–191). A further resource is André's *Noms de plantes* (1985), which identifies the names of plants in Latin authors by scientific and French names.

Archaeology and Plants

We are indebted to Jashemski, a pioneer in plant archaeology, for her work in identifying domesticated plants in Pompeii and the neighboring area destroyed by the eruption of Vesuvius. Farming in land surrounding a villa is well illustrated by a site at Boscoreale that had a vineyard, a kitchen garden with an irrigation system, fig and olive trees, and a threshing floor (Jashemski 1987, pp. 66–71). Plant remains and roots rediscovered by pouring plaster of Paris into the space left when the plants degraded determined plants grown in the area.

The survey by Zohary, Hopf, and Weiss, *Domestication of Plants in the Old World* (4th edition, 2012), is useful for information about plant remains and seeds in the Mediterranean basin and wild native plants from which domesticated plants may be considered to have developed. Agricultural plants included are cereals (20–74), pulses (75–99), oil- and fiber-producing crops (100–113), fruit trees and nuts (114–152), vegetables and tubers (153–162), condiments (163–165), and dye plants (166–168). Sections referring to plants in Greece (177–179) and Italy (184–185) are useful for individual agricultural plants.

Geography, Climate, and Soil in the Mediterranean

Geography and Climate

References in the ancient Greek and Roman authors to snowfalls, colder winters, and changes in rainfall patterns are sometimes taken as evidence of climate change (Neumann 1985) though Grove and Rackham (2001, pp. 141–142) caution that they may be evidence of only normal variations in climate or limited to specific geographical areas (microclimates).

The ancient Greeks lived in the Greek mainland, the Peloponnese, and the islands; a range of mountains, the Pindus stretched from central Greece into the Peloponnese, and most of the Greeks lived near the coast. (For more on the physical geography of Greece, cf. Hammond

1967). They also lived along the coast of Asia Minor (present-day Turkey), and beginning in the 8th century in colonies in Sicily, North Africa, and along the coast of the Black Sea. In choosing locations for colonies, the Greeks looked for places where they could grow grain, grape vines, and olive trees (Irwin 2003; Isager and Skydsgaard 1995, p. 9). The climate in Greece and the other settlements was Mediterranean, defined as falling between 30° and 45° from the equator. Summers were hot and dry, winters mild and wet. In winter, rain fell, sometimes heavily, and in summer, rivers dried up and growth slowed or stopped, leaving little water for irrigation. In the interior, in the mountains where few Greeks lived, the climate was Alpine, with cold winters when snow fell on the mountains and summers when the snow melted and provided irrigation. The climate appears to have been stable in the period of our sources (Isager and Skydsgaard 1995, 12–13; Grove and Rackham 2001, p. 141). It has been argued that the clearing of the land led to erosion of the soil, but *maquis* and *garrigue* with their characteristic vegetation covered the area and prevented or reduced erosion (Rackham 1983, p. 14). The soil on the whole was poor but not changed from the Classical period to the present (Sarpaki 1992, p. 62; Zangger 1992, p. 18). Farmers were well aware that untreated soil would give less by way of return unless they added animal manure, plowed in green manure, and planted pulses which returned nitrogen to the soil (Garnsey 1992, pp. 151–152; cf. Howe 2008, p. 25 for the contribution of farm animals to the fertility of the soil).

The Roman Empire extended over much of the Mediterranean and north into Europe. Italy, the home of the Romans, also has an interior mountain range, the Apennines, which extends from north to south. The northern part of Italy, drained by the Po River, has a central European rather than Mediterranean climate with harsh winters and hot dry summers, while the central and southern parts of Italy have a Mediterranean climate (White 1970, pp. 52–54). Because of the mountain range and the prevailing west winds, more rain falls on the west than on the east. One feature of the landscape is the volcanoes, which were active in the Classical period and continue to be active: Vesuvius near the Bay of Naples, Stromboli in an island off the coast, and Aetna in Sicily. Volcanic ash caused devastation where it fell, but after a time made the soil very fertile. Because of the volcanic action, Sicily, Campania, Etruria, and much of Latium are very fertile (White 1970, p. 55). This had been realized in Classical times; in his commentary on Sicily, Strabo (6.2.3) noted that volcanic ash from Aetna improved the soil and made it suitable for growing vines and other crops. Other substances in the soil were limestone which helped against acidity, sandstone, marls, and clays (White 1970, p. 55).

Types of Soil

Soil was characterized by color, moisture content, and how it felt in the hand, and the decision on what to plant was based on past experience. For Theophrastus, soil was dense or loose, dry or wet, light or heavy (*Caus. pl.* 2.5.9). For Cato, the soil content, whether ash, clay, gravel, or sand, determined which crops would do well (*Agr.* 34–35, 40). Varro (*Rust.* 1.9) classified soils by texture, whether the prevailing texture was sandy or clayey, how large the particles of soil were (crumbs, clods, etc.), and whether the soil was able to absorb moisture (White 1970, p. 87). Columella (*Rust.* 2.2.2–2.2.7) classified soil as dry or wet, fat or lean, loose or compact, concluding that fat, crumbly, well-watered soil was most productive, and lean, dense, and dry was the worst. Pliny (*HN* 17.33) described three kinds of soil: red earth and clay, which was hard to work, gray ash and white sand, and sterile earth with a hard crust. He attributed poor plant growth to bitter, cold, damp soil. (On soils and crops, cf. White 1970, pp. 86–96).

The Roman Warm Period

A number of recent studies have explored climate change in the Mediterranean. Zielhofer et al. (2017) look at climate variability in the Holocene period, in particular, the change in winter rainfall in the Western Mediterranean affected by warming or cooling in the Atlantic. Several studies are more focused on the Roman imperial period. Chen, Zonneveld, and Versteegh (2011) present evidence for relatively high, stable temperatures in the Mediterranean between 60 BCE and 90 CE, followed by a slow decline in temperature between 90 and 200 CE. The authors estimate that the Roman Warm Period might have been warmer than 20th century temperatures. On the effect the warming might have had, they point to an interesting overlap with the years of the *Pax Romana* from Augustus to Marcus Aurelius (27 BCE to 180 CE) and raise the possibility of a causal connection. One interesting statistic is the temporary dip in temperature they detected corresponding to the eruption of Vesuvius in 79 CE, which they speculate might have been caused by the ash spewed into the air.

The study by McCormick et al (2012, pp. 174–183) looks further afield to Britain, Europe, and Egypt and concludes that the Western Roman Empire enjoyed warmer temperatures from 100 BCE to 200 CE, which, they suggest, would have contributed to general peace and stability. (cf. also Mensing et al. (2015, p. 87), who note "exceptional climate stability" in the period 1–200 CE, coinciding with the rise of Imperial Rome).

Two further studies are of interest. Neumann (1985) assembles references to climate change in Greek and Latin authors. Helms (1996) considers the likely effect of climate change on modern North American agriculture.

Taking Chen's dates of 60 BCE to 90 CE, Varro and Vergil would have experienced the Warm Period for most of their lives and Columella and Pliny for all of theirs. One possible evidence of change in plant life is the change in olive culture. Pliny (*HN* 15.1) found a comment (in the Roman writer Fenestella) that the olive tree had not grown in Italy or Spain or Africa in the reign of Tarquinius Priscus (6th century BCE) but that in his day it grew further north on the other side of the Alps and in Gaul and Spain. He contrasted this, as did Columella (*Rust.* 5.8.5), with the widely held belief that olives did not grow far from the sea, but it is possible that warmer temperatures north of Italy allowed olives to grow and fruit. What Greeks and Romans expressed as distance from the sea may have been a matter of altitude, which is a limiting factor in olive growth (Foxhall 2007, pp. 112–113).

Grain

Information about grain from planting to harvest can be found in Hesiod (*Op.* 383, 458–492, 571–581, 597–608), Xenophon (*Oec.*16–18), Theophrastus (*Hist. pl.* 8.1–8.10; *Caus. pl.* 3.20.1–3.24.4), Cato (*Agr.* 35, 37, 91 and 129), Varro (*Rust.* 1.34, 1.48–1.56), Vergil (*G.* 1.43–1.117, 1.204–1.230), Columella (*Rust.* 2.4–2.20), and Pliny (*HN.* 18. 61–91).

The Greeks and Romans grew barley (*Hordeum vulgare*) and several different kinds of wheat (Jasny 1944, pp. 26–28, p. 53): emmer (*Triticum dicoccum*), einkorn (*T. monococcum*), and bread wheat (*T. aestivum*). Barley was more tolerant of drought and ripened faster than wheat and thus was grown widely in Greece and Italy, while emmer and einkorn were hardier than bread wheat (Sarpaki 1992, p. 69). By Pliny's time (*HN* 18.74–18.75), barley was mere animal feed, though he considered barley water good for health. Both barley and wheat exhausted the soil and were generally not planted in the same field in successive years (Theophr. *Hist. pl.* 8.9.1). In order to replenish the soil after a grain harvest, farmers usually allowed the land to lie fallow.

Plowing and harvesting marked the beginning and end of the growing cycle, plowing in November and harvesting in May. The earth was plowed after harvest in spring to get rid of the weeds, at midsummer to expose the earth to the sun, and in November for sowing (Xen. *Oec.* 16. 10–15). Pulses were known to enrich the soil and were sometimes planted in alternate years instead of leaving the land fallow (Cato *Agr.* 37).

Rain was essential to the growth of grain. There was a debate about whether to wait to sow till the rains began. Hesiod (*Op.* 479–492) reflected that if the farmer sowed late, the harvest might be poor but if Zeus sent rain, it might be good. Rain made the field muddy and the seed might not germinate, but if the rain came too little or too late, the seed might also not germinate. Xenophon recommended several sowings in succession to spread the risk (*Oec.* 17.1–17.5). When the autumn sowing failed, seed could be sown in early spring for a "three-month" harvest, though this was definitely second best (Cato *Agr.* 35).

The seed was scattered by hand and hoed in (Xen. *Oec.* 17. 12–15). Pliny (*HN.* 18.197) noted that there was an art to sowing, the right hand coordinated with the right foot. White (1970, p. 179) gives more detail: the sower raised his right hand to shoulder height and opened his fingers in succession to secure an even distribution of seed.

The grain was cut with a sickle in early summer. Some cut the stem in the middle, dried the stalks and attached heads, and carried them to the threshing floor, where the stem and hulls were separated from the kernels. Others cut the head of grain only and stored the heads to thresh when they were needed (Columella *Rust.* 2.20.4). The stalks left in the field were plowed under, sometimes after burning, to fertilize the earth (Xen. *Oec.* 18.2). For threshing, the stalks were spread on the threshing floor and trampled by animals, usually oxen, though Columella (*Rust.* 2.20.4) preferred horses, until the kernel was separated from the husk. The threshers threw the unthreshed grain under the animals' hooves until all was threshed (Xen. *Oec.* 18.3–18.5). Some used a sledge pulled by animals to thresh (Varro *Rust.* 1.52, Columella *Rust.* 2.20.4). Barley, emmer, and einkorn wheat were "hulled," with the covering adhering closely to the kernel, while bread wheat (*T. aestivum*) was "naked" with a brittle covering easily separated from the kernel. Threshing separated the kernels from the outer coverings. The resulting mixture was winnowed to separate kernels from hulls and stalks, the kernels collected, and the chaff swept up to use for animal feed as well as storing vegetables like turnips and onions to absorb any moisture.

The threshing floor was prepared by digging in chaff and *amurca* (olive lees) and tamping down the soil to make a hard surface coated with more *amurca*, which discouraged mice, ants, moles, and weevils (Cato *Agr.* 91, Varro *Rust.* 1.51, Columella *Rust.* 2.19). The best of the grain was set aside for sowing next year (Varro *Rust.* 1.52, Columella *Rust.* 2.9.11).

Grain was affected by a fungal disease called rust; the Romans celebrated Robigalia in April in hopes of avoiding this rust. Good ventilation helped to avoid the development (Theophr. *Hist. pl.* 8.10.1; Cato *Agr.* 35, cf. Brehaut 1933, xxix), and some kinds of wheat (emmer and einkorn) were rust resistant. Grubs might eat the roots, especially in a drought (Theophr. *Hist. pl.* 8.102). Weevils and mice were pests which could eat away at the stored kernels. One way of protecting the grain was to coat the storage bins with clay, mixed with chaff and *amurca* (Varro *Rust.* 1. 57).

The kernels were ground for use from flour (the finest grind) to groats (the coarsest). The finest grind was used for bread; groats were used for a drink, porridge, or soup. We can get a good idea of the various ways grain was used in cooking from Galen's description of the dietary value of wheat and barley (Grant 2000, pp. 62–67, 78–86, and 86–89). Neither the Greeks nor the Romans made beer from grain (Nelson 2014).

Grapevines

Grapes along with olives and grain were the three main crops in Greece and Italy. The cultivated grapevine (*Vitis vinifera*) grew well in a Mediterranean climate even in poor soil but, unlike the olive, which grew and fruited *only* in a Mediterranean climate, the vine could grow further north in Europe in cooler and more humid conditions (Zohary, Hopf, and Weiss 2012, pp. 121–126). Wild vines, related to the cultivated vine, still grow in the eastern Mediterranean.

Viticulture required more work from the farmer than oleiculture (Columella 5.8.1; Hanson 1992). The importance of vines in agriculture is shown by the subject's inclusion in our various sources (Hesiod *Op.* 564–570, Xen. *Oec.* 19.1–19.12, Cato *Agr.* 32–33, and 112; Vergil *G.* 2. 397–419; Varro *Rust.* 1.40–1.41), but it was Theophrastus (*Caus. pl.* 3. 11.1–16.4) and Columella (*Rust.* 4.8.1–4.8.16) who provided the most detail on the practical issues of caring for vines, harvesting grapes, and establishing new vines.

New vines were commonly started from a cutting or by layering. In the first method, a branch cut from the vine was placed in a trench with the base covered until it formed roots. This trench was usually treated as a nursery from which the new plants were transplanted (Columella *Rust.* 4.16). In the second method, a branch still attached to the parent vine was bent to the ground and covered with earth to prompt it to begin to send out roots (Cato *Agr.* 33; Columella *Rust.* 4.14–4.15). A third method, grafting, used widely for fruit trees, was developed for vines by Columella (*Rust.* 4.29.13) in which a hole was made in a vine, a branch from another vine passed through it and left in place until it rooted and could be separated from its parent vine. In another version of this method, a cutting was fitted to the borehole to root (see also Pliny *HN* 17. 116).

The earth needed to be prepared for planting or transplanting by digging a deep hole or trench; the hole was left open for a year before planting the new vine to open the texture of the soil (Theophr. *Caus. pl.* 3.4.1). Vines should not be planted too close together.

It was important to choose a straight branch for a cutting and to encourage the new plant to develop growth on all sides (Theophr. *Caus. pl.* 3.13.3–3.13.4). Although some vines did not grow tall enough to need support, most were tied to supports to train them (Columella *Rust.* 4.12, 13). This was an old practice as can be seen from the vineyard on the Shield of Achilles with vines supported on poles (Hom. *Il.*18. 561–568). Vines could also be planted close to trees and trained to climb up these trees. Amouretti (1992, pp. 81–82) has drawings to show pruning and support for vines as well as cutting and grafting.

Vines needed constant care during the growing season. They were pruned to keep the growth compact and to encourage fruiting (Theophr. *Caus. pl.* 3.14.1; Columella *Rust.* 4. 9–11), and their roots were pruned to make them grow deep (Theophr. *Caus. pl.* 3.8.1; Columella *Rust.* 4.8.1–4.8.4). They were fertilized (Theophr. *Caus. pl.* 3.9.5) and watered if necessary (Theophr. *Caus. pl.* 3.11.3). Cato (*Agr.* 33) advised sowing *ocinum* (possibly a kind of clover) between the vine rows and enriching the soil with manure, straw, and grape dregs. The earth round the main stems was hoed to keep down weeds and loosen the soil. When the grapes were ripening, they were covered with fine dust as a screen against the sun to keep them from ripening too quickly (Theophr. *Caus. pl.* 3. 16.3–16.4). Vines might be attacked by budworms (Theophr. *Caus. pl.* 3.22.5) in warm weather.

Once the grapes were ripe, they were picked and spread out in the sun to dry. They were then placed in a vat where they were trampled to release the juice. The juice was poured into storage vessels to allow the fermentation process to begin. All the steps in wine making were depicted as occurring simultaneously in Alcinous' vineyard, where some grapes were being spread to dry, others picked, others trampled, while unripe grapes were forming and turning purple to give us a complete picture of the vintage process (Hom. *Od.* 7. pp. 122–128; Isager and Skydsgaard 1995, p. 26).

Olive Trees

The main discussions of olives are to be found in Theophrastus (*Hist. pl.* 2 *passim*), Cato (*Agr.* 43–45, 54), Varro (*Rust.* 1.24, 55), Columella (*Rust.* 5. 8.1–8.17), and Pliny (*HN* 15.1–15.34; 17.125–17.130). Hesiod in *Works and Days* does not mention the olive (Edwards 2004, 145–146), and Vergil (*G.* 2. 420–425) has little to say.

The cultivated olive (*Olea europaea*) differed from the grapevine in demanding a Mediterranean climate, in general not far from the sea, to produce fruit (Theophr. *Hist. pl.* 4.4.1; 6.2.4), though Columella (*Rust.* 5.8.5) and Pliny (*HN.* 15.1) knew of olives which did well further inland (which might be an indication of climate change). The wild form (*Olea europaea oleaster*) and a feral form of the cultivated tree grew in the same geographical range, the feral form being naturalized (Zohary, Hopf, and Weiss 2012, pp. 117–119). The Greeks distinguished the wild tree from the cultivated one by giving unrelated names: *kotinos* for the wild tree and *elaia* for the cultivated tree. The seed of the cultivated olive produced the wild form (Theophr. *Hist. pl.* 2.2.5), so the method of reproduction of the cultivated olive had to be vegetative, by cuttings or grafting.

Olive trees were remarkable for the length of time they remained fruitful; many continued bearing for two hundred years or more, and Theophrastus had heard of olive trees much older (Theophr. *Hist. pl.* 4.13.5). Olive trees required much less work than vines and did well in any kind of soil as long as the drainage was good (Columella *Rust.* 5.8.1). Manuring and pruning was done less often than for vines and other fruit trees (Columella *Rust.* 5.9.15). Trenches were dug round the trunks in autumn to bring water to the trunks, and suckers were removed (Columella *Rust.* 5.9.13). It took five or more years for an olive tree to bear fruit. To destroy an olive tree was particularly grievous because of the length of time required to bring it to maturity (Dem. 43.69, 53.15; Pomeroy 1994, pp. 47–49). Olive trees bore a full crop in alternate years (Theophr. *Caus. pl.* 1.20.3). For this reason, Columella (*Rust.* 5.9.11–5.9.12) advised dividing the trees into two groups for equal return each year. However, Foxhall (2007, p. 8) found that olive trees tend to synchronize to bear fruit in the same year; Columella's attempts at evening out the return would have been unsuccessful.

Cato (*Agr.* 45) described planting a cutting to make a new olive tree. The slip should be three feet long, the soil should be worked to make it soft, and the slip should be pressed into the ground leaving four fingers height showing rather than digging a hole. Some authorities, but not Cato, stressed the importance of orienting the cutting in the direction it had been facing on the parent tree (Theophr. *Hist. pl.* 2.5.3, *Caus. pl.* 3.5.2; for vines, Verg. *G.* 2. 270, Columella *Rust.* 5.9.8), but Pliny (*HN* 17.83) disagreed with the practice. Whatever showed of the cutting above ground should be smeared with clay or *amurca* and topped with a potsherd to prevent rot (Xen. *Oec.* 19.13). Columella (*Rus*t. 5.9.4) recommended covering a cutting completely with earth, leaving it for five years, and then transplanting it. Preparation to receive the new plants was made by digging deep holes a year before transplanting. The trees were taken up with a ball of soil round their roots and set in rich top soil.

If grafting was used, the stock could be a wild olive or an unproductive tree. Columella (*Rust.* 5.9.16) described the method of boring a hole with an augur and inserting the slip. The grafted tree must be helped by digging round the trunk and adding *amurca* and urine.

Lack of productivity might be caused by poor soil, which could be remedied by digging trenches round the tree and adding lime. As a final step, an unproductive olive could be regenerated by cutting it down and allowing new shoots to grow from the stump (Theophr. *Hist. pl.* 2.7.2–2.7.3).

Olives were picked by those standing under the tree to reach fruit on the lower branches and climbing ladders to pick from the higher branches. The olives which could not be reached by these methods were shaken or beaten with a reed, but not on the fruit directly. Varro (*Rust.* 1.55.1–1.55.3) advised using bare hands instead of gloves to avoid bruising the fruit.

Olives were picked when ripe, allowed to lie for a short time, and then milled to extract the oil (Cato *Agr.* 64–65). The oil was skimmed off, leaving *amurca* (olive lees), which had value in keeping down weeds around trees (Varro *Rust.* 1.50.7). It was also used as a coating to make a threshing floor (Cato *Agr.* 91–92) and to keep weevils and mice from damaging grain. Olives were preserved in brine and vinegar for eating (Cato *Agr.* 117–119).

Other Important Plants

Grain, grape vines, and olive trees were given the most attention in the Greek and Roman agricultural writers, but they were not the only crops. Pulses, vegetables and herbs, and fruit and nut trees were important food for people and animals. Some of these plants, particularly the vegetables and herbs, were credited with treating medical conditions. There were also plants used for dyeing.

Pulses

The term pulses covers a number of plants of the *Fabaceae* family grown for human food and animal fodder, including peas (*Pisum sativum*), green peas (*Lathyrus sativus*), beans (*Vicia faba*), bitter vetch (*Vicia ervilia*), fenugreek (*Trigonella foenum-graecum*), lupin (*Lupinus* sp.), and chickpeas (*Cicer arietinum*), as well as lentils (*Lens culinaris*). Pulses are discussed in Theophrastus (*Hist. pl.* 8.1.1), Varro (*Rust.* 1.23.1), Columella (*Rust.* 2.10-1-21), and Pliny (*HN* 18.123-18.144). Alfalfa (*Medicago sativa*) was introduced by the time of Varro (*Rust.* 1.23.1; cf. Columella *Rust.* 2.10. 24–28, Pliny *HN* 18.144). *Ocinum,* according to some authorities, was a mixture of beans, vetch, chickpeas, green peas, and oats sown together, cut, and fed to animals (Columella *Rust.* 2.10.1–2.10.21; Pliny *HN* 18.143; cf. Brehaut 1933, pp. 51–52), though Cato and Varro treated it as a particular plant, possibly clover (Cato *Agr.* 27, Varro *Rust.* 1.23.1). Pulses were pulled and fed green to animals. At the end of the growing season, pulses were cut and threshed, the seeds kept for human food and some for next year's crop, and the dried husks, stems, and leaves stored for fodder.

It was recognized early that pulses enriched the soil. Most of these plants returned nitrogen to the soil, the exception being chickpeas (Theophr. *Hist. pl.* 8.9.1), though Columella (*Rust.* 2.10.5) differed from other authors in thinking that the bean, too, did not enrich the soil. The other pulses could be planted and plowed under to leave the soil better able to grow grain, which was notorious for depleting the soil.

Peas, lentils, and beans were dried and stored for human use round the year. Along with grain, they provided filling and nourishing food. Apicius gave recipes for pulses in *De re coquinaria* 5:5.2 lentils, 5.3 peas, 5.4 conchicla (probably peas, Grocock and Grainger 2006, pp. 339–340), 5.6 green beans and Baian beans, 5.7 fenugreek, and 5.8 black-eyed peas and chickpeas, though being Apicius, he often adds meat to the dish. We now recognize that pulses provide protein, an important source of nutrition for people who did not eat much meat, though the Greeks and Romans would not have articulated it this way. Wilkins and Hill (2006, pp. 114–115) discuss the nutritional benefits provided by grain and pulses.

Vegetables and Herbs

There are extensive discussions of garden vegetables in Theophrastus (*Hist. pl.* 7), Columella (*Rust.* 10 and 11), and Pliny (*HN* 19), augmented by recipes for vegetables in Apicius *De re coquinaria* 3. Vegetables were grown in a garden near the farmhouse with a convenient supply of water, which was essential for the growth of the plants. The soil was prepared initially by being dug, manured, and marked out in plots with irrigation channels and walking paths for access to the plants (Pliny *HN* 19. 20; Cato's irrigated garden *Agr.* 1.7; Jashemski 1987, p.69). Even in urban areas, there were vegetable gardens which provided food for poor people and luxury items for the rich (Pliny *HN* 19. 19. 52). The care of the garden was women's responsibility, and neglect meant that the household would have to buy produce at the market (Pliny *HN* 19.19.57).

Vegetables grown in kitchen gardens were domesticated from wild native plants, first gathered in the wild and later planted in gardens, either by gathering seed or transplanting young plants. There is archaeological evidence for most of the garden vegetables and condiments in Theophrastus, Columella, and Pliny (Zohary, Hopf and Weiss 2012, pp. 152–165).

Because of the mild winters, vegetables could be planted in autumn as well as spring (Theophr. *Hist. pl.* 7.1.1–7.1.3, Columella *Rust.* 11.3.14–11.3.18, Pliny *HN* 19) and be ready for harvesting at different times, depending on when they had been planted. This had the advantage of providing a continuing (and varied) supply of fresh food, though storage and preserving was also important, with turnips and onions stored in chaff and others kept in brine and vinegar. Some seeds, especially herbs, were planted in successive sowings to provide a continuous supply.

The vegetables grown by the Greeks and Romans were root crops (turnips, radishes, parsnips, onions, garlic, and leeks as well as flowering bulbs), green crops (cabbage, artichokes, and celery), leafy crops (lettuce, cress, celery, and other leafy plants) and vine crops (gourds and cucumbers). The leaves of root crops like turnip, radishes, and beets were eaten by both people and animals. It is rather surprising to us that flowering bulbs like crocus and squill appear in Pliny's list of edible plants (*HN* 19.93).

Some vegetables may be unfamiliar: orach (Andrews 1948), monk's rhubarb used as spears like asparagus, purslane, a succulent used cooked and raw, and blite, a herb also known as Good King Henry. Asparagus was introduced as a garden vegetable by the time of Cato, who devoted a section to its planting and care (*Agr.* 160). Cato also waxed eloquent on the virtues of cabbage in maintaining health and regularity (*Agr.* 156–158). Carrots were relative latecomers, and first used for medicine (Dioscorides 3.52, cf. Andrews 1949b, Pliny *HN* 19.89). The *cucumis*, sometimes translated "cucumber," was a melon, a subspecies of *Cucumis melo*; the emperor Tiberius was so fond of it that he ate it every day. To produce it year-round, he had a planter on wheels built so that the plant could be grown outdoors when the weather was warm and moved indoors in cold weather to what was essentially a greenhouse or orangery (Pliny *HN* 19.64; Zohary, Hopf and Weiss 2012, p. 155).

Apicius gave directions for preparing vegetables in *De re coquinaria* 3: asparagus 3.3, cabbage 3.9, leeks 3.10, beets 3.11, turnips 3.13, radishes 3.14, green salad 3.16, cardoon 3.19, and carrots or parsnips 3.21. Greens could be served cooked or raw, roots (even radishes) were cooked, and some plants like beets could be used as both greens and roots (Grocock and Grainger 2006, pp. 159–173).

Fruit and Nut Trees

The Greeks and Romans had developed methods for growing apples (*Malus domestica*); quinces (*Cydonia oblonga*), which Zohary, Hopf, and Weiss (2012, pp. 144–145) say were relative latecomers to the Mediterranean; pears (*Pyrus communis*), plums (*Prunus domestica*), pomegranates (*Punica granatum*), and figs (*Ficus carica*), familiar to Theophrastus (*Hist. pl.* 1.10.10, 2.1.2–2.1.5, 2.2.5), Columella (*Rust.* 5.10.14–5.10.19), and Pliny (*HN* 15.37–15.56).

Fruit trees were propagated by cutting, grafting, and layering. Reproduction by grafting was better than planting a seed or a cutting except for figs, which did well as cuttings. Seeds did not generally breed true (Theophr. *Hist. pl.* 2.2.5). Cato (*Agr.* 40) described how to graft figs, flesh-fruit trees, and pears by inserting a branch between the bark and wood of the tree to which the graft was to be attached, protecting it with a mixture of clay or chalk, sand, and cattle dung. He described layering, the method used also for vines, by bending a branch to the ground with the tip showing and covering the length of the branch with earth until it rooted (Cato *Agr.* 51, cf. also Pliny *HN* 17. 111). A third method, air layering, involved using a pot with a hole in the bottom, passing a shoot through the hole, filling the pot with earth and waiting until the shoot developed roots (Cato *Agr.* 133, Varro *Rust.* 1.40. 1–7). Grafting on a wild olive or fig was successful, but on a wild pear was not.

The almond (*Amygdalus communis*) and, less commonly, filbert or hazelnut (*Corylus avellana*) were cultivated by the Greeks (Theophr. *Hist. pl.* 2.2.5, 3.15.1), who encountered but apparently did not cultivate sweet chestnuts (*Castanea sativa*) and walnuts (*Juglans regia*, *Hist. pl.* 4.5.4). The Romans grew chestnuts, hazelnuts, and walnuts as well as almonds (Pliny *HN* 15.86–15.94). Pliny (*HN* 15.91) added that pistachios (*Pistacia vera*) had been recently introduced into Italy by Vitellius, who was briefly Roman emperor in 69 CE.

The Greeks reproduced the almond from offsets or by grafting, which Theophrastus stated gave a better result than planting from seed (*Hist. pl.* 2.2.5). Pliny agreed with this observation, recording that while almonds could be grown from seed, grafting would produce a more pleasing nut crop (Pliny *HN* 17.63). Hazelnuts, like almonds, could also be grown from suckers (*HN* 17.67). Columella (*Rust.* 5.10.12) described planting the seed of almonds or hazelnuts in fennel roots to keep them from drying out (cf. White 1970, p. 159).

Fruit and nut trees were planted in orchards surrounded by a fence or trench to protect them from thieves. Alcinous' orchard had pears, pomegranates, apple trees, figs, olives, and grapevines growing in a walled garden (Hom. *Od.* 7.115–7.116). Odysseus's father Laertes had given fruit trees to his son as a boy: 13 pear trees, 10 apple trees, and 40 fig trees as well as grape vines (Hom. *Od.* 23 340–341).

Fruit trees were planted with enough space between them to allow for growth, for access, and sometimes so that other crops could be planted between the trees (Pliny *HN* 17.88). It was important to fertilize them and advisable to dig round them to cut spreading roots and force them to grow downward (Theophr. *Caus. pl.* 3.8.1).

Plants with Specialized Uses

Plants with Medicinal Value

Treatment of wounds and diseases with plants goes a long way back in Greek literature. The centaur Chiron showed Achilles a root (probably yarrow) which would staunch bleeding (Hom. *Il.* 11. 831–832, 847), and Helen put plant material (probably poppy juice) in wine to ease the heroes' pain of remembering (Hom. *Od.* 4.219–4.221). People Theophrastus called root cutters were his source for material on medicinal plants in *Hist. pl.* 9. These were not ordinary garden crops; some were gathered in the wild, required specialized knowledge to identify, and were often dangerous (Irwin 2006). But many familiar plants were thought to have medicinal value. Cato had an extended comment on the value of cabbage as a laxative (*Agr.* 156–157). Pliny (*HN* 20–27) and his contemporary Dioscorides (*De Materia Medica*) connected many ordinary plants to treatments for diseases. Dioscorides (2.85) recorded that wheat boiled and made into a plaster reduced inflammation and Pliny (*HN* 23.122) that barley meal applied to an abscess brought it to a head. Jashemski's *Pompeian Herbal* combines practices she learned from the local population about medical treatment with plants which grew (and still grow) around Pompeii and advice from ancient authors about these plants. For example, she was told about the use of fig juice to remove warts and as a laxative, anticipated by Pliny and the physician Celsus (Jashemski 1999, p. 50).

Dye Plants

The stigmas of the saffron crocus (*Crocus sativus* and the indigenous *C. cartwrightianus*) were used for saffron dye as far back as the Bronze Age, captured in the Homeric epithet of Dawn "saffron-robed" κροκόπεπλος (Hom. *Il.* 8.1 and many other places). The great advantage of this dye was that no mordant was needed and that dyed fabric kept its color (Cannon 1994, p. 94). The dye is extremely expensive because of the labor of gathering the stigmas.

Safflower (*Carthamus tinctorius*) had been used in the Bronze Age as a dye and for culinary purposes (Ventris and Chadwick 1959, p. 226). Its Greek name, κνῆκος ("tawny"), suggests the color of both flower and dye though it was the source of both yellow and red dyes and was used in Britain to color "red tape" (Cannon 1994, p. 92). The *knekos* grew wild as well as under cultivation (Theophr. *Hist. pl.* 6.4.5). Elsewhere Theophrastus (*Hist. pl.* 7.7.4) called it the "thorny crocus," presumably because of its use as a dye plant similar to saffron.

Madder (*Rubia tinctorum*) has red roots (Theophr. *Hist. pl.* 7.9.3; 9.13.4) used to dye wool and leather, while the leaves could be used to dye hair. It can be grown from seed, though it was also gathered in the wild. It was believed to act as a diuretic and as a cure for snakebite (Pliny *HN* 19.47; 24.94).

Pliny classified woad (*Isatis tinctoria*) as a kind of "lettuce" whose leaves were used to dye wool blue (*HN* 20.59). It also had medicinal value, staunching bleeding and healing ulcers.

Plants Used for Fiber and Oil

Fiber

From flax (*Linum usitatissimum*) comes the fiber used to make linen (Zohary, Hopf, and Weiss 2012, p. 101). Pliny gives a full account of planting and processing (*HN* 19.7–19.25). It was sown in sandy soil in spring and harvested in summer (*HN* 19.7). The finest flax grew in Egypt, Gaul, and northern Italy; what grew in central and southern Italy and Spain was used to make nets. Flax made heavy demands on the fertility of the soil (Pliny *HN* 19.7, cf. Verg. *G.* 1.77) and was not a crop for grain land (Thomas 1988, v.1, p. 80). To make thread, fiber was extracted from the plant stem in a laborious process. The stems were weighed down in water, then dried and pounded; the inner fiber was combed and beaten to make thread (Pliny *HN* 19.16–19.19). The thread was used for nets, sails, and clothing and had, long before, been used for protective gear for warriors (Hom. *Il.*2. 529, 830). The Romans used it for awnings to protect the spectators in amphitheaters from the sun (Pliny *HN* 19.23–19.24). It took dye well, though its natural white was the most usual color (*HN* 19.25).

A second plant used for fiber was hemp (*Cannabis sativa*). According to Herodotus (4.74), it could be made into fine fabric indistinguishable from linen, but for the most part it was used for rope and sacking (Pliny *HN* 19.173). It was planted in spring and harvested after the grape harvest. Hemp seed was known to produce an intoxicating vapor when thrown on to hot rocks (Htd. 4.73–4.75). The medicinal and recreational uses of marijuana (cannabis) are well documented (Zohary, Hopf, and Weiss 2012, pp. 106–107).

A third plant used for fiber was cotton (*Gossypium arboretum*), which did not grow in Greece or Italy (Zohary, Hopf, and Weiss 2012, pp. 107–109); it was cultivated in Tylos in the Arabian Gulf and in India (Theophr. *Hist. pl.* 4.4.8; 4.7.7–4.7.8) and in the Roman period, in Egypt (*gossypion,* Pliny *HN.* 19.14). Theophrastus did not give it a name, referring to it only as a "wool-bearing" plant from which clothing was made. The plants were arranged in rows and gave the impression of a vineyard.

Reeds, rushes, and willows were planted or grew on farms and were put to use for lamp-wicks, woven baskets, and mats. Willow bark made ties for vines, soft enough not to damage them (Cato *Agr.* 31, 33).

Oil

Olive trees had been the most important source of edible and lamp oil for the Greeks and Romans since the Bronze Age (Ventris and Chadwick 1959, p. 130), but there were a number of other plants whose seeds could yield oil: flax, sesame, poppy, and several cruciferous plants, cabbage, turnip, and radish. The seeds of flax, sesame, and poppy were used for cooking and eating.

Sesame (*Sesamum indicum*) was an annual summer crop, along with millet (Theophr. *Hist. pl.* 8.1.1). It exhausted the soil but was able to withstand the heat of summer without irrigation (Theophr. *Hist. pl.* 8.9.3; 8.6.1). Sesame oil was valued because it kept fresh for a long time (Zohary, Hopf, and Weiss 2012, pp. 112–113).

Radishes (*Raphanus sativus*), turnips (*Brassica rapa*, *B. napus*), cabbage (*Brassica oleracea*) and mustard (*Sinapis alba*), all cultivated by Greeks and Romans as vegetable crops, have oily seeds (Zohary, Hopf, and Weiss 2012, 112–113). Our authors offer little evidence that oil was produced from them, although Pliny had heard that the radish was used for oil in Egypt (*HN* 19.79). One of the cultivars of the turnip, variously called rapeseed or canola, is an important modern source of cooking oil.

Animal Fodder

Cato, Varro, and Columella have preserved considerable detail about the plants which were fed to farm animals. Different animals had different purposes, and this determined what they were fed. Sheep and goats did not need to have fodder provided. Sheep ate fresh grass year-round, moving between winter and summer pastures (White 1970, p. 306). Goats ate leaves, buds, and shoots and, unguarded, could do harm to young plants (White 1970, p. 314). Pigs, in contrast, needed fodder in order to fatten them. According to Varro (*Rust.* 2.4.6), they should be fed acorns first, then beans, barley, and other grains to make them fat and flavorful. Columella (*Rust.* 7.9.6–7.9.8) also recommended beginning with acorns, adding beans, and then turning them out in a grassy orchard of apples, pears, nuts, and figs, where they could enjoy the windfalls, while not forgetting to feed them grain (cf. further White 1970, pp. 318–319). Oxen were working animals and needed to have their diet watched carefully, especially in spring when they were plowing. In addition to meadow hay, they were fed barley, vetch, and chickpea (Columella *Rust.* 6.3.3).

Hay was the basic fodder, made up of grass and plants growing in the grass, cut with a scythe in late spring, dried and stored (Cato *Agr.* 53, Columella *Rust.* 2.18.2; 11.2.40). Cato (*Agr.* 27) listed crops planted for fodder: *ocinum*, vetch (*Vicia sativa*), fenugreek (*Trigonella foenum-graecum*), broad beans (*Vicia faba*), and bitter vetch (*Vicia ervilia*). The identity of *ocinum* is uncertain: Cato (*Agr.* 27) and Varro (*Rust.* 1.31.4) seem to indicate a particular plant, possibly clover, and Varro connected the name with the Greek ὠκέως ("quickly"), presumably because it was the earliest crop ready for use. Pliny, however, following Sura Manlius, understood it to be a mixture of beans, vetch, chickpeas or chickling vetch, and oats sown together (Pliny *HN* 18.143; André 1985, p. 175; Andrews 1980, p. 527). Elsewhere, Cato (*Agr.* 54) adds to the list of fodder plants panic grass (*Panicum miliaceum*) or Italian millet (*Setaria italica*). Alfalfa, also called lucerne, was introduced by Varro's time (*Medicago sativa*, Varro *Rust.* 1.31.4–1.31.5, cf. Verg. *G.* 1.215).

In addition to crops intentionally planted for fodder, there was side-produced material like leaves of elm, oak, poplar, ilex, ivy, and fig trees growing on farms and material discarded from farming tasks like grape husks, wheat and barley chaff, husks of beans, and windfall fruit (especially good for fattening pigs). Nothing was wasted.

Religious Practices Associated with Fertility or the Agricultural Calendar

Fertility and Myth

For the Greeks, the role of gods and goddesses in the fertility of the earth was enacted in the myth of the coupling of Demeter and Iasion in a "thrice-plowed" field, that is, a field which was ready to be sowed (Hes. *Theog.* 969–974) and by rain falling from Ouranos, the sky, to impregnate Gaia, the earth (Aesch. *Danaids* fr. 44 in Guthrie 1968, p. 54). The Romans thought of their relationship with their deities as a contract by which human worshippers gave offerings which would enable the gods and goddesses to help them, in the formula *do ut des* "I give in order that you may give" (Scullard 1981, pp. 22–27).

Kinds of Offerings

Offerings to deities were often produced from the farm. Wine from the vineyard was poured in libation. Animals raised and fed on the farm were sacrificed. Flowers and foliage were woven into wreaths to be worn at festivals or placed at statues (Cato *Agr.* 143). Plants gathered at the beginning of the harvest were offered to the gods as a foretaste of the harvest and a promotion of fertility (Nilsson 1940, pp. 28–30).

The Farmer and the Gods

Generally speaking, Greeks and Romans began tasks on the farm by prayer or sacrifice to obtain good results. The right amount of rain at the right time was needed for a successful harvest, but no human effort could cause rain to fall. When Hesiod was ready to sow, he prayed to Zeus Chthonios, the god "operating in the earth" (Hes. *Op.* 465; West 1978, p. 276), and to Demeter, the goddess who taught the Greeks how to grow grain (Isager and Skydsgaard 1995, p. 163; Zeidman and Pantel 1992, p. 43). For Xenophon, "sensible" people honored the gods when they began an activity, not least an agricultural activity (*Oec.* 5.20; Pomeroy 1994, pp. 257–258). The god – in the singular, influenced by Socrates' monotheistic language – determined when to send needed rain (Xen. *Oec.* 17.2).

The Romans were punctilious about propitiating the gods before they began an action (Cato *Agr.* 115). A sacrifice was offered before the harvest, before thinning a grove (*Agr.* 139), and before tilling the ground (*Agr.* 140). The area to be protected was defined by the ceremony of *suovetaurilia* in which a pig, a lamb, and a calf were led around the boundaries of the farm to mark the area which the gods were asked to protect (*Agr.* 141).

At the beginning of his *Res Rusticae* (1.1.4–1.1.7), Varro invoked the twelve councilor gods instead of Hesiod's Muses. In addition to familiar deities – Jupiter, Minerva, Venus, Ceres, and Liber (Bacchus) – he named Tellus (Earth); Sol, and Luna (Sun and Moon); Robigus, the god who prevented rust on plants; and Flora, the goddess of flowers; and Lympha (Water) and Bonus Eventus (Success) as powers (almost personifications) which were thought to bring good harvests (Tilly 1973, pp. 132–140).

Vergil (*G.* 1.338) advised his readers "above all, worship the gods" though his prayer (*G.* 3. 513) "may the gods give better to the pious" suggests that religious practice is no guarantee of success (Thomas 1988, v. 2, p. 137).

The City and the Gods

Many Greek and Roman public religious festivals marked important points in the agricultural year: sowing, grain harvest, gathering grapes, and making wine (cf. Cartledge 1985, p. 100). In Attica, for which we have the most information, Dionysus was honored at the Oschophoria in autumn when the grapes were harvested and in spring at the Anthesteria when the first wine was ready for drinking. The Thargelia was celebrated in early summer in honor of Apollo; a scapegoat (pharmakos) was paraded and then expelled from the city in a rite of purification to protect the crops (Nilsson 1940, p. 27). The olive harvest may have been celebrated at the Arrephoria (Simon 1983, pp. 39–46; cf. Håland 2012, p. 273) in midsummer. The Haloa celebrated Demeter, Persephone, and Dionysus in winter when the vines were pruned (Nilsson 1940, pp. 32–33).

In April, the Romans held several agriculture festivals: the Cerialia in honor of Ceres, the Vinalia when the new wine was ready, the Robigalia to protect grain from rust, and the Floralia as a spring celebration (Scullard 1981, pp. 102–103, 106–111). In May, the Ambarvalia was held as a public observance of the *suovetaurilia* described above when officials walked the bounds of the city with a pig, sheep, and bull (Scullard 1981, pp. 124–125). A second Vinalia was held in August (Scullard 1981, p. 177).

Conclusion

Agricultural plants provided food for people and their animals and many other necessities of everyday life: ropes and cloth, oil to light lamps, wood to make fires for warmth and cooking and to make into axe handles and plows, and plants to treat common ailments. They were featured in religious cults in libations and offerings. The more farmers knew about planting, tending, and harvesting, the more successful they would be. The authors who wrote instructions for caring for farm crops made an important contribution to the quality of life of the ancient Greeks and Romans and also make us appreciate the depth of their knowledge of agricultural plants.

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FURTHER READING

Studies of ancient Greek and Roman agricultural plants begin with Hesiod *Works and Days*, Xenophon *Oeconomicus*, Theophrastus *Enquiry into Plants* and *Causes of Plants*, Cato *On Agriculture*, Varro *Res Rusticae*, Vergil *Georgics*, Columella *De Re Rustica*, and Pliny *Natural History*. I have indicated in the chapter the sections of these books in which agricultural plants are discussed and in the reference section (Classical texts and translations) an English translation of each author. White (1970) is still useful for an overview of agriculture in the Roman world, in particular as a guide to Roman writers on agriculture. A symposium on agriculture in ancient Greece, 16–17 May, 1990, resulted in the publication of Wells (1992) with an emphasis on the production and organization of agriculture. The introductory essay by Skydsgaard (in Wells 1992) surveys the problems presented by Greek sources. Zohary, Holz, and Weiss (2012) assemble paleobotanical evidence for the domestication of agricultural plants in the ancient world, in South Asia and Europe as well as the Mediterranean. Grove and Rackham (2001) survey climate, weather patterns, and erosion in Mediterranean Europe and compare ancient to more recent evidence. Work remains to be done comparing ancient references to climate change (Neumann 1985) to scientific analyses (e.g. Chen, Zonneveld, and Versteegh 2011). For some of the difficulties, cf. Grove and Rackham (2001).

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CHAPTER SIX

Animals: The Major Domesticates

Michael MacKinnon

As providers of various resources (including meat, milk, hides, wool, labor, etc.), animals assumed important roles in antiquity. Nonetheless, the position, nature, and scale of stock raising can show significant variation within ancient agricultural regimes across time and space. This chapter overviews the contribution of the major domesticates – cattle, sheep, goats, pigs, equids (i.e. horses, donkeys, mules), and domestic fowl – to agricultural practices in antiquity. Such a suite arguably represents the core of work and food "barnyard" animals.[1] Temporally, assessment spans the initial phases of domestication (i.e. Neolithic times for some taxa) through to Late Antiquity (roughly, c. 500 CE). The focus is on Greek and Roman antiquity, however, as these periods mark major frames of cultural expansion. Geographically, the Mediterranean, Aegean, Near Eastern, and temperate European contexts are stressed, settings where a number of key ancient civilizations emerged, or otherwise extended into.

Sources of Evidence

Our understanding of animals in antiquity fundamentally draws upon three principal sources. Each is not always available among any specific culture, however. Moreover, the extent to which any single source of evidence, even when attainable, can be utilized may vary tremendously. First, a number of ancient texts may exist, for example, cuneiform script in Mesopotamia, ancient Egyptian hieroglyphics, Linear A and B script in the Bronze Age Aegean context, or ancient Greek and Latin texts among the later Greco-Roman empires of antiquity. Among these, Greek and Latin sources, perhaps our most extensive forms of ancient texts, themselves encompasses diverse forms (e.g. commemorative and dedicatory inscriptions, literary works, histories, encyclopedic volumes, didactic manuals, poetry, legal codes,

1 Dogs, cats, camels, and other domesticates will not be discussed, since in many cases these taxa were not commonly consumed across phases of antiquity (e.g. dogs and cats), or were not as widespread in their exploitation (e.g. camels).

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

among multiple other categories or genres) which, as regards animals, range in content and function from descriptions of various types encountered and used, to details about animal care, maintenance, and contribution to ancient life. Caution must be exercised to scrutinize the various sources and information to understand the context. The list of such components is complicated. Descriptions of animals, for example, may be embellished or otherwise modified for poetic or dramatic effect, depending on the situation. Metaphorical messages involving animals within some texts might not reflect accurate situations. Accounts and tallies of animals might be exaggerated to communicate prosperity, excess, or generosity; the reverse might be used to exemplify opposite attributes.

Iconography provides a second source of information. Studying images of animals allows exploration of morphology, characterization, and physical variation, among other concepts. A host of media may surface, including painting, mosaic, sculpture, etc. Nonetheless, the extent of the iconographic database, not to mention its value for animal research, can vary widely. Oftentimes, animal iconography can be rendered in multiple ways (e.g. abstractly, naturalistically, stylized, etc.), with assorted (known and unknown) cultural messages or purposes affecting image content and character. Nevertheless, assessed judiciously, images can help us understand how ancient cultures viewed, portrayed, and subsequently perceived animals.

Finally, archaeology, most notably zooarchaeology, supplies physical remains of animals to examine for cultural, biological, and environmental reconstructions. Excavated faunal remains reveal data about species representation, age, sex, and state of health; they may also yield evidence about cultural practices such as consumer decisions in marketing, resource acquisition and use, butchery, cooking, and eating. Archaeological analyses, consequently, can disclose much about animals themselves, as well as the cultures that kept, controlled, killed, ate, and exploited them. Moreover, recent explorations of isotopic, chemical, and physical properties of ancient bones, not to mention the vast potential of information from DNA extraction and analysis on these bones is shaping new directions in assessing species distributions, migration patterns, trade, animal breeding, genetic relationships, and other components (Larson 2011; Larson et al. 2014; Pilaar Birch 2013; Van Neer and De Cupere 2013). Collectively, zooarchaeological knowledge is crucial, not only as comparanda to information presented in ancient texts and iconography, but in providing key evidence otherwise not recorded within them.

Near East

Domestication marks a crucial step to the subsequent involvement of animals in agricultural and husbandry schemes. Significant attention has focused upon the domestication process and its impact upon wider economic and subsistence changes under the "Neolithic Revolution" (Childe 1936; Flannery 1973; Arbuckle 2012). In the Near East, sedentary cultivation of plants appears first, around 10 000–8500 BCE, in the "Fertile Crescent" region of southwestern Asia, including the Levant, and eastern Iraq/western Iran (Bar-Yosef and Meadow 1995). Domestication of various animals, first sheep and goats, followed by pigs and cattle ensues, around 8800–6500 BCE (Bar-Yosef and Meadow 1995). Morphological changes, including a decrease in body size and modifications in various physical features such as horns and cranial/dental proportions, have traditionally assisted scholars in identifying the effects of domestication of animal taxa from their wild progenitors. Understanding the overall process of domestication, however, has been enhanced greatly through recent genetic and cultural studies that focus upon the sustained, multi-generational, mutualistic relationship between humans and animals (Zeder 2008, 2011). Within this symbiotic framework, humans shape animal morphology and behavior through selective breeding, management, and exploitation, including culling practices. Traits of interest can vary, however, such as meat, finer coat, greater fecundity, augmented power, docility, etc. leading in turn to potentially complex and diversified techniques for managing, controlling, and developing the livestock. Some animals seem initially domesticated primarily as a source of food [e.g. sheep, goats, cattle, pigs, and horses (in some circumstances – see Howe 2014a, b; Willekes 2016)], even if their subsequent exploitation could additionally yield a host of secondary products, such as wool or traction; other animals may have served in commensal roles, adapted to human care and contact, but in turn exploited for products and services (e.g. pigs, dogs, domestic fowl); still others entered domestication presumably by way of more targeted selection of draft and nonfood products (e.g. donkey, camel). Variation also develops as regards the role and use of animals locally and regionally at this time. An investigation of zooarchaeological patterns among Bronze Age sites reveals an overall predominance of sheep and goats across the wider Near East, but considerable regional variability in the proportions of these and other domesticates (Arbuckle 2012). Cattle, for example, register among all areas of the Near East, but, alongside sheep and goats, form central components of pastoral economies in highland eastern Turkey and Arabia. Pigs, by contrast, were important to economic ventures in Mesopotamia and Anatolia, especially among rural sites. Ecological factors often play a role. Hot, dry environments restrict husbandry of pigs and sheep, given that these animals are compromised, physiologically, under such conditions. But cultural and historical preferences and traditions as regards diets, husbandry schemes, and overall behaviors further shape patterns. For example, ovicaprids best suit mobile pastoral systems traditionally practiced in highland Iran and eastern Turkey (Zeder 1998); pigs have historically been exploited in the upper Euphrates valley since the Neolithic (Hongo et al. 2004), before broader dietary prohibitions for them developed in later periods across areas of the Near East (Hesse and Wapnish 1998).

The exploitation of primary resources (i.e. meat, fat, bone, and skin) appears as a key stimulus initially for domestication for many taxa, but additionally through time, and most predominantly with the development of historic periods in the Near East (c. 4th and 3rd millennia BCE), renewable, or secondary products, such as milk, wool, hair, and traction power achieve widespread prominence. This is also the time when horses (first domesticated in the Eurasian Steppes) and donkeys (domesticated in North Africa) are introduced to the broader Near East region. Domestic fowl appear a bit later. Recent genetic research indicates that chickens were domesticated from the red jungle fowl (*Gallus gallus*) multiple times across various areas of Southeast-, East-, and South Asia (Xiang et al. 2014), reaching the Near East, as an import, in the 3rd or 2nd millennium BCE. Overall, by that time, textual and iconographic sources throughout the Near East attest to the importance of animals and their products, in particular highlighting the place of ovicaprids within woolen textile industries. The sources further recount practices in animal husbandry. Middle Assyrian cuneiform tables, for example, offer some glimpses into aspects concerning agricultural products and livestock management, listing the names of shepherds and cowherds working for the government, inventories of taxa, as well as types of animals being herded (Becker 2008, p. 562). Preserved textual records from Ur, dating to the Babylonian period, document administrative matters related to herd care and management (Van de Mieroop 1993). Arguably, animal iconography on cuneiform tablets acts more as a representation, rather than a naturalistic impression. Other forms, such as figural work, offer both naturalistic and abstract portrayals of animals, framed often under traits or qualities the artist wished to emphasize, be that ferocity, nurturing, etc. Animal imagery may offer a deeper metaphor for authority, protection, and dominance, for example, in the case of symbolism of ruler/king as shepherd (Aruz and Wallenfels

2008; Aruz, Benzel, and Evans 2009). No doubt, such aspects tie into larger patterns of a rise of complex societies and increasing production and commodification of textiles, among other resources, across wider areas of the Near East. Horses and donkeys add to this as symbols of prestige and wealth, variously harnessed as elite beasts of burden for traction, riding and chariot pulling, or as conveyors of goods, in the case of donkey caravans.

By the Bronze Age in the Near East, the complement of domestic taxa that factored with any significance to subsequent agricultural regimes is basically set. Local domestication of cattle, sheep, goat, and pig has occurred, with import and expansion of domesticated equids, and later domestic fowl, further solidified at this time. Regional variation within livestock patterning and exploitation has emerged. Both primary and secondary resources are utilized, and the importance of animals as indicators of wealth and prestige, reflected in turn through their roles in providing meat, milk, wool, traction, and other products, is shaped and codified in various cultural pursuits, with perhaps the broader production and commodification of the textile industry, itself increasingly a politically administered operation, serving as a prime example.

Ancient Egypt

As a society with pastoral origins, animals were integral to life in ancient Egypt. All the major livestock domesticates were raised from Neolithic times in Egypt. Cattle were probably the first. Debate exists surrounding their origin, and to what degree domestic cattle in ancient Egypt were introduced from the Near East or descended from endemic populations of Aurochs (Houlihan 1996; Troy et al. 2001; Bruford, Bradley, and Luikart 2003; Beja-Pereira et al. 2006). Nonetheless, evidence from Dynastic times, in the form of tomb paintings, hieroglyphics, and zooarchaeological remains, collectively attests to the central importance of cattle in ancient Egyptian culture. Both economically and symbolically, these animals were connected with wealth, power, and prestige; indeed, despite the ubiquity of domestic cattle in Dynastic Egypt, beef remained a relatively high-status meat. Nevertheless, a close relationship existed between the farmer and his working cattle. Scenes of the humble cattle herdsmen, as depicted in tomb paintings, highlight the attention paid not only to the care and maintenance of these animals (in everything from calving to mating to transport), but also to the array of products and services exploited from them. Cattle were invaluable as agricultural plow animals, but also assisted at harvest in threshing and treading of crops. Oxen were further employed to draw wheeled vehicles and to haul sledges. Herds on large estates were sometimes branded, and administrative tactics employed to tax and count numbers in regular censuses (Houlihan 1996, p. 16). Livestock, especially cattle, often appear among lists of commodities presented in tribute to the Pharaoh, or acquired as booty in conquests. Finally, in addition to these practical and economic uses, as sacred animals, cattle factored widely in religious customs and practices in ancient Egypt. Cows were associated with the goddesses Isis and Nut, and the bull was worshiped in the cult of Apis.

The ancient Egyptians also kept sheep, goats, and pigs. Domestic sheep and goats certainly must have reached ancient Egypt from abroad, specifically the Near East. The situation for pigs is less certain, with conjecture as to what degree they migrated on their own from the Near East, in wild forms to be subsequently domesticated in Egypt, or were imported as domesticates already (Lobban 1998, p. 137). Regardless, the role of each of these taxa varies. Sheep and goats were important to ancient Egyptian pastoral economies. Two distinct breeds of sheep can be distinguished, on the basis of iconography: a fleeceless, long-tailed, corkscrew-horned type (the presumed original stock), and a fat-tailed, wool-producing, curled-horned variety (introduced from the Near East during the Middle Kingdom, and predominant in the New Kingdom) (Houlihan 1996, p. 22). Although flocks of sheep and goats (some of which, in practice, could number into the hundreds) are represented in Dynastic tomb paintings, it seems neither taxon contributed significantly in terms of exploited resources, at least in relation to cattle or pigs, for example. Wool does not factor predominantly in textile production in Egypt until later Greco-Roman times, while mutton is less popularly consumed, compared to other meats (Ryder 1983, p. 113). Nonetheless, the ram figures prominently in Egyptian religious beliefs, notably as a symbol of fertility (Houlihan 1996, p. 22).

The role of pigs in ancient Egypt is complex. Some groups, notably lower classes, consumed them; others considered pigs impure, unclean, and symbolic of evil. The origins of this taboo are unclear; it is often linked with notions of the pig wallowing in dirt and filth. The fact that pigs are typically absent from tomb paintings, and strictly avoided among funerary and temple offering lists, lends credence to a division along status lines. The Greek historian Herodotus (2.47) remarks upon this disdain noting "if an Egyptian touches a hog in passing, he will at once plunge himself into the river, clothes and all, to wash himself; swineherds, native to Egypt, are the only people in the country forbidden to enter a temple."

Among other domesticates, a local variant of the African wild ass (*Equus africanus*), the resident Nubian wild ass (*Equus africanus africanus*), likely served as the progenitor of the domestic donkey in Egypt (Rossel et al. 2008). Pinpointing an exact date for this process is difficult, owing to a lack of good skeletal evidence, but donkeys are firmly established by Predynastic times in Egypt, and are well integrated as pack and transport animals after that period. Horses were introduced into Egypt around the 13th dynasty, becoming more widespread from the Second Intermediate Period onward. They were largely considered luxury animals, used in warfare, in hunting, and in drawing chariots, and not normally for agricultural plowing (Houlihan 1996, pp. 33–38). Chickens were imported into Egypt, from the Near East, during the 2nd millennium BCE, originally as fighting birds and additions to exotic aviaries; however, increasingly throughout the 1st millennium BCE, they were commonly exploited for eggs, feathers, and meat among the wider populace of Egypt.

Bronze and Iron Age Europe

The disparate nature (and sometimes lack) of zooarchaeological data, coupled with oftentimes less robust (or absent) archaeological, textual, and iconographic evidence presents challenges in deciphering the intricacies of animal use among Bronze and Iron Age cultures in greater Europe. Initially, domesticated taxa from the Near East make their way, largely through trade and diffusion, into the region, after which husbandry operations reliant on domestic animals develop significantly in areas of continental Europe (Bruford and Townsend 2006; Larson et al. 2007; Zeder 2008). As elsewhere, variability exists; thus, it might be better to characterize the wider European region in these Ages as practicing a mixed agricultural strategy, with local iterations as suited particular environmental and cultural conditions. The principal domestic taxa – cattle, sheep, goat, pig – occur across all regions, often integrated into wider agropastoral economies. Nevertheless, evidence shows that systems were by no means static, and could change over time (Harding 2000, p. 134).

Generalizing, one finds that cattle tend to be most common in temperate northern Europe during the Bronze and Iron Ages. Cattle were exploited for both meat and for secondary products, including milk and traction. Ovicaprids and pigs follow in importance; however, their popularity tends to increase over time, through into Greco-Roman antiquity, perhaps an indication of augmented demands for wool (among sheep) and meat (in the case of pork).

To the south, in Mediterranean Europe, sheep and goats usually dominate assemblages, integrated in some areas into schemes of transhumant pastoralism; however, pigs and cattle also register in varying importance, depending upon local conditions. To the east, the predominately mobile pastoral cultures of European steppe zones also emphasized sheep and goat husbandry. However, these groups are particularly known for their horses, and indeed this area sees the initial domestication of the horse.

Bronze Age Aegean world

All the major domestic livestock taxa are variously represented in the Aegean world throughout the Neolithic. Initially, schemes seem to emphasize what might be termed more "household-type strategies" geared around the production of meat, notably of sheep and goats, with less attention to secondary resources. Cattle and pigs were raised, but ecologically limited within mountainous Aegean landscapes, which are more amenable to herding of sheep and goats. Aspects shift, however, throughout the Neolithic and into the Bronze Age, to more balanced mixtures of livestock in some areas, and increasing exploitation of both primary and secondary resources from taxa, especially sheep and goats (Halstead 1992). Essentially, within this new framework, what arises during the Bronze Age is a greater diversity in agricultural operations, which variously span from small-scale herding practices by mixed farmers to large-scale pastoral operations. The latter become particularly instrumental to Bronze Age economies. Arguments exist concerning the overall origin and scale of pastoralism in the ancient Aegean, notably in how best to quantify and qualify intensification and specialization in crop and animal husbandry (Halstead 1992, 1996). Nonetheless, any grand-scale development of pastoralism appears predominantly linked to the rise of palatial complexes in the Aegean world throughout the Bronze Age, with the focus, of a number of these, upon wool economics. Linear B records (retrieved primarily from the palaces of Knossos and Pylos) that pertain to livestock from this time attest to highly specialized modes of pastoralism, which outline strategies for trade, marketing, breeding, and herding of flocks (Halstead 1998–99). Zooarchaeological evidence confirms such a shift in focus to exploitation of secondary products, in registering a rapid increase in the proportion of adult and male ovicaprids among sites (Nosch 2014). Developments and "improvements" among various livestock "breeds" also register in the zooarchaeological record with some significance at this time. Increasing size among sheep and goats is reported for Bronze Age Kastanas in northern Greece, with a number of other sites following afterward (Halstead 2014, p. 31).

In some respects, intensification of Bronze Age Aegean pastoral activities perhaps parallels similar concentrations among Bronze Age Near Eastern cultures. Ovicaprids could be herded fairly easily and economically within these regions, and their products exploited (sometimes on a grand scale) under elite/palatial administration. The scale in pastoral stock farming depends upon factors such as access to pasture land, population densities, and sociopolitical conventions and situations. A relatively low human population density coupled with general political unease and territorial disputes during the Bronze Age within the Aegean context often left wide regions of the land available as pasturage for grazing migratory flocks. Pastoralism could flourish under such conditions.

Although deliberations about ovicaprids and wool economics tend to dominate discussion of Bronze Age Aegean animal husbandry, other taxa should not be forgotten. Indeed, highly diversified, mixed agropastoral ventures likely accounted for the bulk of small-scale farming schemes at this time, with each farmstead keeping a range of livestock, including cattle, sheep, goats, and pigs, as best suited individual circumstances. Domesticated horses were brought to the Greek peninsula between 2100 and 1900 BC during the Middle Helladic Period, but they were predominantly regarded as an elite luxury and status symbol, and reserved as mounts, race horses, and in military cavalries. Donkeys served as pack animals. Oxen were harnessed as work animals, but judiciously in this respect, given the added costs in maintaining plow animals. Small animals could graze on neighboring pasture lands, or be fed on scraps; and a series of primary and secondary resources could be acquired as necessary from these animals. Domestic fowl were not introduced into the wider Aegean world until sometime in the 1st millennium BC, but once incorporated were commonly exploited. Overall, mixed agropastoral schemes afforded diversification, which helped buffer risks in yield or production Bronze Age Aegean farmers might otherwise have faced (Halstead 1992, 1996). Imprinted upon this, moreover, were degrees of malleability or flexibility to farming strategies and practices, themselves contingent on various factors, including the quality of the land, the effects of climate, the livestock and labor available, and the circumstances of individual years. Such aspects are applicable to both the past and the present, and well illustrated in ethnographic exploration of Mediterranean farming practices (Halstead 2014).

Greek and Roman Antiquity

Greco-Roman antiquity (here, broadly c. 800 BCE–500 BCE) denotes a key phase in the assessment of animals in ancient agricultural practices, for a variety of reasons. First, compared to earlier times, relatively abundant textual, iconographic, and zooarchaeological evidence exists. Relevant textual sources as concerns animals and agriculture include works by Aristotle (*History of Animals*), Strabo (*Geography*), Pliny, the Elder (*Natural History*), Aelian (*On Animals*), as well the farming manuals of Cato (*On Agriculture*), Varro (*On Agriculture*), Columella (*On Agriculture*), and Palladius (*The Work of Farming*). Several works that consider animals in Greco-Roman antiquity in particular through investigation of ancient textual (and less comprehensively, iconographic) evidence include White (1970), Toynbee (1973), Isager and Skydsgaard (1992), Chandezon (2003), Howe (2008, 2014a, b), Kron (2008, 2014), MacKinnon (2001, 2004), and McInerney (2010). Bibliographies and syntheses of zooarchaeological reports from various regions and time frames of antiquity are published elsewhere (e.g. King 1999; MacKinnon 2007).

A second factor to note is that the geographic extent of the Greco-Roman world provides an array of ecological and physical frameworks under which crop and animal husbandry schemes are situated, and which in turn affect strategies pursued. Economic, cultural, and social factors, moreover, play key roles in shaping aspects, with dynamic interplays between agricultural practices that might seem better allied to local traditions and ecologies, versus changes brought from cultural diffusion, migration, and contraction (as empires grew and shrank over the course of time) not to mention distinctions among cultural preferences and trajectories in terms of diet and animal husbandry techniques. In many respects, one sees similar integration of animals in Greco-Roman antiquity as may traditionally have been developed in earlier contexts – notably exploitation of various primary and secondary resources as best fits particular cultural and environmental situations and demands – but with additional complexities. Great variations in character and magnitude may arise, depending on the context, with operations ranging from small-scale, mixed-farming ventures with just a few animals, to large-scale schemes that specialized in one particular taxon or resource. Similarly, the requirements and logistics involved in herding, maintaining, feeding, and transporting livestock could fluctuate in scope, scale, and nature.

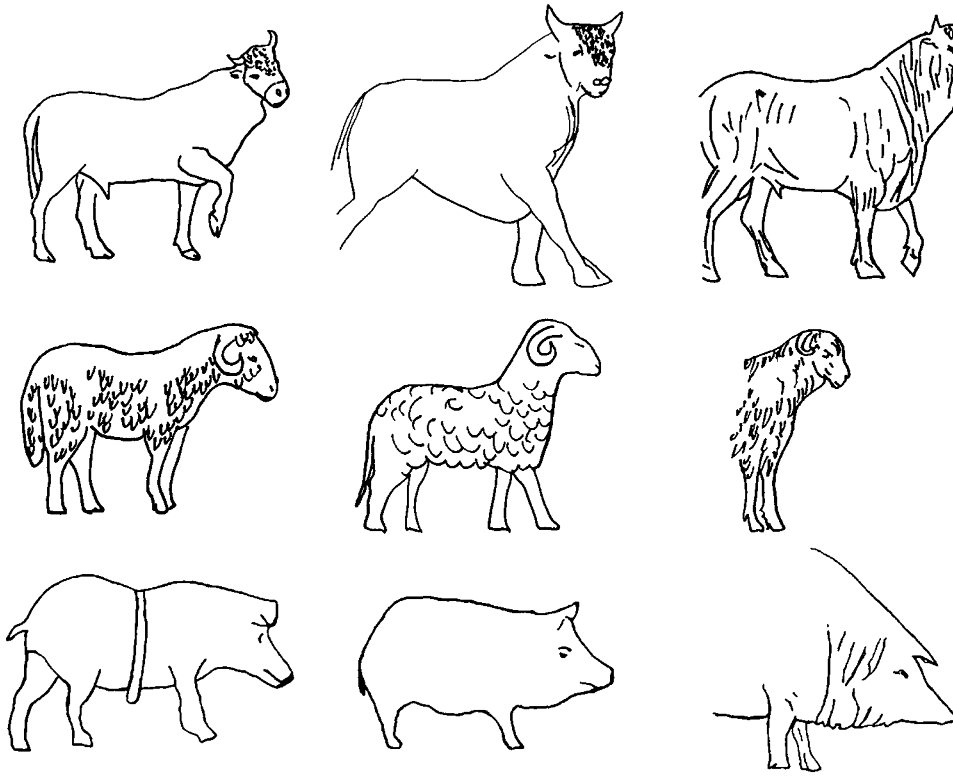

Figure 6.1 Outline drawings depicting variations in iconographic depictions of cattle (top row), sheep (middle row), and pig (bottom row) from Roman sculptural scenes of *suovetaurilia* sacrifice (sources from left to right: Column of Trajan; Altar of Domitius Ahenobarbus; *Suovetaurilia* of the Louvre). Note variation in traits such as horns, body size, leg proportions (cattle); tail, fleece, forehead/nose shape (sheep); body size, snout dimensions, legs (pigs). Not to scale. Source: Illustration by Michael MacKinnon.

A third component to consider in the assessment of animals in Greco-Roman antiquity centers upon consumption. Although animals held similar roles within each culture, debate exists as to the extent to which any meat consumed within Greco-Roman societies derived from "sacred" or "secular" contexts. Certainly consumption of meat among both cultures was probably limited, compared to modern standards, and very much dependent upon aspects such as availability, affordability, supply, and status; however, strict delineation that all meat consumed in Greek antiquity derived from sacrificial contexts, with a relaxation of such policies into Roman antiquity, creates too simplified a parameter, which is increasingly being challenged from zooarchaeological investigations (Ekroth 2014; MacKinnon 2014a).

Fourth, Greco-Roman antiquity represents a phase marked by greater morphometric manipulation of domesticates than previously witnessed. The Romans, in particular, were instrumental in developing a vast array of "breeds" or types of domestic cattle, sheep/goat, and swine – a testament, it may be argued, to their command over livestock resources (Figure 6.1). Although modern genetic principles were not known, ancient farmers and herders did understand that "favored" characteristics could be assured by mating the best individuals. On one level, there was an overall drive to "improve" stock by breeding larger animals, notably during Roman times. General "improvements" and height increases, among all major livestock taxa are noted, but develop neither equally nor simultaneously. Within the Roman world, for example, some regions, such as Italy, see larger gains in these measures, and from earlier times. Height was not the only characteristic manipulated. Indeed, changes surface in various efforts to select and promote a range of physical and behavioral features (e.g. weight, stockiness, fat content, strength) within different livestock as suited local and regional demands and settings.

Finally, Greek and Roman antiquity marked a time of advancements in the care and nutrition of livestock. Feeding regimes were improved through new fodder sources and better management of resources. Moreover, animals were more effectively integrated into arable farming schemes, notably through convertible husbandry, wherein lands were subject to rotational schemes through cereal and legume crop production, and conversion to pasture (Kron 2008, 2014). This more effective use of land resources provided numerous benefits for livestock: (1) they could pasture and manure fields as needed; (2) they could be provided with excellent fodder, particularly legumes; and (3) greater security in timing and management overall might be afforded. Concern for livestock is further noted in Greco-Roman times as regards measures in stalling or stabling animals, as well as in health and veterinary care.

Cattle

Cattle, typically oxen, were principally bred for traction among most Greco-Roman sites, notably in areas where agricultural crop production flourished. Nevertheless, regional climates and topographies affected representation. Drier conditions in the Mediterranean region, for example, coupled with the critical importance of that area as a cereal-producing zone, an agricultural scheme in which cattle would compete directly with available arable land, combined to limit or restrict many large-scale cattle herding ventures in the Greco-Roman Mediterranean world. In regions where lusher pastures existed, such as in northern Europe or among well-watered lowland Mediterranean valleys, cattle ranching could, and often did, flourish. This is evident in the relative frequency of taxa between "pre-Roman" and "Roman" times throughout regions of the Old World, as displayed in Figure 6.2. Essentially, cattle were fairly ubiquitous as plow and traction animals, but limited in any larger ranching venture to regions that afforded good, reliable pasturage. Zooarchaeological data help confirm these trends (King 1999; MacKinnon 2004; Halstead 2014). A majority of adult deaths and a fairly balanced ratio of male to female cattle among most Greek and Roman sites suggest implementation geared principally toward draft animals. Working oxen were particularly valued, and the strong demand for them was embodied by the attention devoted to their care and breeding among the ancient agricultural writers. Oxen that were maintained year-round at the farm required stabling. The Roman agricultural writers note that such stables or stalls should open toward the south to facilitate drying and to allow for maximum warmth (Varro, *Rust.* 1.13.1; Col. 6.22.1; Pallad. 1.173). The interior should be paved with stones, gravel, or sand, to prevent hooves from rooting, and treated with a bed of straw or leaves for the animals' comfort. Nonetheless, relatively higher frequency of cattle bone with pathologies compared to other animals (including equids) attests to an elevated degree of age- and work-related stress, possibly a factor of the demand for sharing and renting plow oxen. Conditions such as osteoarthritis, exotoses formation, and eburnation on bones of the lower leg (metapodials and phalanges) predominate. Research has connected such ailments with plow stress (Bartociewicz 2013, pp. 13–52).

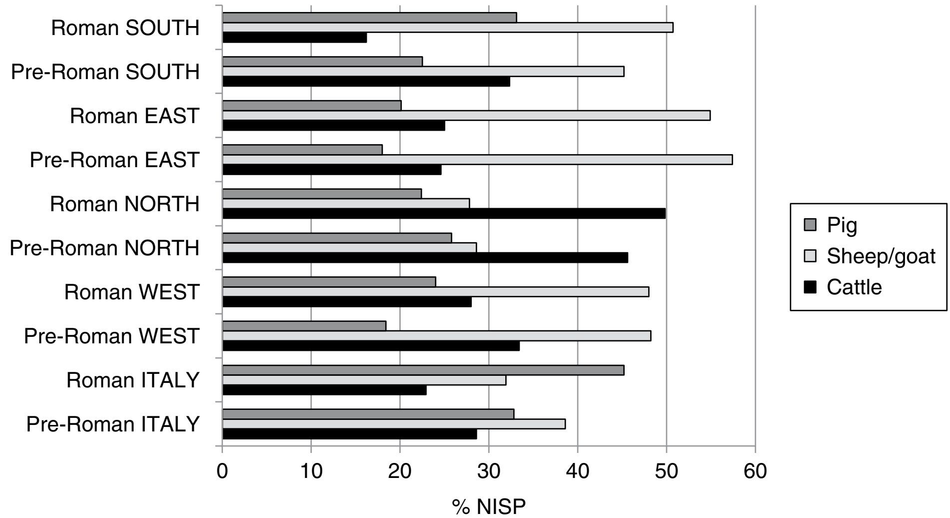

Figure 6.2 Relative frequency of cattle, sheep/goat and pig by NISP (=Number of Identified Specimens) count among various regions of the ancient world as separated broadly into "Roman" and "Pre-Roman" temporal contexts. Source: Illustration by Michael MacKinnon.

Although pockets of noticeably larger cattle exist in Hellenistic southern Italy, widespread increases in cattle sizes throughout Italy, for example, do not occur until Republican and Imperial times, coincident with marked agricultural and demographic changes in the country (MacKinnon 2010). Distinct clusters of cattle breeds develop during these periods, which see representation in both zooarchaeological and textual databases. The ancient Latin texts describe the physical traits, including size and shape parameters, for several types of cattle, separated by specific geographical regions (MacKinnon 2004, 2010). Available metric data from zooarchaeological assemblages collected from across Italy confirm modifications to cattle breeds that are generally consistent with ancient textual recordings (MacKinnon 2010). Several factors interplay to bring about these changes, among which is an augmented market and military demand for grain and other foodstuffs, including beef and other meats, as well as the import and export of cattle brood stock from other areas of the Empire into and out of Italy.

Ovicaprids

Environment and culture again intersect in the exploitation of sheep and goats in Greco-Roman antiquity. Owing to their morphological similarities, the two taxa are often discussed together in zooarchaeological reports. Where distinctions have been made, sheep tend to predominate, indicative of the importance of the wool industry at this time; however, ratios vary, with higher proportions of goats in regions with less favorable environmental conditions, or during phases which witness a general reduction in large-scale pastoral activities and a shift to greater localized husbandry operations (such as late antiquity). Overall ovicaprids are better suited to North African, Near Eastern, and Mediterranean scrublands, an environmental compatibility that no doubt promoted their exploitation in these areas during Greco-Roman times (Figure 6.2).

The ancient agricultural writers discuss various schemes for raising sheep and goats (see Howe 2008, 2014a,b; MacKinnon 2004; and White 1970 for collected references). These range from localized, small-scale, farmstead operations to large-scale, mobile herding. The latter ventures have prompted great debate about the magnitude and nature of transhumance in antiquity, fueled predominantly by the attention large-scale transhumance gains from the ancient authors and legal sources because of the opportunities (and associated problems) that could ensue. No doubt conditions favoring these ventures, including growth in the wool industry, expansion in land holdings, augmented opportunity for agricultural wealth, and sociopolitical support that facilitated movement of livestock across regions during phases of Greco-Roman antiquity, could act to promote such operations, and it is certainly likely such schemes were practiced at some level (Howe 2008, 2011). Nevertheless, the scale should not be inflated, especially in light of zooarchaeological patterns that indicate greater predominance of small- and medium-scale non-transhumant or semi-transhumant pastoral activities that themselves were geared toward a more diversified exploitation of wool, meat, and milk, as opposed to strict specialization in any one commodity (MacKinnon 2004, p. 180; Halstead 2014, pp. 33–34).

Regardless of methods of herding, evidence for proper maintenance and care of ovicaprids is exhibited in Greco-Roman antiquity. In terms of shelter, pens are said to contain flocks in lowland farms during the winter and early spring (Col. 7.3.25). Depending on conditions and resources, these could span from makeshift to more permanent in nature. Columella (7.3.18) mentions keeping young lambs in a pen fenced with willows. Varro (*Rust.* 2.2.9) says that shepherds should carry hurdles or nets with which to make enclosures for their flocks in desolate regions. Discussions of various diseases among sheep and goats and their subsequent care also factor within the ancient texts. The fact that zooarchaeological evidence registers few skeletal pathological disorders among ovicaprids suggests flocks were fairly healthy (MacKinnon 2004, p. 133).

The ancient texts offer little substantive information, aside from wool color and general notions of size, to distinguish breeds of sheep. Varieties such as the Apennine, Gallic, Apulian, Tarentine, Ligurian, Laodicean, and fat-tailed Arabian are noted, but not always clearly separated (MacKinnon 2004, 2015). As is the case for cattle, "breed" names for ancient sheep largely correlate with geographical regions and areas. Zooarchaeology adds greater texture. Sheep increase in height as a consequence of Greco-Roman "improvements" to livestock across much of the larger Mediterranean world; however, tremendous variation is noted. Smaller "breeds" are often never eliminated; while the introduction and spread of taller, slender types, heavier, thicker-set types, smaller, rustic types, among other varieties of sheep attests to the shrewd, productive breeding tactics as regards sheep. Various "breeds" seem to coexist across different regions, presumably as herders and farmers adapted stock to suit the range of environmental and cultural demands existing at any individual local or regional level.

Pigs

Unlike cattle and ovicaprids, pigs yield no important secondary resources. Consequently, they are chiefly exploited for their meat, as exemplified in Greco-Roman antiquity through zooarchaeological evidence that consistently displays younger mortality profiles. Moreover, pigs produce large litters, making them even more beneficial to agricultural ventures that wished to capitalize on demand for pork, a choice meat of the Romans, in particular, in many areas. Breeding and exploitation of pigs in Greco-Roman antiquity largely centered upon provisioning of markets, with urban and military sites providing the most demand. Augmented frequencies for pigs during Roman times across sites in Italy, Iberia, and North Africa, in large part, reflect local intensification schemes to supply dietary requirements in rising urbanized settings (Figure 6.2). Nonetheless, while increased pork consumption often coincided with Roman cultural influence, regional and temporal variation existed over and above this aspect to present no clear universal pattern for pig exploitation.

Pigs are rather low-maintenance animals in some respect. They can be contained in stalls, even within urban settings, and adapt as necessary. Integration into agricultural ventures is also rather easy. The Roman agricultural writers discuss husbandry principles used to exploit the full potential of pigs. Two levels of operation are apparent. First, a pig or small group of pigs can be kept around the farm to feed off scraps and litter. Alternatively, large-scale breeding tactics to supply market demands can be practiced. The latter could be of two forms, according to Columella (7.9.4). Farms located closer to markets might capitalize on demand for sucking-pig and allow sows to breed twice per year. Farms without easy access to markets might concentrate upon production of good stock, where annual litters are suggested, timed with piglet births in July when the sow has plenty of milk and much food is available. The sources are less clear about varieties of pigs, noting a generalized distinction between "larger" and "smaller" types, which may be borne out through zooarchaeological and iconographic evidence (MacKinnon 2001).

Equids

Equids had been brought to Italy by earlier Bronze Age cultures, and subsequently bred for a variety of purposes including transport, traction, and sport throughout Greco-Roman times (Donaghy 2014; Willekes 2016). Considerable attention was devoted to equid breeding, care, and maintenance. Horse ownership carried certain economic and social prestige in antiquity; Greek and Roman texts are filled with equine references. Some ranching ventures could be quite specialized. Typically, horses were not commonly incorporated into routine agricultural practices. They were expensive to maintain, required abundant fodder, and were not particularly well suited for heavy haulage or traction, notably in pulling the plow. By contrast, donkeys and mules were better adapted for agricultural work. Some assisted in pulling plows, but by far their principal duties were as traction and burden animals. Their breeding was not neglected, however. The ancient sources provide much technical data about desired characteristics of donkeys and mules, outlining procedures to ensure proper cross-breeding. Zooarchaeological evidence confirms variation in equid "breeds" across antiquity; however, not simply within horses. Mules, in fact, appear to become more prominent in the zooarchaeological record throughout Roman antiquity, a testament, perhaps to their central importance as beasts of burden.

Domestic Fowl

Following their introduction into Greece, sometime during the 1st millennium BCE, domestic fowl subsequently spread westward. By Roman times, they are fairly ubiquitous across the ancient world, with ventures to raise, breed, and manipulate poultry birds occurring in wider measure. Domestic fowl were certainly kept on rural farms during Greco-Roman antiquity and integral to many agricultural schemes as a source of meat, eggs, and feathers. Nevertheless, it appears many more were likely raised at the household level in urban areas. Bone metric data show great ranges among elements, suggestive of various types of domestic fowl. Such variation proliferates across Roman urban sites in particular, heavily populated places with correspondingly some of the biggest markets for poultry, and areas where different "breeds" of birds might be introduced (MacKinnon 2014b). Domestic fowl register relatively higher frequencies on sites where pigs are also well represented. This may reflect Roman dietary preferences. It may also indicate that both species were commonly kept in towns. Overall, domestic fowl were relatively convenient and economical animals to exploit, regardless of one's resources.

Conclusion

Once domesticated, the principal livestock animals form important components among agricultural and husbandry schemes throughout the ancient world. Environmental conditions certainly set limits and conditions upon animal husbandry; however, it is important to recognize the role of cultures in shaping aspects too. The specific interplay of environment and culture, moreover, can produce both similarities and differences among groups that might otherwise be linked or differentiated in other aspects. Although for convenience's sake, the discussion here considers the role of domestic livestock within broader temporal/regional brackets as defined by major episodes and cultures of antiquity, it should be appreciated that in many cases schemes employed may endure across time and space, often with regional characteristics as influenced by particular environmental and cultural conditions at any given time or place. Cattle, for example, were instrumental as plow animals among most ancient agricultural regimes, regardless of time or region. Their role beyond that aspect, particularly in regards to wider ranching or herding measures, often depended upon a blend of cultural practices and environmental opportunities. Thus, one sees a greater concentration of cattle herding in ancient Egypt, for example, among a culture that arguably valued this animal to a larger degree, and saw a longer tradition of its pastoralism. Cattle also factor with wider significance among ancient cultures in northern European areas, zones that provide better pastures for these animals. By contrast, ovicaprids adapt well to mountainous and drier conditions across the wider Mediterranean and Near Eastern worlds, so it is not surprising that cultures within those areas, including Bronze Age, Iron Age, and Greco-Roman peoples, focused upon ovicaprid exploitation, sometimes developing transhumant pastoral schemes, contingent on particular economic demands and sociopolitical conditions. Pigs were important meat animals among some cultures, especially the Romans, but they were also taboo to the dietary schemes of some groups. Overall, variation is apparent among which taxon might form the focus of any husbandry scheme across regions and phases of antiquity, but, in most cases, one still finds the full range of domesticates – cattle, sheep, goats, pigs, equids, and domestic fowl – being exploited to some degree across each.

Variation is further revealed as regards animals in ancient agricultural systems when one considers the scale of operations. Small-scale agropastoral ventures likely predominate, regardless of time or place. These mixed-farming measures typically kept a range of domestic animals, variously exploiting them for both primary and secondary products as a means of diversifying operations and reducing economic and dietary risks. Where opportunities existed, however, largely propelled by available resources, market demands, and environmental and sociopolitical favorability, specialization and intensification within animal husbandry operations could result, as witnessed in Bronze Age palatial administration of wool economies, or in the creation of specialized pig farms or cattle or equid "ranches" during Roman times. Specialized attention to animals, in turn, augments the development of breeds. Morphometric analysis of animal "breeds" in antiquity exposes extensive regional and temporal variation in manipulation of livestock traits and characteristics, in turn detailing the complexity of cultural and environmental factors shaping animal use. Studies of livestock "breeds" for antiquity, moreover, reveal targeted, shrewd, and dynamic manipulations of animals, notably during

Greek and Roman times, adding texture to our understanding of cultural choices and the interplay of culture and nature in the past.

GUIDE TO FURTHER READING

Assessments and overviews of domestic animals in the past tend to be compartmentalized generally by taxon (e.g. cattle, sheep, goat, pig), by temporal period (e.g. Egyptian, Greco-Roman times), by geographic location (e.g. Near East, Mediterranean), or by broader topic (e.g. domestication, pathological conditions, breeding, sacrifice). Ryder (1983) offers perhaps the most comprehensive account of sheep in global prehistory and history, as drawn from a variety of sources. Willekes (2016) offers a similarly broad temporal and regional account for horse use in the past. MacKinnon (2014a) provides a long-term perspective for animal use in the Athenian Agora, from the Neolithic through to more recent times. More regional and/or temporal overviews of domestic animals can be found among the following: Collins (2001) and Arbuckle (2012) for the ancient Near East; Houlihan (1996) for Dynastic Egypt; Isager and Skydsgaard (1992), Chandezon (2003), and Howe (2008) for ancient Greece; and White (1970), Toynbee (1973), King (1999), and MacKinnon (2004) for the Roman world. For wider accounts of the role of animals in Greco-Roman society, more generally, see Howe (2014a) and Kron (2014).

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PART II

THE NEOLITHIC

CHAPTER SEVEN

The Beginnings of Agriculture

Phillip C. Edwards

Introduction

The advent of domesticated plants and animals, commencing around 10 000 BCE, ranks as one of humanity's most important socioeconomic transitions. The accumulation of food surpluses freed elite professionals, artisans, and laborers to perform the different social and economic functions that were required in the first complex societies. Today all urban, sedentary, and socially stratified societies are dependent on agricultural surpluses grown by farmers for their ultimate wealth, and these resources all derive from the ancient village way of life (Scarre 2013). The origins of farming also rank as one of science's big questions. Was it was a single invention that spread around the world, or was it a matter of many independent developments? From the mid-nineteenth century, each generation of antiquaries and archaeologists has examined the subject of agricultural origins anew, and they have been gradually joined by scholars in many other disciplines: botanists, zoologists, geneticists, chemists, demographers, and linguists among them. As a critical human transition requiring explanation, earliest agriculture has also become, in recent decades, something of a battleground in the contest of ideas over proper forms of explanation in the social sciences. Some archaeologists have focused attention on internal, societal, and ideational factors as causes, and others on external factors such as climate change and population pressure as reasons for the agricultural transition. Thus, the subject has sometimes become dichotomized in the pursuit of scholastic politics. These issues are addressed in the next section, followed by a conspectus of current global evidence on the subject.

Historiographical Review of Theory

By the late nineteenth century, geologists and archaeologists had unlocked the reality of deep time and a long human prehistory (Van Riper 1993). Darwin had published *On the Origin of Species* in 1859, providing a framework for the concept of biological change in humans, plants, and animals. Colonization and conquest brought European scholars to the realization

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

that parts of the world were populated by people different from them, including non-industrialized, traditional farmers of various kinds, and mobile and semi-mobile hunter-gatherers. Some of these groups were seen as vestiges of vanished early farmers and their forbears, and were used to model the communities who developed early agriculture. The term "Neolithic," which became synonymous with early farming by the opening decades of the twentieth century, was introduced by John Lubbock (1865) in his book *Prehistoric Times*, although the concept had been understood some time before that (Richard 2008).

Specifically, the term was intended to define certain types of new stone tools found in European farming sites of the mid-Holocene, namely, edge-ground adzes and axes; tools that were not only shaped by chipping or flaking, but also polishing and grinding along an edge to produce a tough, durable cutting blade. European colonization encountered traditional farming people, such as in Africa and the Pacific, who used similar edge-ground adzes. "Savagery" and "barbarism" in the nineteenth (Tylor 1871) and early twentieth century (Sollas 1911) were the conjectured social states of hunter-gatherers and prehistoric village farmers, respectively, and so these kinds of modern people came to be viewed as living relics of the Neolithic. Further, Neolithic artifacts became claimed as the material proof for food production in the prehistoric record. Gradually, other artifacts and facilities became incorporated into the definition, so that by the early twentieth century, a prehistoric farming site could confidently be expected to contain – besides edge-ground axes – pottery, sickles, plant-processing equipment like mortars and pestles, weaving equipment like loom weights and shuttles, storage pits, and huts amalgamated into hamlets or villages.

Some early theories of agriculture in this period grew from contemporary classifications of human groups into technological and social stages. Thus, Henry L. Roth (1887) opined that herding of domesticated livestock must have preceded agriculture, since he considered agriculture as a more complex undertaking than pastoralism, but not because he had any evidence to bring to the discussion. As we now know, the opposite scenario occurred. Considerations which began with the actual study of plants and animals were more useful. Alphonse de Candolle (1882/3) argued that the hundreds of domesticated plant species should have specific areas of origin, and that these locales would be revealed as the original hearths of agriculture. He did so from a theoretical perspective, but again, he had little evidence to work with. French antiquaries of the nineteenth century also explored the likelihood of animal and plant domestication in the last Ice Age (Late Pleistocene epoch), stemming from their excavations at important Paleolithic sites. At La Roche de Solutré, Adrien Arcelin and colleagues (1890) investigated possible horse domestication by considering evidence of bone frequency and bone element size, as well as the number of bone element types represented in the assemblage. All of these indices became staples of archaeozoological method a century later. Édouard Piette (1896) investigated the possibility that carbonized plants from Le Mas-d'Azil were cultivated by comparing the remains to modern seeds. Again, this is a fundamental technique employed by recent archaeobotanists. A major advance came in the 1920s with the epic fieldwork journeys of Nikolai Vavilov (1951) (Figure 7.1), a Russian botanist and geneticist who spent many years mapping the natural distributions of the wild ancestors of modern plants across the globe. Vavilov predicted nearly all of the regions now identified as major centers of agriculture, including the Middle East, China, Central America, and Peru (Figures 7.2 and 7.3). He also identified several more important centers of diversity, such as Amazonia and north-east Africa (including Ethiopia).

Although he was not the first to theorize on the subject, the archaeologist V. Gordon Childe (1928) (Figure 7.4) produced the first cohesive synthesis on the origins of agriculture and reached some perceptive conclusions about the process, even in the virtual absence of reliable field data. He correctly pinpointed the transition between the Pleistocene and the

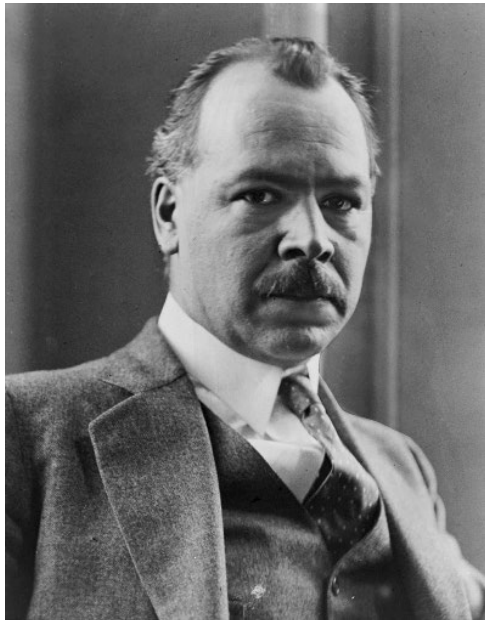

Figure 7.1 Nikolai Vavilov. Source: Library of Congress, http://www.loc.gov/pictures/item/97513426/. Courtesy of Library of Congress.

Holocene as the time of the event, even though the period was characterized by cold and dry conditions, rather than the hot, desiccated period he proposed. He was the first to focus on the Fertile Crescent in the Middle East as the arena for the process, which he called the "Neolithic Revolution." Presciently, given the virtual absence of evidence in the early twentieth century, Childe correctly nominated the oasis settlement at Jericho as a critical locale in the origins of food production. For this locale, he also forwarded a specific theory called the Propinquity Theory, or Oasis Theory, to elucidate the transition. It explained that post-Pleistocene desiccation had concentrated people around water sources, where they were able to closely observe the habits and reproductive processes of plants and animals. Drought and declining food stocks then prompted them to utilize this knowledge and harness these resources in food-producing economies. This theory, long associated with Childe, was virtually identical to the prior formulation of Raphael Pumpelly (1908), who had undertaken the earliest field projects to directly investigate early farming (at the site of Anau in Turkmenistan).

Though brief in formulation, the theory combined three quite different strands of argument. The first one invokes external environmental pressure, arguing that the environment dried up and forced people to produce food. Conversely, the second strand is an internalist or essentialist argument, suggesting that people needed to learn about the germination process to plant seeds; third, the Oasis Theory promulgated a version of population pressure as an accelerant – more people pushed into small areas with declining resources. The accumulation of palaeoenvironmental and archaeological field data, and broadening ethnographic perceptions on hunter-gatherer food procurement strategies, especially since the 1960s, gradually overturned and outdated all of the precepts of the Oasis Theory.

In the 1960s and 1970s, anthropologists began to question the notion that Pleistocene hunter-gatherers, even those living in marginal environments, would have faced chronic food shortages (Sahlins 1974). In order to test the proposition, they began to examine how modern hunter-gatherers get by. Influential in changing attitudes was the 1968 publication of

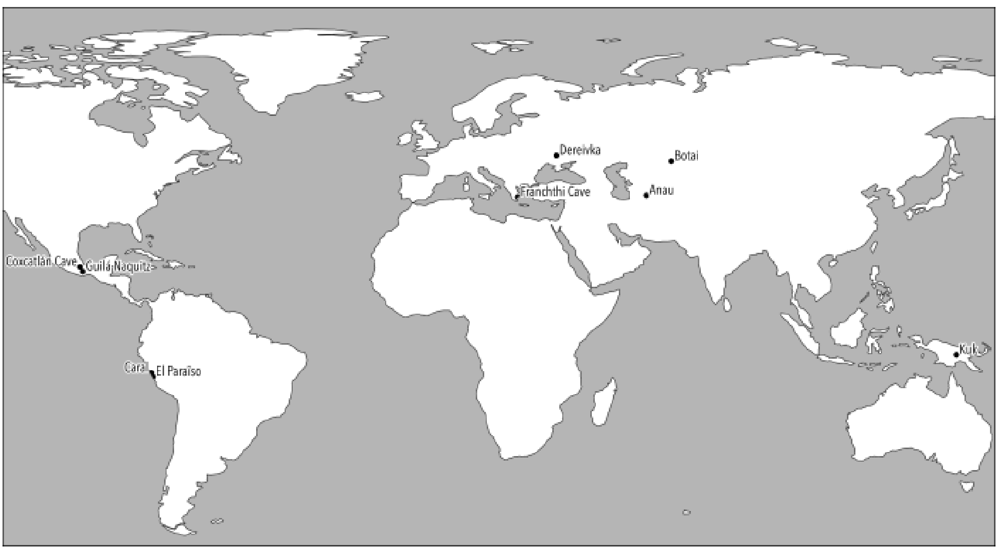

Figure 7.2 Map of major centers of early agriculture. Source: Map by David Hollander with QGIS and map files from the Ancient World Mapping Center. "ba_rivers.shp", "coastline.shp", "inlandwater.shp", "openwater.shp", and "carte_hillshade.tif". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm].

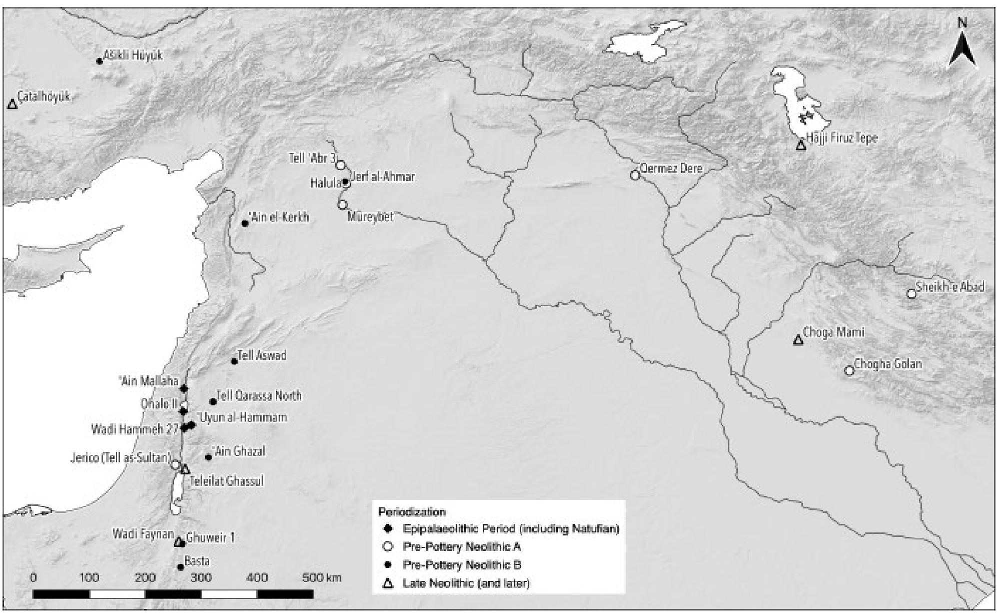

Figure 7.3 Map of sites in the Middle East. Source: Map by David Hollander with QGIS and map files from the Ancient World Mapping Center. "ba_rivers.shp", "coastline.shp", "inlandwater.shp", "openwater.shp", and "carte_hillshade.tif". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm].

Figure 7.4 V. Gordon Childe. Source: © National Portrait Gallery, London.

papers from the 1966 "Man the Hunter" conference, and the study by Lee (1968) of !Kung San people in the Kalahari Desert of southern Africa. Lee found that although the !Kung San lived in a desert, they lived well. They had a broad, reliable, and nutritious plant diet, augmented by occasional hunting. They habitually ate 29 species of fruit and berries, and 30 species of roots and bulbs. To obtain a week's food, they worked on average only two-and–a-half days. The gathering of plant foods anchored the food quest since plants are sessile and predictably distributed. !Kung San women, burdened with their small children, would return to camp after a day's foraging laden with baskets of the staple mongongo nut. It is a pattern also found across Aboriginal Australia (Meehan and Jones 1988). From experiments gathering wild einkorn (wheat) in Turkey, Harlan (1967) estimated that a nuclear family could gather enough grain in three weeks to last a year. Similarly, Beadle (1978) reckoned that a Mexican family could annually harvest a metric ton of teosinte (the wild ancestor of maize), in about the same time. Given the invariable importance of plant foods in the ancestral human diet, it is no surprise to find that plants were domesticated first rather than animals in almost every major early agricultural sequence. The evidence refuted Roth's early (1887) theory to the contrary.

Later discoveries showed that early farming is not a matter of simple technological determinism and that Pleistocene hunter-gatherers used similar kinds of gear as those later used by Neolithic farmers (White 1971). For example, edge-ground axes were in used in Australia by Pleistocene hunter-gatherers, where agriculture or livestock herding was not adopted (Jones 1975). Pleistocene hunter-gatherers (at Wadi Kubbaniya in Egypt; Hillman 1989) used mortars and pestles to process plant foods 10 000 years before farming. Pottery was also used by Late Pleistocene hunter-gatherers in Siberia, China, and Japan from 16 500 BCE (Jordan and Zvelebil 2010). Yet, the earliest farmers of the Middle East chose not to use pottery for some three thousand years, although they understood the concept and utilized fired ceramics to make small figurines (Tsuneki, Nieuwenhuyse, and Campbell 2017).

The final element of the Oasis Theory is population, and from the 1960s, attention turned to this as a possible push factor. An explanation was developed by Binford (1968a) – and a similar one by Flannery (1969) – which became known as the "marginal zone" hypothesis. It postulated that rising population in the Fertile Crescent at the end of the Pleistocene forced some people to separate from their parent communities living in optimum and well-watered environments, to settle in more arid marginal ones. Here, equipped with knowledge of plant life and an array of plant-processing tools developed in the Pleistocene, they were obliged to take up food production to supplement their food resources. External pressures were thus not limited to the environment per se, but to the demographic structure of human populations in relation to the productive environment. We are now in a position to judge this prediction quite well. It turns out that key innovations related to early sedentism and food-processing technology among Late Pleistocene hunter-gatherers emanate in the core Mediterranean zone in the better-watered and better-provisioned areas, and not in the marginal zones (Henry 2013), echoing similar findings from modern hunter-gatherers (Keeley 1988).

Cohen (1975) applied a population pressure model more generally to explain the origins of agriculture on a global basis. His idea was that by the end of the Pleistocene, people had colonized all of the habitable continents, and the world was beginning to fill up. One would indeed predict overpopulation to be a factor in the relatively tiny territories of the Levant, where thousands of archaeological site reflect an intensive record of human and hominin occupation stretching back over a million years. And yet, only two large mammals, a wild horse and a rhinoceros, became extinct in the region at the end of the Pleistocene (Tchernov 1984).

In the late 1960s, several archaeologists began to develop "systems theory" and propose "multivariate causality," following current thinking about human societies as cybernetic systems (Clarke 1968; Flannery 1969). They felt that "prime movers," or single-cause explanations, were unrealistic as causal explanations and that multiple interactive factors should affect innovations in society. Factors such as environment, population, technology, and ideology were conceived as combining in complex ways, with changes in any one of them likely to exert feedback effects on other components. Systems theory makes intuitive sense, but it is almost impossible to operationalize in prehistoric scenarios. Spratt's (1989) detailed examination of the coke-fired blast furnace serves as a useful example. The complex network of events that led to the invention of the furnace in the nineteenth century required detailed historical knowledge to reconstruct, including the specific order of events of several technological advances, knowledge of price cycles of coal and iron, accurate knowledge of labor-market statistics, and a strong understanding of social conditions and political attitudes – and this is only a single product of the Industrial Revolution. Archaeologists studying events such as the origins of agriculture 10 000 years ago have none of these data, and only coarse-grained dates with errors of decades or centuries to work with. Hodder's later (2012) exploration of "tanglegrams" to connect specific artifacts and features at the Neolithic site Çatalhöyük is an attempt to deal with this kid of complexity in a prehistoric framework.

During the 1960s too, archaeology became increasingly self-conscious about its epistemological underpinnings (Binford 1968b; Clarke 1968; Wright 1971). "New" or "processual" archaeologists such as Lewis Binford and Patty Jo Watson (1974) postulated that human behavioral trends required universal, scientific, and law-like explanations, proved deductively from evidence. Well before this agenda was taken up, however, Popper (1960) had delivered a comprehensive repudiation of the concept that human behavior can be encapsulated by absolute trends or universal law-like generalizations. The features of any one period not are not reducible to a series of laws that could predict features of a future society. For example, as Popper argued, one could not predict the state of Elizabethan England from the experience of Roman Britain (cf. Chalmers 2013).

Rindos (1980) argued that plants and people coevolved, external to human intention, in a form of symbiosis, such as the interdependence of squirrels and oak trees (propagation of acorns) or aphids and ants. The Mesoamerican evidence offers partial support for this idea, in that the maize plant is dependent on humans for its survival. However, the reverse is not true, and there exist many nutritious plants besides maize in the Americas that people exploit. Another prediction of Rindos, that plant domestication happened prior to and independently of human intervention, has been falsified by the evidence from every major region. Humans inadvertently domesticated wheat and barley in the Middle East, rice and millet in China, and maize in Mesoamerica after a long period of exploitation of the wild progenitors of these staples.

Archaeology was caught up with the post-modern turn which swept through humanities disciplines in the 1980s, and this mirrored a parallel mode of practice called "post-processual" archaeology (Hodder 1984; Bintliff 1993). The movement reacted against processual archaeology's scientism and its search for proofs, and instead urged the toleration of relativism and individual interpretation of events. It focused attention on internal, societal, and ideational factors, rather than external factors such as environment, as reasons for the agricultural transition. The remarkable hilltop sanctuary of Göbekli Tepe (Schmidt 2012), located in Southeastern Turkey and dating from 9500 BCE (Dietrich et al. 2013), has become a test case for these ideas. The site contains a number of massive, T-shaped stone pillars, engraved with complex figured and ritual scenes. Some scholars endorse the idea that Göbekli Tepe was built by cooperative groups of hunter-gatherers, before the origins of agriculture, and this indicates an ideological shift which happened in human society first, paving the way for a technological change in food-getting later (cf. Cauvin 2002).However, Göbekli Tepe's animal bones and plant remains have yet to be studied in detail, and the site dates after the advent of crop cultivation in surrounding areas (Banning 2011).

Some scholars believe that the scramble for social status in ancient societies explains the advent of farming, as powerful individuals sought to accumulate resources, then redistribute them to the community in exchange for labor obligations (Bender 1978). The model was derived from ethnohistoric examples, such as the "potlatch" feasting ceremonies of the North-West Pacific coast of America (Hayden 2009). There are a few likely examples of feasting ritual evident in early mortuary contexts in the Middle East (Goring-Morris and Horwitz 2007; Grosman, Munro and Belfer-Cohen 2008), but not many in comparison to the thousands of burials accumulated over thousands of years. And in Mesoamerica, the development of agriculture was not accompanied by the kinds of socioeconomic intensification we see in other places, and there were evidently few high-status goods produced for thousands of years after the appearance of earliest agriculture. Such models themselves are inherently ahistorical, and one might ask: why did such developments suddenly appear at the end of the Pleistocene?

In recent years, the theoretical pendulum has rebounded from a recourse to universal laws in the study of ancient agriculture to a historically contingent view of explanation, which views the origins of faming agriculture as a specific series of historical events. This view supposes that each key event only happened once because of a combination of particular circumstances. Additionally, an appreciation has developed in archaeological theory of the multiple levels at which short-term human decisions and long-term external pressures operate (Bailey 1983; Fletcher 1992). The actors play out their roles, but they are also constrained by the stage they play on. In this regard, it is worth recalling Darwin (1859 [1985]), p. 121) on competition for food resources:

> In so far as climate chiefly acts in reducing food, it brings on the most severe struggle between the individuals, whether of the same or of distinctive species, which subsist on the same kind of food.

Thus, food shortages brought on by long-term forces such as climate change or population pressure might be manifested as struggles for status or social dominance as a means of coping.

Flannery drew a parallel with the way in which paleontologists explain the evolution of mammals: not as a law of increasing fitness of mammals over dinosaurs, but as a particular historic set of circumstances which led to the extinction of the dinosaurs. Archaeological explanations should also try to investigate the uniqueness of major events in their own terms. Flannery (1986a) thinks that the endless question "Why did agriculture begin?" is as futile as asking "Why did some dinosaurs evolve into birds?" In such cases, we can never recover the general laws of such development because there are no multiple trials to compare – both are unique events that only happened once.

Further reflections on theories of the emergence of agriculture are embedded in the following section, which provides a summary of evidence from the field. In general, grand theories have diminished in potency as data have accumulated. It has become increasingly apparent that the origins of farming were not marked by a series of invariant cultural stages that all societies passed through. Rather, each region has emerged as an idiosyncratic trajectory with its own intrinsically different order of innovations and developments.

Archaeological Data

In order to judge the emergence of agriculture as a global phenomenon, it is necessary to compare the evidence from many regions and continents. This review begins with a summary of events that unfolded across the Middle East over some 15 000 years, beginning with the Late Pleistocene epoch (Ice Age). The locale was the better-watered region of South-west Asia known as the Fertile Crescent, the U-shaped upland arc stretching up the Jordan Valley along the eastern Mediterranean coast; framed to the north by the Taurus Mountains in Turkey, and to the east by the Zagros Mountains, lying between Iran and Iraq.

Around 23 000 BCE, at the height of the last Ice Age, hunter-gatherers visited the shores of Lake Tiberias (the Sea of Galilee in modern Israel) and constructed oval, brush huts at the late Upper Paleolithic site of Ohalo II (Nadel 2002). They gathered many kinds of local plants to eat, including large quantities of wild barley (*Hordeum spontaneum*). They made simple vessels and grinding tools to process the grain. A broad spectrum of lacustrine food resources and terrestrial animals were also hunted and gathered. The site occupants had evidently formed an emotional attachment to their precocious houses; given that one of their number, a man, was buried next to one of the huts. Sporadic examples of settlement intensification follow during the next 10 000 years, during the Early to Middle Epipalaeolithic periods (21 000–15 500 BCE and 15 500–12 700 BCE, Maher, Banning, and Chazan 2011) but there is no significant subsistence evidence from such sites to illuminate trends in food procurement. An important innovation in the residential tethering of human communities appeared between 15 300 and 14 400 BCE, at the Middle Epipalaeolithic site of 'Uyun al-Hammam in Wadi Ziqlab, (Jordan), an easterly tributary of the Jordan Valley (Maher et al. 2011). It takes the form of a burying ground, not associated with a specific settlement or landmark, consisting of 11 adult burials embellished with various grave goods, including a fox-human burial. Movements of bone elements from grave to grave were made, implying maintenance of the site over the long term, and the development of strong social ties to a home base. Though not specifically attesting food procurement as such, this site represents a key development, since the advent of sedentary living is an aspect correlated with the emergence of agriculture in the Middle East.

Figure 7.5 Mortars and pestles from the Natufian site of Wadi Hammeh 27. Source: Photo by Phillip C. Edwards.

The subsequent Natufian culture, (12 700–10 300 BCE) forms a critical juncture in the human story. It can be considered as the transition to our modern way of living, paving the way for settled life in villages (Bar-Yosef and Valla 1991, 2013; Valla 1998). It remains enigmatic due to its transitional nature, and because it has few, if any, ethnographic analogues. The Natufian represents a culmination of the ancestral ways of hunting and gathering but also foreshadows elements of the first farming villages. Significant subsistence and settlement intensification occurred in the Natufian period in the Levant, with the appearance of small villages and stone huts (around 12 500 BCE). Previous sites are short-lived and feature a small number of brush huts. Natufian sites are larger and contain many stone huts, rebuilt on the same spot over hundreds or even over thousands of years. Notable exemplars of the open-air settlements are Wadi Hammeh 27 in Jordan (Edwards 2013) and ‘Ain Mallaha in Israel (Perrot 1960; Valla 1998). Natufian hamlets were also founded on burial grounds, like those that previously existed at ‘Uyun al-Hammam, a physical linkage which consolidated a community's attachment to its home locale.

Natufian hunter-gatherer settlements are associated with a range of new artifact types, including a repertoire of figurative and geometric motifs carved in bone and stone. Most pertinent to the process of food gathering and processing are large numbers of bone sickles armed with trimmed flint blades, and a massive rise in the numbers of mortars, pestles, and grindstones (Figure 7.5). Remains of carbonized plant foods have proved elusive, but rare examples include edible grains and nuts such as wild barley, lentils, chickpeas, and almonds, and a range of other small-seeded plants such as Chenopodium. Overall, the combined evidence of charred plant fragments and phytoliths currently favors a collecting strategy based on a number of small-seeded plants, but not necessarily a focus on cereals (Rosen 2013). Natufian hunters procured a remarkable range of animal prey, from large wild cattle to crabs and tortoise, but gazelle was their favorite target (Munro 2004; Edwards and Martin 2013). The Natufian period does witness the arrival of the region's first domesticate, in the form of the dog, although the animal was domesticated as a companion rather than as a food source (Davis and Valla 1978).

Drill-core data from deep sequences of ice have given us an accurate picture of Late Pleistocene–early Holocene climate and raised new issues for the period.

It is now clear that the Early Natufian occupied the best climatic conditions in the Middle East to have occurred over the past 20 000 years. This sophisticated hunting and gathering culture arrived at its semi-sedentary adaptation not under conditions of environmental stress, but in times of relative plenty. During the later Natufian period, an intensely cold and arid period called the Younger Dryas, saw the rapid return of the northern Eurasian ice sheets between 11 500–9700 Cal BCE (Alley et al. 1993; Taylor et al. 1993). Some of the large Natufian sites like Wadi Hammeh 27 were abandoned, but others, like 'Ain Mallaha, located in optimum conditions near lakes and swamps in the Jordan Valley, continued on. The Younger Dryas caused colder, dryer conditions in the Middle East, but its regional impact is unclear. Vegetation modeling indicates that a reconfiguration of vegetation zones did occur, but that this was not extreme (Soto-Berelov et al. 2015). Measurement of carbon isotopes in the teeth of gazelle found in Natufian sites indicates that the Younger Dryas was a cool period in the Levant, which may have disrupted the growing season of edible plants such as cereals, but that it was not necessarily a particularly arid interval (Hartman et al. 2016). Critically, the ice-core data indicate that the stable seasonality typical of the modern Mediterranean climate had not been established during the Late Pleistocene. Instead, warm or cold phases occurred as irregular oscillations of variable extent; there was little regularity to climate during the Early Natufian period (Alley et al. 1993). The absence of rhythmic seasonality during the Late Pleistocene may have prevented a crossing of the threshold to farming (Richerson, Boyd, and Bettinger 2001).

In any case, the modern climatic reconstructions rule out the environmental basis for the Oasis Theory. Its vision of an isolated point source of water at Jericho also misrepresents the topography of the Jordan Valley. The image it conjures, of a waterhole fringed by data palms and surrounded by tractless wastes, is false (not that early agriculture began or prospered in those sorts of environments anyway). Notably, the Jordan River meandered its way through the middle of the valley and was bordered by a dense riparian flora, home to a diverse fauna including wild pig. It was not a matter of an isolated point source of water; rather, it was a ribbon of freshwater connecting the Jordan Valley to the large freshwater Lake Tiberias to the north (Sea of Galilee); the marshlands of Lake Huleh lay to the north of that. Peripheral to the valley, sufficient if sporadic rainfall supported patches of steppe and Mediterranean plant communities, including a range of small-seeded plants. In these habitats, medium-sized and small mammals lived, including herds of gazelle, which rarely need to drink. Wild animals would not, in any case, venture to drink in an oasis inhabited by humans.

The end of the Younger Dryas episode at 9700 BCE brought the onset of regular Mediterranean climate to the Levant, characterized by long dry seasons and cool, moist winters. Coincident with the arrival of modern climate, the first food-producing communities of the "Pre-Pottery Neolithic A" (PPNA) period (10 000–8700 B.C.) now appeared across the Levant, housed in the first sedentary villages (Kuijt and Goring-Morris 2002). The phase was first identified in the 1950s at Jericho (Tell as-Sultan) in the southern Jordan Valley (Figure 7.6). Other key sites in this phase, which spans the length and breadth of the Levant, include Mureybet (Ibanez and Cauvin 2008) and Jerf al-Ahmar on the banks of the Euphrates River in north Syria, and GöbekliTepe on the southern flanks of the Taurus Mountains in Southeastern Turkey. Still operating as hunters, and predominantly as plant gatherers, these people developed a crucial addition to the food basket, known as "pre-domestication cultivation." The term refers to the deliberate planting, tending, and harvesting of wild cereals such as barley, emmer wheat, and einkorn wheat.

PPNA settlements were bigger and more complex than the Natufian hamlets, attaining 4 hectares in area. Individually, the round or oval dwellings were no bigger than before and often small and cramped, but were finished with complete perimeter walls, built of coursed

Figure 7.6 PPNA tower at Jericho. Source: Photo by Phillip C. Edwards.

stones or mudbricks, and equipped with entrance stairs and central hearth features. A striking development in this period was the appearance of monumental building projects. At Jericho (Tell es-Sultan) in the south, they included an impressive round stone tower, reaching 8 meters high, and fitted with an internal staircase of dressed stone slabs (Kenyon and Holland 1981). There was also a section of monumental stone walling bordering the western extent of the settlement and a number of large mudbrick rooms or tanks built inside the wall. At Jerf al-Ahmar in north Syria, a succession of sunken "communal buildings," some equipped with hexagonal arrays of stone benches decorated with figured scenes, were built through several phases of the village (Stordeur 2015). Near the end of the PPNA period, monumental building projects reached their apogee at the hillside settlement of GöbekliTepe, located in southern Turkey. This 7.5 hectare complex features massive T-shaped pillars adorned with a complex array of geometric symbols and figured scenes (Schmidt 2012).In recent years, new fieldwork projects have extended the range of PPNA and equivalent sites around the hilly flanks and pans of the Fertile Crescent to the north and east, with the excavations of Qermez Dere in Iraq (Watkins, Baird, and Betts 1988) and Chogha Golan and Sheikh-e Abad in Iran (Matthews, Matthews, and Mohammadifar 2013; Riehl, Zeidi, and Conard 2013).

The first farmers of the PPNA period were "low-level food producers" (Smith 2001) who engaged in limited "pre-domestication cultivation" of wild cereals to augment their gathered food stocks. Within a long register of gathered wild plants, several PPNA sites begin to show higher proportions of wild barley, and wild wheats called emmer and einkorn, along with a number of other cultivars (Kislev 1989; Willcox and Stordeur 2012). The evidence of cultivation in these cases includes the finds of suites of companion plants which occur as weeds of cultivation in disturbed garden plots, in higher than normal proportions, and larger-seeded varieties. But the plants concerned were not distinguishable in terms of their appearance from wild types. What are regarded as the first morphologically domesticated cereals are in fact recessive genetic variants that occur naturally (at a low rate of about one in a million in wild plants) in stands of wild cereals. The key distinction is that the rachis or the "neck" of the stalk that held the seed-head is "non-shattering" rather than "brittle." This inhibits natural propagation because the seeds do not come to ground to germinate, and so wither on the plant or are consumed by predators.

Under a regime of sickle harvesting, the reaper collects the non-shattering as well as the brittle types, and then replants them, enabling the "domesticated" brittle type to grow in prominence. Hillman and Davies (1990) estimated that, if the seed were planted in virgin fields, the domestic type might rapidly rise to 90% of plants over 20–200 generations (i.e. 20–200 years). Experimental cultivation efforts have not yet verified Hillman and Davies' model (Willcox 1999), and it remains the case that domesticated cereals took millennia to appear after the initial cultivation of their wild predecessors (Arranz-Otaeguia et al. 2016). Initially, the reaper could not have identified the domesticated types, since they were indistinguishable in a ripening field. Consequently, there was no prior discovery of domesticated types. The rise of domesticated cereals was an unintended side effect of an intensified regime of wild crop harvesting, and most importantly an expansion of the fields under cultivation, in order to feed rising village populations in the early PPNA. Once the new non-shattering types were abundant, however, they would have been apparent, and farmers at that point probably started to select preferred varieties, such as those with big grains or a palatable taste, and carefully propagate them and even trade them around the Neolithic world. We see a slow and steady appearance, over the course of a millennium, of a range of different cereal types in the various regions of the Levant (Willcox 2013). Originally, eight "founder crops" in the Levant were considered to have been taken under cultivation by the earliest farmers. As well as the cereals (barley, emmer, and einkorn) they comprised lentil, pea, chick-pea, bitter vetch, and flax (Zohary 1996). Now, however, more early cultivars are recognized across the Middle East according to their availability and the decisions of the societies who took them under control (Fuller, Willcox, and Allaby 2011). They comprise two-grained einkorn, durum wheat, rye, oats, rambling vetch, broad bean, grass pea, wild lentil, and the common fig.

The initial changes in livestock were also probably unapparent to the first herders and not intentionally selected. The earliest husbanded sheep and goats grew somewhat smaller than their wild forebears (Davis 2012) and not larger, as might be expected if they were bred for meat. The ways that herders directed the animals' foraging, controlled their mating patterns, and maintained large groups of animals on territories where they had been less numerous had the unintended consequences of increasing birthing rate and physiological stress on females, and decreasing the size of progeny *in utero* (Tchernov and Horwitz 1991). Wild rams and billy goats use their natural headgear in dominance duels associated with mating access to females. The change in male horn shape from sharp scimitars to smaller, straighter horns with more gently rounded sections may also be attributed to the relaxation of selective pressure on horn morphology, given the artificial herds controlled by humans. These realizations show that early farming was not so much a matter of invention but a consequence of the new ways by which humans were interacting with their environment.

Consequently, theorists turned to the likely pressures that induced Late Pleistocene communities to give up the hunting and gathering mode of existence – which had, after all served humanity well in colonizing the globe. The foraging existence was in many ways more attractive than village life, which came burdened with the detriments of dietary restriction, overcrowding, the running down of environment, the perennial struggle against pestilence and drought, the appearance of new infectious diseases, an increase in social inequality, and the

Figure 7.7 PPNB houses at Basta. Source: Photo by Phillip C. Edwards.

drudgery of manual agricultural labor (Cohen 2007). These considerations supported a growing consensus that people must have been pushed into the farming way of life rather than embracing it with open arms.

The subsequent Pre-Pottery Neolithic B (PPNB) period (8700–8000 BCE) witnessed the consolidation of village farming across the Levant. In this period, the farming village was transformed into a much larger entity, with the biggest examples attaining over 15 hectares in area. The farming process was fueled by the appearance of a number of morphologically domesticated cereals and legumes, and the addition of livestock herding to the long-established practice of plant cultivation. Goat and sheep were introduced in the northern Levant at 8400 BCE, followed by cattle and pigs (Conolly et al. 2011; Helmer and Gourichon 2017; Zeder and Hesse 2000). The artifactual and architectural innovations of PPNB material culture emerged in the preceding PPNA phase in the north Syrian (Euphrates River) region, in sites such as Mureybet, and Tell ʻAbr3. Thereafter these innovations spread southward in Syria to sites such as ʻAin el-Kerkh, Halula, Tell Qarassa North, and Tell Aswad, westward across the sea to Kissonerga-*Mylouthkia*and Parekklisha-*Shillourokambos*in Cyprus; and thereafter to the southern Levant during the Middle and Late PPNB phases. Notable sites in the south excavated more recently than Jericho include Motza and Yiftahel (Edwards 2016).

PPNB settlements featured orderly arrays of rectangular, multi-roomed houses built of mudbrick or stone. From a distance they would not have looked very different from a traditional Middle Eastern village. In Jordan, broad-scale excavations of several large sites have recently revealed the extent and architectural sophistication of these settlements (Simmons 2007), particularly the chain of villages that spread down the highlands east of the Wadi Arabah during the Late PPNB. Deep deposits at Basta (Figure 7.7), located near Petra in the south of the country, have preserved vestiges of double-storied stone houses. Perhaps to reduce the access of vermin to the interiors, Basta's houses are built with step-through windows, rather than doors (Gebel, Nissen, and Zeid 2006). Baja, located nearby, has a multitude of agglomerated rectilinear houses. Further north, near the Wadi Arabah, Ghuweir 1 is a large site furnished with an open space or "plaza" with a broad staircase leading from it. Most remarkably, long ducts are built into the walls of some of the houses, apparently as a temperature control measure. The earliest phases of 'Ain Ghazal (in the Middle PPNB) located in the suburbs of modern Amman featured large, square houses with plastered walls and floors, often painted red. Long, stepped alleyways permitted access between the residences. The widespread production of burnt lime plaster during the PPNB, a precursor to modern cement, was a key pyrotechnological innovation.

During the PPNB, we see evidence for more intensified economic contacts and amplified levels of exchange and trade, marked by increased quantities of Turkish obsidian dispersed along both arms of the Fertile Crescent (Chataigner, Poidevin, and Arnaud 1998). Small ceramic tokens formed into geometric shapes such as spheres and pyramids also appear and have a more or less overlapping distribution with the obsidian (Schmandt-Besserat 1992; Michalowski 1993). These objects may have functioned as counters for tracking trade items. New ritual beliefs become widely established, manifest in repertoires of human figurines, imposing shrines, and cults emphasizing decorated human skulls, with facial features modeled in plaster and eyes inlaid with seashells (Bonogofsky 2005).These remarkable memorials to dead kinfolk were first unearthed at Jericho; subsequently, several instances were excavated from other PPNB villages, including a spectacular cache at Tell Aswad in southern Syria.

The PPNB village system, wound down and disappeared after 8000 BCE. Some evidence suggests that the way of life was a victim of its own success, with the first signs of destruction of local habitat occurring through the pressure of agricultural development. Village life involved settling down in one spot for centuries or millennia. Security was gained by this new strategy, but it was also fraught with issues of sustainability. Quitting territories, like previous hunter-gatherers, to allow them to fallow and recover was no longer an option, once the Levant was dotted with numerous villages which controlled their own limited territories. Perennial sedentism may have brought difficult consequences for the early farmers which regularly resulted in both short-term and long-term failures; the former through drought and pestilence, and the latter through soil fertility decline and habitat destruction.

'Ain Ghazal, located in modern Amman, Jordan, offers the best insight into these possibilities. The site lies on the present limit of dry farming (around 250 mm of rainfall per year) on the steppe/desert ecotone, a boundary which is sensitive to variations in precipitation, and which migrates respectively west under drier conditions and east under wetter regimes. 'Ain Ghazal is situated in a classic "brittle environment," sensitive to destabilization. Habitation at 'Ain Ghazal began around 8700 Cal BCE. Following its foundation as a 1–2 hectare settlement, the settlement underwent periodic expansion. By the end of Middle PPNB Phase 4, it had reached 4–5 hectares, and it grew to 10 hectares during the Late PPNB. By the next period, the "PPNC," the site had attained an area of c. 12–13 hectares, sprawling north over the Wadi Zarqa. The earliest phase contains large, single-roomed structures up to 5 × 5 meters in area, with plastered floors and large posts, 50–60 centimeters as roof supports. But these decline to 15–20 centimeters in structures dated 7500 BCE. Room sizes shrink further to c. 2 × 2 meters in the LPPNB and PPNC, and during these phases the use of timber in building is scaled down, to be replaced by interior stone wall segments, culminating in the characteristic, convoluted "corridor buildings."

Large numbers of trees were consumed, not only to provide the posts, but also to burn lime plaster. Each house plastering required an average of 13.2 metric tons of wood for fuel. Under such heavy demands, it appears that the settlement's environs became logged out. By the Pottery Neolithic (Yarmukian) period, the use of kiln-fired plaster had been abandoned, with the builders resorting to a simple cold-puddled mixture of chalk and mud. High quantities of oak charcoal in the early layers give way to poplar and tamarisk in the later ones, and the size and density of wood charcoal fragments in the sediments decrease through time. The oak-pistachio forest would normally revive itself, but goats provided the "knockout" environmental punch. Initially, 'Ain Ghazal hunters took over 50 species of animals, but the diversity diminishes by the LPPNB, coinciding with a noticeable increase in the numbers of goats and sheep, which jump from 51.0% to 70.8%. The researchers (Rollefson, Simmons, and Kafafi 1992; Köhler-Rollefson 1988) see a nexus between the rising numbers of goats and their feed requirements, the disappearance of wild animals, and the inability of the woodland to regenerate itself. Unprecedented grazing pressure by goats short-circuited the normal processes of regeneration. According to this model, early villagers may have contributed to their own demise by unwittingly setting off severe environmental problems.

It is difficult to gauge the regional applicability of the 'Ain Ghazal case since no other PPNB site has yielded such long-term data. Alternatively, life at PPNB sites such as 'Ain Ghazal may have been abandoned because of a climatic downturn known as the "8.2 kiloyear event." It is recorded in Greenland ice cores as a relatively brief but dramatic cool and arid event around 8200 BP (7300–7000 BCE). Not all settlements were disrupted, however, and contemporary Tell Sabi Abyad in north Syria managed to continue by making some adjustments (van der Plicht et al. 2011). At this time, a series of large lakes and fertile grasslands in the Sahara and Arabian Peninsula also disappeared, to be replaced gradually by modern deserts.

As archaeological fieldwork expanded from the 1960s, it seemed for a time that other regions of the world might catch up to the Middle East, to reveal a pan-global agricultural transition around 10 000 BCE (at the Pleistocene–Holocene boundary). That scenario would have reinforced the belief in universal explanations, and pointed to climate change as a key factor. However, this outcome has not eventuated, with some regions undergoing significant chronological extensions and reverses. This situation has come about for several reasons: the natural accumulation of data, new regionally based investigations that have probed multiple sites in new research areas, and many technical advances which have provided archaeology with more powerful tools. At a basic level, digging technique has rapidly improved in the past half-century, leading to more reliable and comparable datasets. Professionally run excavations nowadays are routinely committed to fine-scale digging (both vertically and horizontally); dry- and wet-sieving to recover small items; flotation of sediments to recover fragile, carbonized plant remains (Hole, Flannery, and Neely 1969, p. 385); and micromorphological analyses of sediments. Before 1960, these things were hardly ever done.

The widespread application of accelerator mass spectrometry (AMS) radiocarbon dating from the early 1980s (Taylor 1995) revolutionized the field. This technique enabled tiny particles such as fragmentary burnt seeds to be dated, whereas conventional radiocarbon dating methods required large samples of 100 grams, which are rarely obtainable. The adoption of further scientific techniques has supplied us with more lines of evidence, and these have led to more nuanced judgments. They include pollen core analysis to delineate the profiling of ancient vegetation provinces and their clearance by farmers (Bryant and Holloway 1983); improved techniques to identify the soft (parenchymous) tissue of carbonized roots and tubers (Hather 1994); analysis of phytoliths or the tiny silica particles found in grasses (Piperno 2006); the identification of starch granules (Torrence, Wright, and Conway 2004); genetic analyses (Zeder 2006); "proteomics" or the chemical characterization of food residues (Evershed 2008); isotopic analyses of human diet (Buikstra and Milner 1991); and isotopic tracking of the geographical origins of humans and livestock (Price, Wahl, and Bentley 2006).

In the Americas, a broad range of large animals became extinct at the end of the Pleistocene: mammoth, horse, giant turtle, giant rabbit (the so-called megafaunal extinction) by 10 000 BCE. This change left few animals to exploit, much less consider for domestication. Subsequently, early farming communities in Mexico lacked many suitable animals to domesticate; the turkey and the Xoloitzcuintli, or Mexican hairless dog, were the only options (Flannery and Marcus 2005). Unlike other regions, no hoofed mammals were available for meat, wool, traction, or transport. On the other hand, Mesoamerica offered a wide range of important vegetal resources. Maize, beans, squashes, gourds, chili peppers and capsicums, avocadoes, amaranths, and chocolate are some of the Mexican food plants that have conquered the world.

The disappearance of the megafauna implies a human hand in extinction through overpopulation, which would explain moves to food production, but human presence in the Americas is scant, and the human influence in the extinctions remains unclear. The rock-shelter site of Guilá Naquitz in Mexico at 8700 BCE is the earliest agricultural site in the Americas, and one of only a few that has yielded evidence for food production, not only for that time but also for many succeeding millennia (Flannery 1986b). Before Guilá Naquitz there are less than a handful of clearly attested archaeological sites for the entirety of two large continents. Santa Isabela Iztapan in Mexico is one such; a mammoth kill site, dated 11 000 BCE, where large projectile points were used to kill the animal (de Anda and Maldonado-Koerdell 1953), but there are few such sites in Mesoamerica. More curiously, the first plant domestication is not accompanied in Mesoamerica by the sorts of socioeconomic intensification we see in other places such as the Middle East and China. There are no villages or obvious signs of aggregated human residence. The first simple huts, and indeed pottery traditions appear as long as 6,000 years after the first domesticated plants, and thus the question arises: where was everybody, if population pressure was the cause?

The Middle East and Europe have yielded hundreds of key sites, whereas the history of research in early Mesoamerica is mainly due to two fieldwork programs. The first project was undertaken in the Tehuacán Valley during the 1960s by R. Scott MacNeish, and a second one was carried out in the Oaxaca Valley by Kent Flannery. In Coxcatlán Cave, MacNeish (1981) found a sequence of domesticated maize (or corn) cobs dating from 5000 BCE. The earliest cobs were accompanied by domesticated avocado, beans, squash, peppers, and gourds. The cobs showed a gradual but significant increase in the size of the cob through time. The initial dating was done on charcoal fragments lying close to the cobs, by conventional radiocarbon dating, not on the edible cobs themselves. At Guilá Naquitz Cave in the Oaxaca Valley, a span of 3000 years (from 8700–5800 BCE) was represented in a sediment column a little over a meter thick. This pattern suggests brief, discontinuous habitation over a long period. The earliest phase (ca. 8700–7800 BCE) yielded squash (*Cucurbita pepo*) seeds and gourd (*Lagenaria siceraria*) rinds. According to Flannery's team, they were both cultivated species. Domesticated animals, pottery, houses, and village life did not appear in both sequences until several thousand years later.

By the mid-1990s, the first American farmers seemed to be getting younger (Fritz 1994). Direct AMS dating of MacNeish's maize cob fragments revised their dating from 5000 BCE to 3000 BCE. Subsequently, however, the trend was reversed when Smith (2005) undertook a comprehensive dating program on the putative early cultivars from the Tehuacán and Oaxaca Valleys. The earliest cultivars were found to be squash (8025 BCE), then gourds (7097 BCE), and finally maize, at 4280 BCE. Maize is unusual among early domesticates because it is viable only with human intervention. The plant's ancestry was controversial for 50 years before genetic analyses proved that it is the descendant of a variety of wild grass known as "teosinte" (*Zea mays parviglumis*), located in the Balsas Valley in Western Mexico (Smith 1995). The large seed-laden cobs of the modern plant look nothing like the wild predecessor, and they cannot disarticulate and propagate naturally. This characteristic has been used more recently to claim that maize is considerably older than the 4300 BCE date indicated by AMS dating of maize fragments. The reasoning is that since maize can only exist as an anthropogenic crop, any traces of maize must be domesticated ones. Piperno and colleagues (2009) have determined that maize phytoliths and starch particles occur on ancient grinding stones from Xihuatoxtla in the Balsas Valley, dated 6750 BCE. Therefore, she argues that domesticated maize existed at this date.

These findings are also pertinent to the idea of universal explanations. Carl O. Sauer (1952), an American geographer of the mid-twentieth century, reasoned that food production ought to have developed first in tropical areas and have been based on tropical fruits, vegetables, and tubers, rather than seed-based crops. The former are productive, nutritious, and ready to eat. Seeds, on the other hand, are small, scattered, take significant effort to reap and process, and must be eaten in concert with other plants to form a balanced diet. As the evidence stands, Mesoamerica provides a likely example of Sauer's thesis. Better still as an exemplar is Melanesia, where a separate, indigenous center of agriculture was discovered at Kuk in the highland Wahgi Valley of Papua New Guinea.

Unlike more conventional early farming sites, Kuk is composed almost entirely of human marks upon the landscape. It comprises six superimposed networks of drainage ditches and garden features (the earliest, Phase 1, dating to 8000 BCE; the latest, Phase 6, to 1900 AD), brought to light by Golson's (1980) extensive excavations in the 1970s. Phase 1, dated 8000 BCE, included a ditch traversing the excavated area, passing by a concave basin and associated stake-holes. Golson interpreted the ditch as constructed for draining excess water for cultivation, and the basin and stakes as a possible pig wallow. The ditch features are disputed and the wallow now refuted, but Phase 1 did reveal traces of the edible plants yam, taro, and banana (Golson et al. 2017). More plausible evidence for banana cultivation appears in Kuk Phase 2 between 5000 and 2000 BCE. Denham believes that banana production began in the Papua New Guinea highlands and spread westward through Southeast Asia. The Kuk archaeological sequence can be compared to palynological and geomorphological evidence for vegetational and landscape change across the Papua New Guinea highlands during the Holocene. The date indicate that forest clearance became pronounced after 5000 BCE, equivalent to the time of Kuk Phase 2 (Denham, Haberle, and Lenfer 2004). These changes correspond to a disruption of the local forest ecosystem and mark the point of major clearance for farming. Papua New Guinea's earliest food crops were roots and fruits as Sauer predicted, whereas cereals are indicated as the earliest domesticates in the Middle East and in China (in the form of rice and millet), and so Sauer's idea does not find universal application.

In the Americas, a second independent locus of food production occurred in the Andean mountains and adjacent coastal plain of Peru. It also yielded a distinctive suite of plant and animal resources, and bequeathed two global favorites in the potato and the tomato. In the 1970s, Peruvian urbanism and agriculture were thought to have followed a contrary development trajectory to the rest of the world. Monumental coastal temples such as El Paraïso (1800–1500 BCE) seemed to precede farming and agricultural surpluses. Michael Moseley (1975) developed the "Maritime Foundations of Andean Culture" model of Peruvian Civilization for sites like this one, oddly disembedded from a town or village setting. Moseley argued that native cotton was used to make nets and gourds used as floats, which enabled coastal fishermen to accumulate large surpluses from the most abundant coastal fisheries in the world (schools of anchovies). This resource then provided the means for small groups to congregate seasonally to erect large ritual buildings. Quilter and colleagues' (1991) later excavations at El Paraïso indicated that indeed 90% of protein was derived from fish, and that cotton and gourds were important crops; fragments of cotton fishing nets were even found.

Yet the excavations also yielded many cultivated food plants: squash (*Cucurbita ficifolia, C. maxima, and C. moschata*), chili pepper (*Capsicum sp.*), and common and lima beans (*Phaseolus vulgaris and P. lunatus*). Since that time, even earlier monument building has been discovered on the northern Peruvian coast, counting as some of the earliest in the world, and always accompanied by agriculture.

Caral in the Supe River Valley consists of a cluster of mounds and pyramids, some dating to 2600 BCE – as old as the Great Pyramid in Egypt. At Caral, protein was also derived from fish, and the site produced large amounts of cotton and gourds. Cultivated food plants included beans, squash, sweet potato, and imported maize (Shady, Haas, and Creamer 2001). Even earlier monumental architecture occurs at Aspero (3000–2500 BCE), which covers 13.2 hectares and has six truncated pyramids overlooking 17 mounds. Aspero has also yielded cultivated foods, including maize (Haas et al. 2013).These sites are all aceramic and precede metallurgy. The origins of ritual architecture in coastal Peru go back to 6000 BCE. In the Ñanchoc Valley, paired mounds, up to 25 meters long, contained ritual items and were associated with facilities for lime production which is used to process coca leaves (Dillehay et al. 2010). Excavations by Dillehay and colleagues (2007) have demonstrated the cultivation of squash (7200 BCE), peanut (5800 BCE), quinoa (a panicle, or clustered, seed grass native to the Andes) by 6000 BCE and cotton by 3400 BCE. Adjacent to the site were located plots for planting, and small-scale canals for irrigation, dating to 5500 BCE. By comparison, the village of Choga Mami on the northern plains of Iraq instituted irrigation by 5900 BCE, building a series of large-scale canals that brought water to barren areas (Oates 1968).This technology paved the way for urban-scale economies in ancient Sumer, further south (see Chapter 8, this volume).

In recent decades, China has emerged as a major counterweight to the Middle East, in terms of early agricultural studies. China shares many of the latter's developmental characteristics, albeit as a tradition founded in a separate region and on an entirely different set of food resources (see Chapter 29, this volume). Both sequences boast a huge number of early agricultural sites, ranging from transitory open-air sites, through to hamlets and developed villages. In both regions, a long period of cultivation of wild cereals (rice and millets in China) preceded the appearance of domesticated plants and animals. The early appearance of ceramics in Late Pleistocene China and adjacent regions is a notable difference, and may be attributed to the longstanding East Asian tradition of boiling or steaming soft grains. The Chinese developments occur relatively later than in the Middle East. For many years, debate raged over whether the earliest hearth of rice domestication was in the Ganges Valley in India, in Southeast Asia, or in south China. A torrent of new data has settled the question decisively in favor of the Yangzi River basin. While the discovery of Neolithic life in China hails only from 1921 (Andersson 1934), a powerful recent momentum has seen the region emerge as the most important contemporary arena for research into the origins of agriculture.

A key theme for Childe was the creation of European identity in antiquity, and the agricultural legacy that the continent owed to the Middle East. Almost instantaneously, in geological terms, the earliest PPNA and PPNB accomplishments of the Levant were transferred by boat to Cyprus, the Mediterranean's easternmost territory. Thence, they traveled along the southern Mediterranean coast of Europe, arriving in Sicily, Italy, France, and Spain as variants of the Cardial culture by 6000 BCE. Another entry route was via Crete and the Aegean islands into the Greek Peninsula, as evident at Franchthi Cave by 6500 BCE (Colledge and Conolly 2007; Perlès, Quiles, and Valladas 2013), and open-air village sites such as Argissa and Nea Nikomedeia by 6400 BCE. Farming also arrived at the shores of the Bosphorus overland from the Anatolian plateau (Özdoğan 2011) commencing with the village of Ašikli Hüyük at 8200 BCE. In later centuries (7500 BCE), the massive, mounded mudbrick tell of Çatalhöyük emerged on the Konya Plain in southwest Turkey (Balter 2005; Hodder 2006).

For many decades, contrary models were maintained to explain the introduction of farming to Europe. Some scholars argued for an autochthonous, independent European development. After all, Europe offered suitable resources such as native species of barley and lentils, and animals such as wild goats and pigs, and indeed these were found in Mesolithic hunter-gatherer sites. There was also suggestive evidence in Upper Paleolithic cave paintings of people exerting control over horses. It has since transpired that farming was diffused from the Middle East to Europe. The earlier Mesolithic levels at Franchthi Cave (11 000–6500 BCE) contained many wild local plants: lentils, and barley – and also pig. However, the superimposed Neolithic levels showed the presence of domesticated Middle Eastern types of lentils, barley, and wild goats. Recent advances in the study of ancient DNA indicate that farming was brought to Europe by immigrants, with Scandinavian Neolithic farmers showing more genetic similarity to southern European Neolithic farmers than to Scandinavian hunter-gatherers (Skoglund et al. 2012).

The earliest famers were quite restricted in their repertoire. Initially, they were hunter-gatherers who practiced small-scale cultivation. Subsequently, they added livestock herding in order to secure meat supplies. Thereafter, a wide range of value-added products came to be exploited. Attention was turning from the dead beast to the potential products of the living animal. Livestock animals could be exploited for wool and dairy products, and for transport and traction. In turn, the latter activities generated the invention of carts, wagons, and plowshares. The phenomenon was termed by Sherratt (1981) as the Secondary Products Revolution. Originally it was thought to have appeared with the first civilizations (c. 3000–3500 BCE), as a consequence of the needs of the city dweller. Civilization drove new levels of trade. Seagoing ships were undoubtedly the most cost-effective way of carrying cargoes in the ancient Middle East, but opportunities for employing them were limited. For overland routes, the humble donkey was a significant innovation as the first pack animal, domesticated at Omari by 4500 BCE (Marshall 2007). It counts as Egypt's highly significant contribution to the suite of Middle Eastern domesticated animals. The animal was an essential adjunct for overland trade with Sinai and the southern Levant, carrying commodities such as copper ore, wine, and olives. Domestication of the camel by faunal evidence is difficult to adduce. Contextual evidence at Shahr-e-Sukhte, an early Iranian city dating from 3000– to 2500 BCE, included camel hair, dung, and a figurine. The organic remains were similar to the modern dromedary (Compagnoni and Tosi 1978). On the southern side of the Gulf, domestic camels are attested in the United Arab Emirates around the same time (Potts 1993).

The horse was domesticated around 3600 BCE on the grassy steppes of Central Asia. Horse riding changed the nature of warfare and ultimately the course of world history. It conferred on nomadic societies a decisive edge in combat and revolutionized military tactics. The domestication of the horse has been difficult to identify through change in bone size and shape, or estimates of age at death. The riding of a few tamed horses to hunt and herd wild horses, and control of horses with fitted bits and bridles, probably occurred at Dereivka in the Ukraine between 4600 and 4000 BCE (Levine 1990). Significant levels of "bit wear" appear on horse teeth at Botai, Kazakhstan (3600–3100 BCE). The bit slides onto the edges of teeth and wears them down, and demonstrates horse riding (Levine 1999).

Advances in archaeological science have shown that some of the innovations associated with the Secondary Products Revolution occurred earlier than initially thought. The chemical characterization of organic residues on Neolithic pottery has revealed that dairying dates to the seventh millennium BCE in Turkey. Similarly, pot residues from the Neolithic site of Hajji Firuz Tepe in Iran demonstrate the production of resinated wine at 5400–5000 BCE (McGovern et al. 1996). The introduction of grapes and olives signal the commencement of orcharding, a capital-intensive mode of agriculture. Tree farming requires sizable tracts of land, intensive labor, and delayed returns, since the crops often take several years to begin producing. Olives were the most important orchard crops of the period. Several lines of evidence indicate the adoption of the olive in the southern Levant by 3500 BCE: increases in *Olea* pollen, higher olive-wood charcoal frequencies, and new types of ceramics designed to utilize olive oil, such as pinched-rim lamps. Olive domestication has its beginnings, even earlier (c. 4500 BCE) at Teleilat Ghassul in the southern Jordan Valley. From the same Ghassulian culture, chemical analyses have revealed the existence of beeswax in ritual ceramics known as "cornet cups" (Namdar et al. 2009). Not only was the advent of beekeeping an important broadening of resource exploitation, but it also played a role in early metallurgy. Ghassulian metallurgy was the most sophisticated in the entire Middle East at this time, ushering in the "Chalcolithic" (i.e. copper stone) stage from 4900 to 3500 BCE, fueled by the natural abundance of copper at Wadi Faynan in south Jordan. Ghassulian copper working included the production of complex ritual paraphernalia and the earliest examples of lost-wax casting, with the wax produced by bees.

Conclusions

The globalized food resources that characterize the modern world are mainly of recent origin and a far cry from the world of the first farmers. By the Late Neolithic and Bronze Age periods, agricultural products were flowing both ways across Central Asia along the precursor to the Silk Road. Wheat, sheep, cattle, and horses were transported to the east, and an array of products were transferred westward to the Middle East, and beyond to Europe, including rice, millets, peaches, apricots, oranges, lemons, persimmons – and not least, silk. Colonization and conquest over the oceans radically transformed the culinary world, with sail providing the means for a worldwide redistribution of food resources. By the Medieval period, chickens, cinnamon, bananas, yams, and sugarcane had been transferred around the Indian Ocean from Melanesia and Southeast Asia to Madagascar and continental Africa (Boivin et al. 2013). Italian Bolognese sauces and vodkas were unknown until the voyages of Columbus and the introduction to Europe of key American crops like the tomato and the potato. Road and rail transport in the nineteenth century made possible the rapid dispersion of easily spoiled fruits such as apples and pears, stimulated experiments in breeding for desired characteristics, and promoted the large-scale plantation of fruit trees (Kingsbury 2009). Today, the browser in the modern supermarket is presented with an extensive tableau of global food resources that are available at any time of the year. The global smorgasbord originated in changes in human food-getting practices that commenced in the late Ice Age and gathered pace from that time on. Most of our knowledge about this fundamental transition stems from archaeological investigations commenced in the 1960s; scientific advances developed in the last two decades have revolutionized our knowledge of the processes involved. We know more than ever now about the timing and specific characteristics of the emergence of agriculture, but exactly why this most fundamental transition occurred, as a recent summit of experts concluded (Larson et al. 2014), remains elusive.

FURTHER READING

The emergence of agriculture has spawned a vast literature, with textbooks and conference proceedings on the subject appearing every few years as new evidence emerges. Journals such as *Antiquity* and *Current Anthropology* often feature articles and reviews on new discoveries. As scientific analyses become common, more results are being published in science journals such as *PLoS ONE, Proceedings* *of the National Academy of Sciences*, and *Science*. Readers may find this discussion quite technical and prefer a more general digest. Although over 20 years old, Bruce Smith's (1995) *The Emergence of Agriculture* remains an authoritative and well-illustrated review of global origins. A detailed source at a global scale is the textbook (2013) *The Human Past*, edited by Chris Scarre. The wealth of Middle Eastern evidence is summarized in *The Neolithic Revolution in the Near East: Transforming the Human Landscape*, by Alan Simmons (2007). Michael Balter (2005) presents a lucid account of the various theories associated with the origins of food production in *The Goddess and the Bull*, as well as entertaining interviews with, and biographies of, leading archaeologists involved in the work at Çatalhöyük. Further details are given below.

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PART III

THE BRONZE AGE

CHAPTER EIGHT

Agriculture in Bronze Age Mesopotamia

Michael Jursa

Geography and Climate

The two main rivers, the Euphrates and the Tigris, are historically the principal foundations on which life in Ancient Mesopotamia rested. They are formed in the highlands of the Taurus, but for most of their course they run through plains as principally exogenous rivers. From the viewpoint of geography and agrarian regimes, the region can be usefully divided into two parts: Upper and Lower Mesopotamia. Upper Mesopotamia corresponds roughly to northeastern Syria and northern Iraq, and Lower Mesopotamia to central and southern Iraq, i.e. essentially the land south of today's Baghdad (Figure 8.1).

In Upper (or northern) Mesopotamia, the Jazīra ('Island' in Arabic) formed by the two rivers is bordered by the Taurus and the Zagros in the north and in the east, respectively. In the west, the Euphrates valley is Upper Mesopotamia's natural border, in the south, the limit of cultivation is set by the arid steppe. The Jazīra's plateau is also incised by the principal rivers' tributaries, the Khabur and the Balikh for the Euphrates, and the Upper and Lower Zab for the Tigris. The Euphrates' gradient is gentler than that of the Tigris, and water flow is correspondingly slower. Upper Mesopotamia can be divided into a dry-farming zone on the Taurus and Zagros piedmonts, with a mean annual rainfall of above 350 mm, a zone of marginal cultivation with mean annual rainfall between 200 and 300 mm further to the south, and an arid zone (rainfall < 200 mm) apt for exclusively pastoral use. These zones are traversed by the aforesaid perennial rivers, whose valleys can be considered river oases. In the Bronze Age, the marginal zone was well populated, with major settlements, but it was in particular the river valleys that offered their inhabitants space for dense settlement and intensive irrigation agriculture (e.g. Reculeau 2011, pp. 9–26) (Figure 8.2).

The principal barrier separating Lower Mesopotamia from the plains of Upper Mesopotamia and the highlands in the east is the mountain range of the Jebel Hamrin north and east of Baghdad. The flat land southwest of the Jebel Hamrin remained (and partly remains) uncultivated, being out of reach of irrigation and too dry for farming without. Past the Jebel Hamrin and this largely uncultivable zone, downstream from today's Hit and Samarra, the rivers flow through vast alluvial plains built up by the rivers' deposits. Uncontrolled, they

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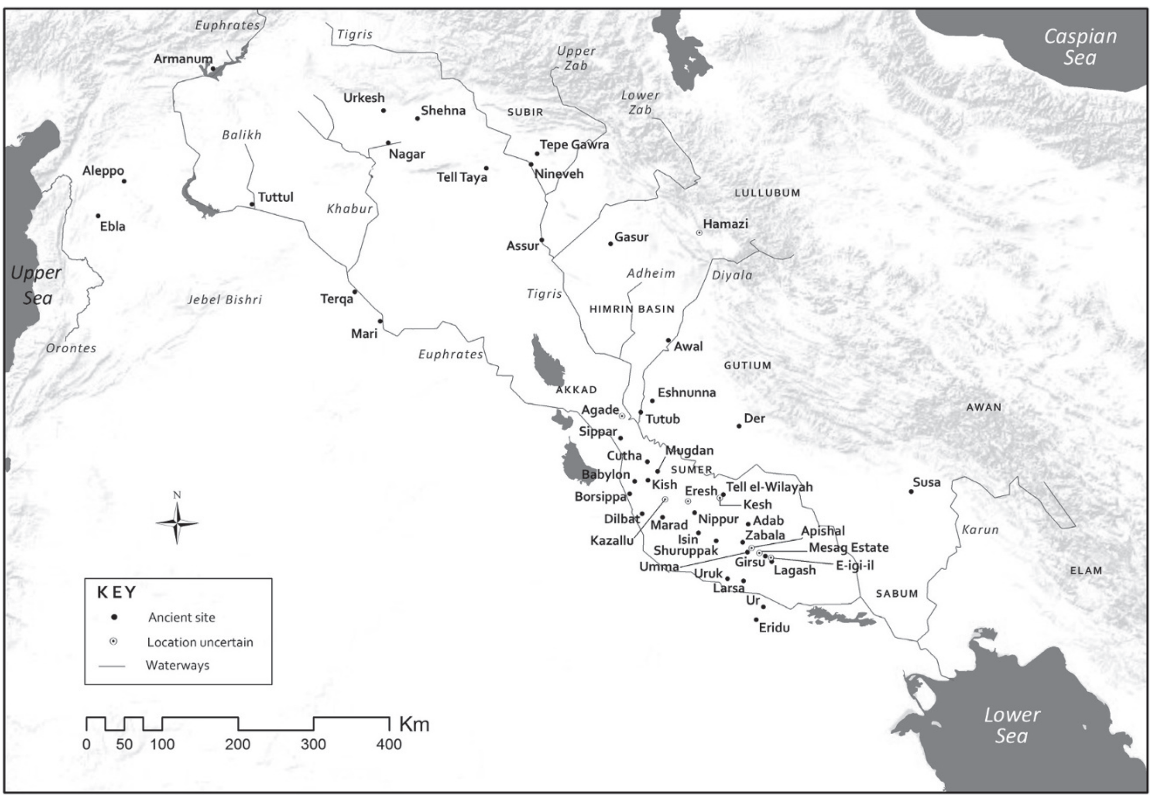

Figure 8.1 Map of the Ancient Near East in the Akkadian period. Source: From Foster (2016). Reproduced with permission of Taylor & Francis.

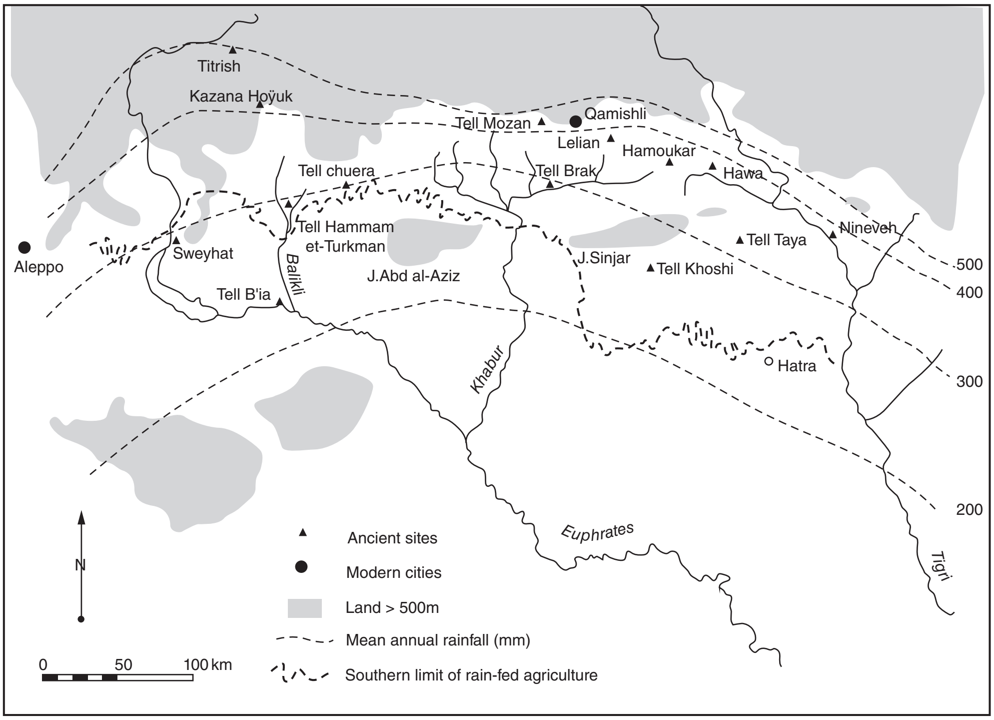

Figure 8.2 The Jazira of Syria, Iraq, and southern Turkey, showing mean annual rainfall (mm). Selected archaeological sites, and the southern limit of rain-fed agriculture. Source: From Wilkinson (2003). Reproduced with permission of the University of Arizona Press.

tend to meander and to burst their banks at high water in spring. Since the river beds are raised above the surrounding countryside due to the rivers' deposits, flooding can be immediate and very widespread. In deep-lying areas, where there is no escape for the collecting waters, marshes rapidly form. In historical periods, the reed forests in these marshes teemed with fish and wildlife (in recent times, most marshes were drained). Otherwise, natural vegetation is thin: there is grazing in the steppe in the wet season, and along the rivers and canals various shrubs and thickets and also trees such as willows and poplars thrive, but rainfall is scarce and does not allow dry farming. The soils, however, are thick and fertile, and due to their flatness the plains lend themselves very well to irrigation. Thus, one can distinguish three principal ecological zones: the central alluvial plain, crisscrossed by rivers and irrigation canals, the swampy river deltas, and generally deeper-lying areas with their reed forests in which hunters, fishers, and bird catchers operated, and the steppe bordering on the alluvium, the realm of the shepherds (e.g. Postgate 1994, pp. 3–21; Potts 1997, pp. 1–42).

In Mesopotamia, winters are relatively wet, and summers, hot and dry. Precipitation, driven by the North Atlantic Oscillation, may vary annually by 50%. River levels in the lowlands depend largely on rainfall and snow thaw in the highlands: high water typically arrives in spring, at the time of the barley harvest, when a superabundance of water, and flooding is potentially highly problematic. Recent palaeoclimatic research does much to clarify the development of Late Holocene climate in Mesopotamia. Multidisciplinary approaches draw on ancient textual data as well as on data culled from climate archives such as Greenland ice cores, lake isotope analyses, and long-term pollen records. Simplifying the complex record, the third millennium BCE experienced a climate that was somewhat warmer and less humid than that of the 'second Holocene Optimum,' lasting until c. 3700 BCE (Reculeau 2011, pp. 47–48). This period saw a change in river dynamics both in Upper and Lower Mesopotamia that led to the development of the principal meandering river courses (in lieu of a plethora of braided channels). There followed a significantly more arid period, initiated by the oft-discussed and controversial '4.2 ka event': a possibly abrupt aridification around 2200 BCE (4200 BP) which resulted in widespread social and economic upheaval and political disruption at the end of the Early Bronze Age (e.g. Kuzucuoğlu and Marro 2007). According to the Greenland ice cores, this event initiated a mostly, but not uniformly, arid phase (in the first half of the Middle Bronze Age), which was followed, between c. 1800 and 1500 BCE, by varying, but generally moister conditions. The Late Bronze Age was ushered in by a phase of renewed drier climate (from c. 1500 to 1300 BCE). Thereafter, a moister period (1300–1100 BCE) and another very dry phase, with an abrupt beginning and far-reaching implications possibly similar to those of the '4.2 ka event,' at around 1100 BCE, brought the period, and the millennium, to its end. It should be noted, however, that regional sequences of palaeoclimatic data recovered from different parts of the Middle East, including an analysis of river sediments, do not always bear out the general picture sketched here, suggesting instead significant inter-regional microclimatic variation before the background of a generally arid climate throughout the second millennium BCE at least in Upper Mesopotamia (Reculeau 2011, pp. 27–59; Dornauer 2016, pp. 56–63, with further references).

Sources

Mesopotamian archaeology contributes to the history of agriculture in the region through controlled excavations of ancient sites in modern Syria and Iraq and through archaeological surveying (Matthews 2003). In an area literally peppered with mounds resulting from ancient settlements, excavations usually focused on larger sites and in particular on these sites' public buildings such as palaces and temples. Less work has been done on private habitations. Large-scale surveys are more profitable for the present topic owing to their potential to allow the reconstruction of irrigation networks, settlement patterns, and land-use zones around settlements (e.g. Wilkinson 2003, pp. 71–127). Textual sources are abundant from the invention of writing in the Late Uruk period (around 3200 BCE), onward (general introductions: e.g. Postgate 1994; van de Mieroop 1999). The distribution of texts and archives over time is uneven, and periods marked by an abundance of the written record alternate with hiatuses that left little or no documentation. Texts are mostly administrative in nature, including, e.g. field plans, rosters of workers and plow animals, receipts for seed grain, and accounts of yields and rents. Such documentation exists from the very beginning of writing (e.g. Nissen, Damerow, and Englund 1991). Its nature is mostly 'descriptive' in that it aims at monitoring agrarian performance, but there is also an interest in planning and prognostication of future performance (e.g. Selz 1999; Jursa 2002, pp. 42–59). Agronomic literature is also represented in the form of a Sumerian 'farmer's manual,' a scholastic poetical instruction for arable farming (Civil 1994). In the Middle and Late Bronze Age, the number of legal documents dealing with land and livestock increase: there are title deeds, leases, herding contracts, debt notes, and so forth. The difficulties resulting from the uneven distribution of the sources notwithstanding, the Lower Mesopotamian agricultural regimes can be reconstructed with sufficient confidence from the Early Bronze Age onward on the basis of texts and survey data alike. For Upper Mesopotamia, in particular for Syria, Early Bronze Age textual data are relatively scarce (if by no means absent); only from the Middle Bronze Age onward do we have a steady flow of information. On the other hand, however, archaeobotanical and geoarchaeological data are much richer than what we know for the south, owing to the far higher number of modern, controlled excavations that were conducted in the area in recent decades (e.g. Riehl et al. 2012). Finally, comparative data can be found, as in Wirth 1962, a comprehensive treatment of agrarian production in Iraq in the mid-twentieth century.

Crops

For both southern and northern Mesopotamian, barley was the main cereal. There seems to have been a discernible distribution between 2-row and 6-row barley, the former being limited to dry farming in northern Mesopotamia, while the latter was grown in irrigated lowlands, especially in the southern alluvium. Wheat was likewise common, but of lesser importance than barley, especially in the south and in later periods. Among the wheats, hulled varieties, especially emmer wheat, are preponderant; naked wheats (in particular, *Triticum aestivum*) are not absent but are relatively rare (Potts 1997, pp. 57–62; Riehl et al. 2013, pp. 126–127).

Among the legumes cultivated in Ancient Mesopotamia, the lentil, the common pea, and the chickpea stand out for the early date of their first attestation (from the Neolithic onward) and for the consistency with which they are mentioned in the textual record (even if establishing the precise meaning of pertinent words is not always easy; Potts 1997, pp. 62–63; Stol 2004, pp. 856–858). While a wide range of vegetables is mentioned in the written sources at least occasionally, it is clear that economically, members of the genus *Allium* – i.e. leeks, garlic, and in particular onions – were by far the most important. Herbs and spices that were found in Mesopotamian gardens include coriander, cress, 'white' and 'black' cumin, and several other cultivars that cannot be identified with certainty (Stol 2004, pp. 856–858; Potts 1997, pp. 64–66).

Oil plants include flax, archaeologically well attested from the fourth millennium BCE onward, both in the north and the south, and sesame. While the latter is less abundantly recorded archaeologically (but not absent by any means), the textual sources are very rich and demonstrate that sesame was the principal source of vegetable oil at least in southern Mesopotamia from the third millennium onward (Potts 1997, pp. 66–68; Stol 2010; Riehl et al. 2013, p. 127).

The most important tree by far in Ancient Mesopotamia was the date palm. In the south, date gardening offered the possibility of establishing an agrarian regime based on two leading crops, barley and dates, with the latter being more labor-intensive, but also potentially more productive (Jursa 2010, pp. 48–53; Stol 2004, pp. 854–855; Potts 1997, pp. 69–70). In the north, the date palm had at best a marginal role, owing to climate-related restrictions of its distribution. Other types of fruit, however, were grown throughout the region, especially figs, grapes, pomegranates, and apples. In northern Mesopotamia, grape cultivation was widespread along the Euphrates, in the hills south of the Taurus, on the Upper Khabur, and in the region of the Jebel Sinjar (Riehl et al. 2013, pp. 128). One notes a certain decline at least in the volume of the evidence for fruit trees other than the date palm in the second millennium; it is unclear whether this implies a decrease in cultivation or a shift toward more small-scale fruit growing that simply left fewer traces in the record (Postgate 1987). The olive was well established in western and central Syria in the Middle Euphrates region (especially at Ebla, Tell Mardikh, around the mid-third millennium BCE: Riehl et al. 2013, pp. 127–128; Archi 2015, pp. 333–349), but is occasionally also found in southern Mesopotamia. Timber was sourced locally from different types of pines and juniper, the

Euphrates poplar, different types of willow, and the tamarisk (Potts 1997, pp. 69–70; Heimpel 2011; Stol 2004, pp. 856–858).

Animal Husbandry

The breeding of sheep and goats was the single most important type of animal husbandry in Ancient Mesopotamia. The flocks were a source of meat and milk, obviously, but their wool and hair was just as important, or even more so, in that Mesopotamian textile manufacture, the most important type of craft production in terms of volume and the source of the principal commodity of Mesopotamian origin for long-distance trade, depended on it. In a religious context, sheep (rams) were important as offerings for the gods (Postgate and Powell 1993 and 1995; Stol 2004, pp. 949–975).

Cattle breeding never reached the scale of sheep breeding for the simple reason that large herds of cattle cannot easily be maintained in southern Mesopotamia. The principal importance of cattle lay always in their use as draft animals, especially for plowing, and for (prestigious) offerings (Postgate and Powell 1995; Potts 1997, pp. 257–259 for the water buffalo in Mesopotamia; Weszeli 2007). Also, large flocks of ducks and geese were held, and bred to contract, again in part for the purposes of the offering regime (Janković 2004). Both in southern and in northern Mesopotamia, pig breeding was of major importance in the third and second millennium, much more so than in the Iron Age (Weszeli 2009). Donkeys were the principal beast of burden and were used in large numbers for caravan ventures; they were also ridden (in the south, its importance as a means of transport was eclipsed by the boat). The horse appears in the Middle Bronze Age and is of societal importance only in the Late Bronze Age, in connection with chariot-based warfare (Weszeli 2004).

Cultivation Techniques and the Agricultural Calendar

Arable cultivation largely relied on the plow team – three (or more) persons, the plow, and the draft animals (usually oxen, but also cows and donkeys are attested) – as the basic unit of production. The seeder plow (e.g. Potts 1997, pp. 78–86) consisted of an ard that was fitted with a seed funnel and often a metal (bronze) plow share (Figure 8.3). The seed funnel allowed dropping seed grain in a controlled fashion into the shallow furrow scratched by the ard directly behind the plowshare. The high returns on seed Mesopotamian farmers achieved (see below) resulted from the use of this ingenious device and its elegant employment of means which economized on the scarce resources of manpower, seed grain, and water, while making (relatively) generous use of land, a lack of which was not the principle constraint for agricultural development in most documented periods and regions of Ancient Mesopotamian history: the distance between the furrows was relatively wide (often 50 cm or more). Alternative techniques are occasionally attested and include highly controlled methods of manual seeding in the context of large-scale institutional farming (by which workers advanced in line, held in place by a long pole; Maekawa 1990, pp. 126–127).

Syria and Iraq experience rainfall principally in winter and early spring; the rivers carry high water, and there is a risk of flooding after the spring thaw in the mountains. For farming, this timing is not necessarily ideal, especially because high water comes at the time of the barley harvest (end of March until the end of May; Babylonian months I–III). The barley harvest was the pivotal event in the agrarian year in the north (in the south, it was one of two such junctures, given the importance of the date harvest later in the year): rents and debts were

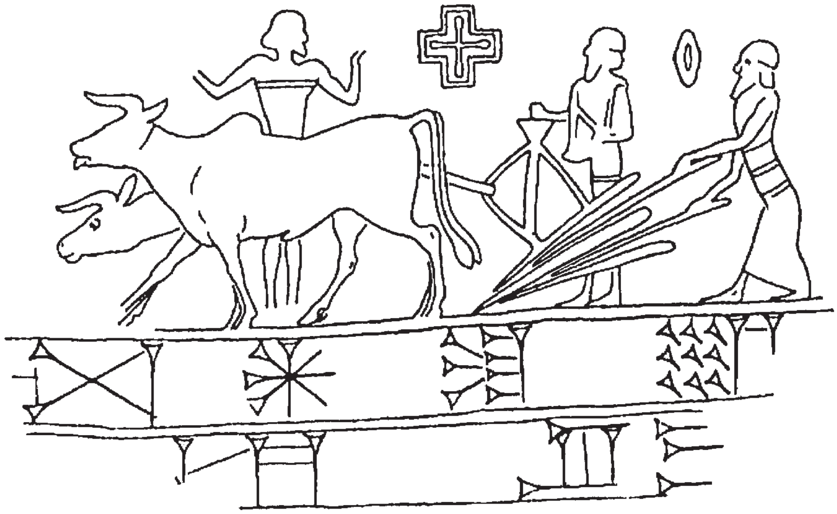

Figure 8.3 Kassite representation of a seeder plow. Source: Courtesy of Potts (1997).

paid thereafter, and new rental contracts were drawn up. After the harvest, those fields that were destined to be planted (at least in the south, it is probable that a two-year fallow cycle was general practice) were flooded (May/June). This 'leaching' not only prepared the field for plowing but also, and importantly, lowered the concentration of salts in the surface by washing them out, thereby counteracting the tendency of south Mesopotamian fields to undergo a process of continuous salinization (which is nearly unavoidable if the two-year fallow cycle is not maintained). Once the field was sufficiently dry again, a first plowing followed. Field preparation took several months through summer into autumn. A field was plowed several times and then harrowed; especially in the case of newly reclaimed land, clods of hard earth might have to be removed or broken by hand. Before the final seed-plowing, the field was irrigated again. Seed plowing was supposed to be concluded in month VIII (November). The field was thereafter irrigated as necessary/possible. Much of the work was done by specialized workmen (plowmen); only during the principal labor-bottleneck of harvest and threshing time were large numbers of other men and women brought in. The sheaves were cut with sickles (in the earliest period, these were made of clay) and brought to the threshing floor (often by boat). Threshing was done by hand or with oxen; for winnowing, shovels were used, and reference is made to the importance of having favorable wind conditions for this step of the work. The grain was then stocked in granaries in the countryside and in the city. These facilities were sufficiently effective to allow keeping grain for several years, but generally, 'carryover' of grain from one harvest to the next was not the rule (e.g. Stol 2004, pp. 824–859; La Placa and Powell 1990; Charles 1990; Reculeau 2011, pp. 159–163 [for long-term storage and 'old grain']).

Both basin irrigation and the more water-conserving technique of farrow irrigation were practiced. Water was brought to the fields by cutting through dykes or opening sluices or by use of lifting devices, bucket irrigation being the most frequently attested (even though it was considered less efficient and desirable than judicious use of sluices: Stol 2004, p. 839). In southern Mesopotamia, fields tended to have a very elongated shape, with only a narrow front facing the canal which was the source of irrigation water. Since canals (and rivers) in the southern alluvium run in beds that are higher than the surrounding flat land, such an arrangement was perfectly suited for the use of the seeder plow and for furrow irrigation: the water

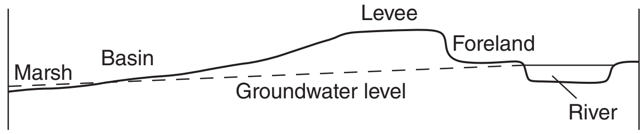

Figure 8.4 Cross section of a river levee and basin. Source: Courtesy of Potts (1997).

could run down furrows perpendicular to the canal. In northern Mesopotamia, with its mixture of irrigation, dry farming and dry farming supplemented by (occasional) irrigation, field shapes are more irregular with a tendency toward squarish or rectangular fields without a great difference in length and width (Charles 1988; Stol 2004, pp. 833–839; Liverani 1996; Reculeau 2011, pp. 182–187). In the northern river valleys, the principal topographical distinctions differentiated between fields directly alongside the river (always in danger of flooding), whose land-side border was the river's levee; fields on the other side of the levee, where minor feeder canals allowed furrow or basin irrigation, and fields beyond this area, on higher ground, which could only be irrigated (if dry farming was not possible or desirable) through bucket irrigation drawing from wells (Stol 2004, p. 840) (Figure 8.4).

The development of large-scale irrigation networks is a separate issue. Irrigation and canal building became a necessity in the south after the climate shift to drier conditions in the fourth millennium BCE. Thereafter, the irrigation landscape was dominated by relatively few major natural watercourses from which minor man-made canals issued that aimed at extending cultivation on a local level (Figure 8.5). Major settlements, however, were always situated on the principal river branches. Growth of the irrigation network was haphazard and decentralized. By the Middle Bronze Age, this changed to some degree; kings sponsored ambitious schemes for the construction of major canals, not always with success. Even in the second millennium, however, there were no attempts for linking up regional irrigation networks; this only happened later in the first millennium BCE (Adams 1981; Wilkinson 2003, pp. 89–91). Bronze Age irrigation systems in the partly dry-farming Jazīra in northern Mesopotamia were normally rather small scale and local; with few exceptions (e.g. Dornauer 2016, pp. 61–62), major water works only occurred from the Iron Age onward (Wilkinson 2003, pp. 100–133).

Barley yields in the south, for exclusively irrigated fields, were generally higher than in the north. Returns on seed of up to 20-fold were achieved regularly (a ratio of 1:6.66 was at the lowest end of the attested spectrum); returns on 'seed and fodder (for the plow animals),' another important cost category recognized by Mesopotamian accountants, were half these numbers, around 8–10, in many cases. 1390 liters, 860 kilograms of barley per hectare are a good approximation for 'standard' area yields that could be expected in the Early/Middle Bronze Age (Jursa 2010, pp. 48–50; Reculeau 2011, p. 127; Widell 2013, p. 64). For northern Mesopotamia, where pertinent evidence is not as rich as in the south, generalization is more difficult, owing to the more heterogeneous conditions and to uncertainties regarding ancient metrology. The most reliable information available pertains to seed/yield rates. In the Late Bronze Age city of Nuzi (around 1450 BCE; the city is close to Kirkuk, Gasur in the third millennium BCE), for instance, a mixed agrarian system (predominantly dry farming) achieved yields from 1:2 ('bad') to 1:8 ('normal') up to 'very good' (1,13.33 and beyond) (Reculeau 2011, pp. 127, 151–154). Elsewhere in northern Mesopotamia in the Late Bronze Age (around 1200 BCE), returns were somewhat lower, perhaps in part reflecting difficult climatic conditions (this is discussed in Reculeau 2011; see also Dornauer 2016, pp. 62–70).

Field rents could be assessed in various ways: in absolute terms, as a certain fraction of the yield (a quarter, a third, half: share cropping), in terms of a certain quantity of barley per unit

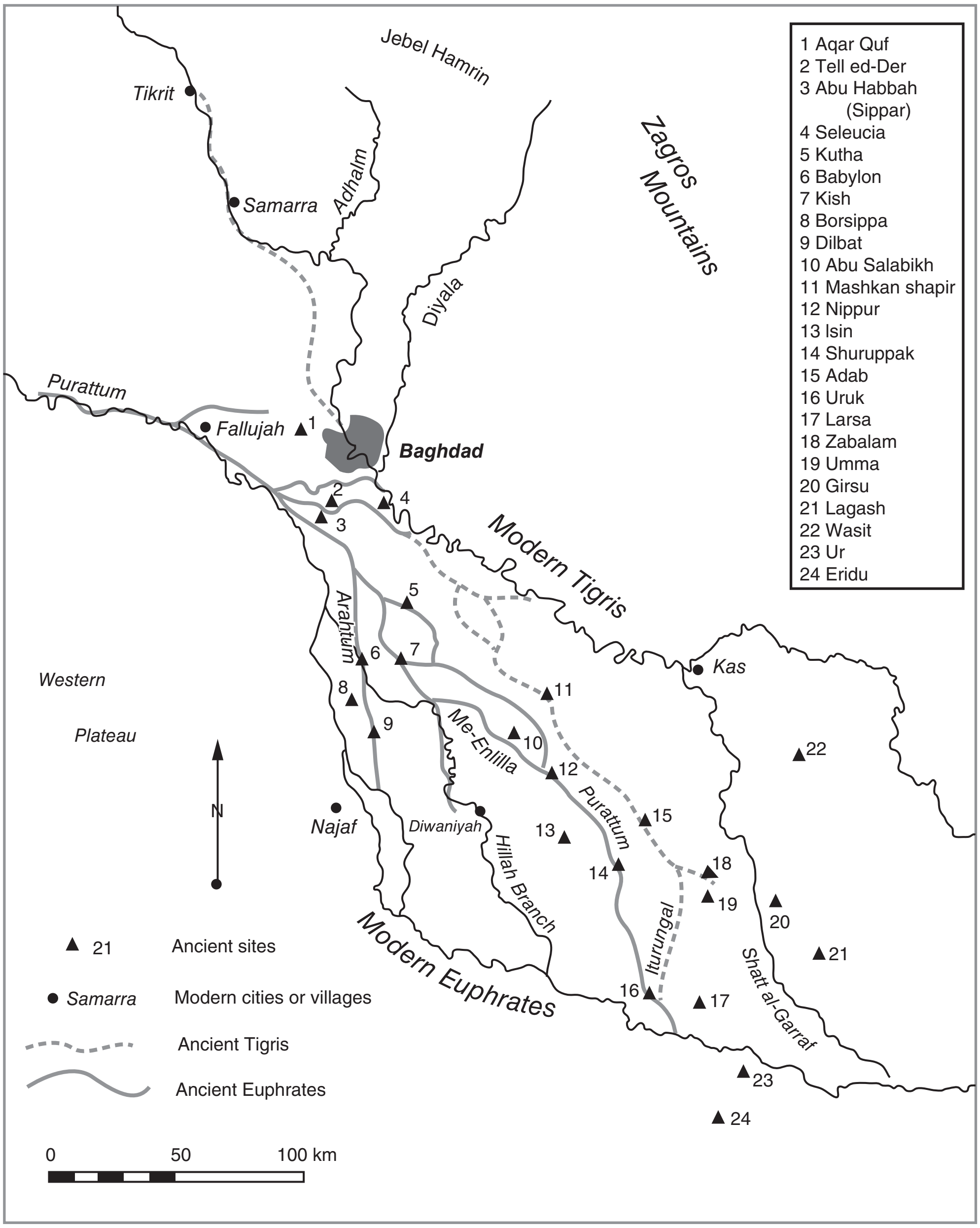

Figure 8.5 Tentative reconstruction of major ancient channels in the Mesopotamian plain. Source: From Wilkinson (2003). Reproduced with permission of the University of Arizona Press.

of land, and "according to custom" (or similar phrases). Details vary from period to period and from region to region (see, e.g. Stol 2004, pp. 847–853).

Barley is the best attested of all field crops; for the others, no complete reconstruction of the pertinent work cycle can be offered. Sesame is a partial exception. It was a summer crop that was sown after the conclusion of the barley harvest; about three months later, the crop was brought in. Sesame cultivation is relatively work intensive. It requires careful field preparation and weeding as well as sufficient irrigation during the peaks of summer heat. Thus, sesame growing was an ‘intensive’ form of cultivation with high investment and relatively high returns, in contrast to extensive arable farming (Potts 1997, pp. 67–68, Powell 1991; Stol 2004, pp. 853-854; Jursa 1995, p. 176).

In the south, the importance of the second leading crop, dates, implied a particular agrarian regime depending on a heavy initial investment and relatively high continuous labor input, but yielding high returns. Date palms are quite salt tolerant and thrive in a hot climate; they are thus ideally suited for the area. They require, however, very regular irrigation and therefore consume a lot of water. Newly planted gardens were productive only after four to five years. Date gardens needed work throughout the year; tasks that are attested include the care of the trees themselves, manual pollination of the female date palms, irrigation and digging work on the ground between the trees, the maintenance of the canal adjacent to the garden and of the irrigation installation, and the construction and maintenance of a protective wall around the garden. The most important juncture in the agricultural calendar from the viewpoint of horticulture was the establishing of rents and dues levied on the date harvest. This was done before the harvest, by inspecting the dates on the trees and estimating the gardens’ productivity. Only then were the dates cut. The harvest fell into the seventh and/or eighth month of the Babylonian year (c. October/November), at which point, as in the case of the barley harvest, loans fell due, and leases were renegotiated.

Available figures for the density of trees in a garden from the second and first millennium suggest a wide variation; 6.5 square meters per tree is a lower limit, 16 square meters will have been more common. Yields per hectare varied widely on the basis of the number of trees and of the care invested in the garden; 4 to 6 metric tons (and more) per hectare are possible and attested (Jursa 2010, pp. 50–53 [the best evidence is from the Iron Age]; Stol 2004, pp. 854–855; Volk 2003).

Date palms and horticulture are indicative of intensive farming. Both yields and workload connected with date cultivation are high. Being situated along canals with ready access to water, the palm trees allowed the planting of other crops below them that profited from the shade cast by the trees. This includes fruit trees (mostly fig trees, apple trees, pomegranate trees, to a lesser extent, the vine) and legumes, especially onions. In the typical southern Mesopotamian agrarian setting, the presence of date gardens along the canals meant that grain fields were pushed further down the levee; they were irrigated by irrigation ditches leading through the date gardens. As for the shape of the gardens, the rule pertaining for grain fields holds true here as well: gardens tended to have an elongated form, with the short side alongside the canal (e.g. Postgate 1994, p. 175) (Figure 8.6).

The annual sheep shearing is the third date in the agricultural calendar that gave rhythm to Ancient Mesopotamian life. As a rule, sheep flocks (which were kept together with goats) roamed widely throughout the year in search of good grazing. In the south and in the area of the Middle Euphrates, horizontal transhumance was practiced: in the winter, the flocks were kept in the Mesopotamian steppe, and in summer, they were either brought into the irrigated areas in the river valleys and along the canals or had to move northeast of the Tigris, in search of pasture. It was a common practice to allow flocks to graze on fallow fields and sometimes, in agreement with field owners, on fields with growing crops. (The resulting dung on the fields may have helped soil fertility; otherwise, its use as fertilizer is not attested.) Northern Mesopotamian flocks could practice vertical transhumance by moving to the adjacent highlands in summer. In any case, shepherds were expected to present themselves in the spring to the urban owners of the flocks they tended – i.e. after the end of the winter-grazing season in the steppe – for the shearing and the annual settling of accounts. Then, lambs were selected for slaughter, and the crop of winter wool was collected. In the Bronze Age, sheep were mostly plucked; in the Iron Age, they were shorn (Postgate 2009, pp. 117–119).

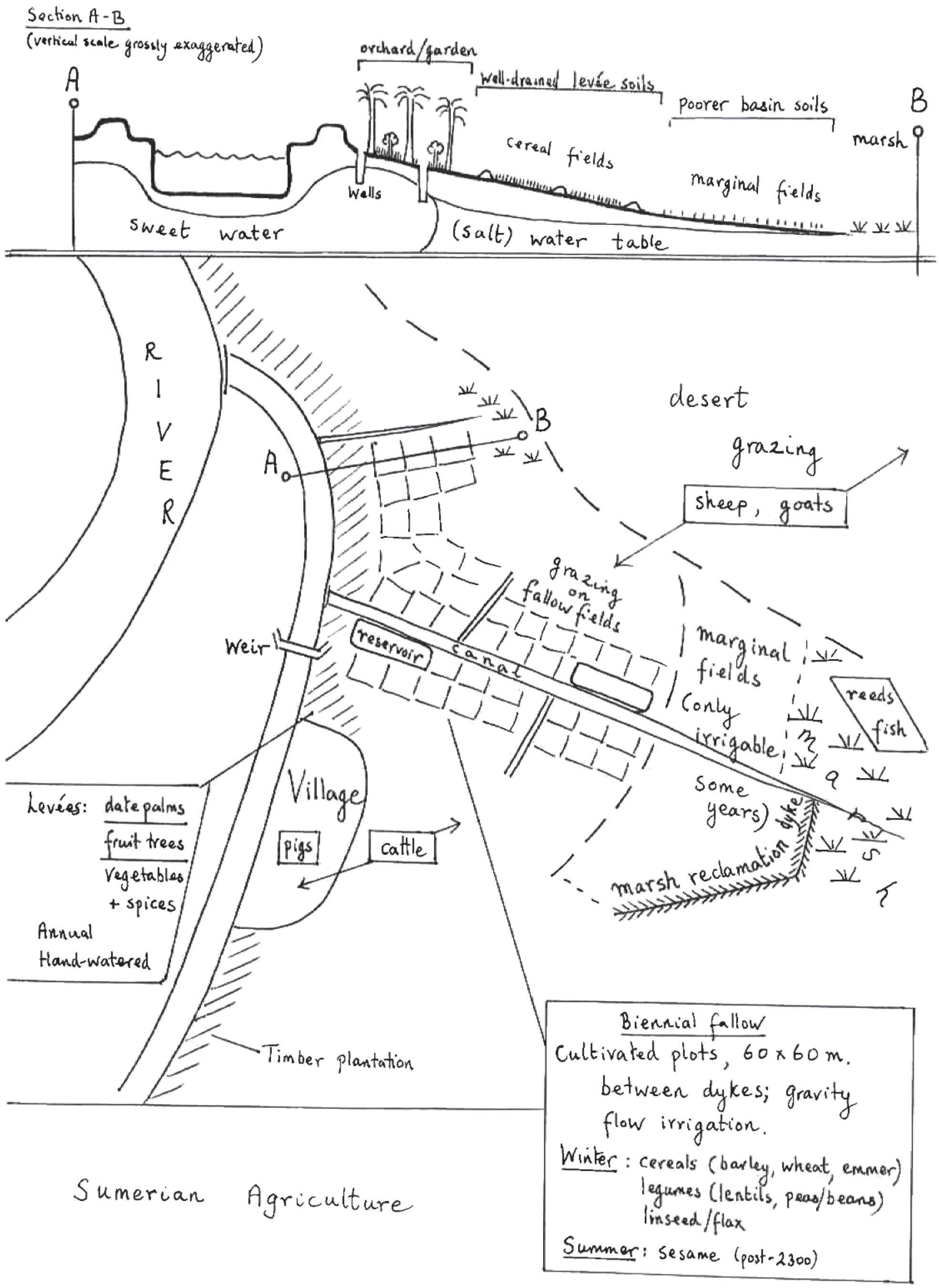

Figure 8.6 Sketch of an agricultural cell in South Mesopotamia. Source: Postgate (1994). Reproduced with permission of Taylor & Francis.

The productivity of animal husbandry can be inferred from preserved accounts of actual herds and from certain rules of thumb employed by Mesopotamian bureaucrats to predict the future development of herds entrusted to shepherds (Jursa 2002). The latter were after all beyond the direct reach of the flocks' owners for most of the year, and it was desirable not to have to rely simply on the shepherd's good faith when establishing his performance and remuneration at the sheep shearing. The administrators/owners set the shepherds' targets based on simple arithmetic models. While these models certainly depended on some degree of experience regarding the (average) rate of herd growth, the risks connected with moving large flocks over some distance, (average) loss of flock due to sickness, old age, predators, and so forth – all aspects not amenable to precise prognostication – they were clearly intended to simplify the task of the accountant. Such models were taught in scribal schools. One pertinent text, from the end of the Early Bronze Age, deals with a herd of cattle over the period of ten years (Englund 1995). According to this text, a cow, from its fourth year onward, calves every second year, and every second calf is female. Also, the milk and cheese production is completely regular. No animals die during the ten-year period, and all the cows remain productive throughout that time, too. The assumption of this didactic text (every year, 50% of the cow's number, i.e. 25% of the total of this fictional herd, are added) is also applied to contemporaneous sheep breeding texts, and it can even be traced back to the very beginning of livestock accounting in the earliest cuneiform archives from the end of the fourth millennium BCE (Liverani and Heimpel 1995). The model is, of course, artificial: sheep and cattle will die, but still it may have come reasonably close to reality because the effects of two unrealistic assumptions probably canceled each other out to some degree: the relatively low birth rate posited offset the losses which were not allowed for explicitly in the model. In the Middle Bronze Age, the model is refined to some degree. In the city of Larsa in southern Babylonia, the following norms were imposed on shepherds (Kraus 1966): every sheep was expected to yield two minas (one kilogram) of wool (Stol 2004, p. 959). For each 100 female animals, an increase of 80 young (male and female) were demanded per year; for each 100 animals (male and female), 15 could be deducted as loss (which had to be proved by presentation of the skins: the shepherd could not simply sell these animals). In terms of an ideal flock of 200 animals, this means: 200 + 80 – 30 = 250, a yearly increase of 25%. This is the same result as that of the third millennium models, but it is couched in slightly more realistic terms (see also the pertinent observations in Chapter 26).

Agriculture and Society

Ancient Mesopotamia was an agrarian society, notwithstanding a remarkable degree of urbanization. Social relations were fundamentally predicated on access to cultivable land, and even more importantly, to the means of production, foremost, labor – labor being the scarcer resource. Here, it is essential to distinguish the agrarian regime in the south from that of northern Mesopotamia. The former will be discussed first.

The Development of the Agrarian Regime in Southern Mesopotamia

Nearly from the very beginning of the earliest phase of Mesopotamian history for which intelligible information is available, private and institutional landownership are attested. Arable land in the hands of individuals or families appears in the earliest sale documents in existence, from the early third millennium BCE (Gelb, Steinkeller, and Whiting 1991). Large-scale institutional landholding, i.e. land owned by large households associated with rulers or temples (i.e. households of divinities), is reflected in Proto-Cuneiform and 'Archaic Texts' from the late fourth millennium onward (e.g. Nissen, Damerow, and Englund 1991, pp. 98–102). Thus, the interplay between these two types of landownership, which is fundamental for the agrarian history of Mesopotamia, can be observed from the very beginning of recorded history. Private and institutional landownership are supplemented by a mixed type: service or prebend land, i.e. institutional land allocated for private use to an individual or a family with ties (and obligations) to the institution. Crucially, given the ecological conditions in southern Mesopotamia after the shift to a drier climate in the course of the fourth millennium BCE, and given the nature of Mesopotamian technology, large institutions had the advantage over smallholders when it came to arable farming. The plow team with its seeder plow, along with irrigation installations, represented a heavy investment often beyond the reach of individual households, but not of institutions; moreover, large-scale landholding spread the risk of crop failures and allowed an efficient use of the plow as well as the observance of the two-year fallow cycle, which was essential to avoid salinization. Of course, these advantages could generally be replicated by close collaboration of private landowners, and it is probable that communal farming on the village level had a bigger role to play than is visible in the written documentation available. It would seem therefore that the crucial advantage of institutions (temples or palaces) throughout Mesopotamian history lay in their ability to coerce outside labor from the population at large in times of need (especially during the harvest or for special labor-intensive activities, such as canal building) – outside labor the institutions did not have to maintain throughout the year. This allowed the institutions to acquire the massive surpluses on which Mesopotamian social stratification and the political order rested (Postgate 1994, pp. 188–190; Liverani 1998; Jursa and Moreno Garcia 2015).

From around the middle of the third millennium, the first substantial tablet archive dealing with the management of institutional land originates from the ancient city of Girsu (Telloh). The estates of the temple in question were managed as 'domain land' under direct management of the institution (using the labor of personnel bound to the temple and of corvée workers) or were allotted to members of the temple household for their needs (for individual cultivation) as 'subsistence fields.' Excess land was rented out on sharecropping terms or against a fixed payment. While the agrarian holdings of this temple and others like it were not coextensive with the entire hinterland of the Sumerian city-states in this period – private landownership did exist, contrary to the opinion held in Ancient Near Eastern studies in the mid-twentieth century (which is still repeated sometimes in the secondary literature) – it is certain that the institutional sector was the overall dominant factor within the economy at large (Selz 1995, pp. 40-47; Huh 2008 with further references).

In the subsequent phase of Mesopotamian history, the Old Akkadian period (roughly 2350–2200 BCE), the arable land held by temples and by the rulers of the Sumerian city-states was the major prize to be distributed to the followers or clients of the victorious kings of the city of Akkade (perhaps not far from today's Baghdad, near the confluence of the Diyala river and the Tigris: Foster 2016, p. 31) who had managed to unite a large part of Mesopotamia under their rule. The redistribution (through requisition or purchase) of land and the accumulation of vast estates in the hands of the Akkadian imperial elite were the principal means of 'state building.'. Although to some degree old local elites were co-opted for the Akkadian imperial 'project' through royal appointment to high imperial offices, overall power in the conquered cities was redistributed through the establishment of a new stratum of dominant landowners without or with only minimal local roots, but with close ties of patronage and obligation to the Akkadian king. The scale of levies and corvée obligations grew in comparison to that of the previous period. This resulted from, and in turn furthered, the extension of agrarian production and the greater centralization of labor organization, reflecting the increasingly supra-regional outlook of administration and government. The surplus reaped from the productive estates in southern Mesopotamia was channeled toward the imperial capital, Akkade, and probably also financed the imperial expansion elsewhere (Foster 2016).

The tendency toward state-controlled centralization of large-scale and extensive arable farming as the mainstay of agrarian production that is in evidence in the period of the kings of Akkade reached its apogee in the final century of the third millennium, when a dynasty of kings based in the southern city of Ur managed to unite Lower Mesopotamia and much of Upper Mesopotamia under its rule. The era of the Third Dynasty of Ur, as it is known in the literature, is one of the best-documented periods of Mesopotamian history; state, provincial, and temple administrations generated a huge quantity of textual records which shed light on many aspects of economic life (e.g. Sallaberger 1999; Garfinkle and Johnson 2008). Arable farming was dominated by huge estates administrated by institutional households which were nominally attached to temples or governmental offices, such as that of province governors. In fact the land was controlled (and exploited) by individuals (as office holders) who enjoyed the crown's patronage or by elite families who were not solely reliant on the benevolence of the king, since they had roots in their city and its past, their ancestors often having been independent rulers (Garfinkle 2008). The countryside gives evidence of the high degree of organization and central control of farming in this period. Cadastral information from one central province reveals the existence of quite regular, clearly standardized field complexes. Under a regime of direct domain management, the overarching field units measured roughly 39 hectares. Ten such units were placed under a single overseer. He directed two 'inspectors of plow oxen' who in turn were responsible for five 'cultivators' each. Each 'cultivator' had three plow teams (each under an 'ox driver') at his disposal with which to work the land (one plow for thirteen hectares).The sources detail also seed rates and questions of labor remuneration. Some agricultural personnel were granted 'sustenance land,' plots for their own use, in return for their service on the domain land, others received a salary (sometimes misleadingly translated as 'rations') in grain while doing their labor service for the institution, and yet others again were free hired workers: overall, the institutional surplus depended on the temporary availability of outside labor, much of which was forced (Widell 2013, pp. 59–64; Steinkeller 2015 [for this period's labor regime]).

The state of the Third Dynasty collapsed at the end of the third millennium; thereafter, political unity in southern Mesopotamia remained elusive for much of the subsequent phase of Mesopotamian history, the Middle Bronze Age. The period was marked by the competition of regional states and statelets which were based on one or another of the ancient cities of the alluvium and strove for dominance over their neighbors. Political fragmentation does not imply cultural fragmentation: culturally, southern Mesopotamia was increasingly part of a wider *koiné* of polities under strong Amorite influence, the Amorites being West-Semitic nomads who had put pressure on the sedentary population of the river valleys in northern Mesopotamia, and increasingly in the south, already toward the end of the third millennium (e.g. Charpin 2004). By the (later) Middle Bronze Age, they were dominant. This transition toward an Amorite social structure brought about gradual but far-reaching changes in the agrarian regime. The first kingdom to achieve regional predominance, or something close to it, was that of Isin. It still stood in the tradition of the empire of Ur of the late third millennium. Centrally administrated latifundia were the mainstay of agrarian production. Later, Isin gave way to Larsa, also in the south, and the latter, eventually, to the newly risen Babylon, which had previously defeated its rivals, Ešnunna in the northeast and Mari in the northwest, on the Middle Euphrates. In step with these permutations of political hegemony, new forms of landownership, labor organization, and resource extraction came into being.

While the basic principles of the new system were the same throughout the Amorite sphere, it is best seen at work in a dossier of texts documenting the reorganization of the royal domain in the region of Larsa after the conquest of the city at the hands of the Babylonian king, Hammurapi (Charpin 2004, p. 271; Stol 2004, pp. 732–746). Crown land was parceled out to individuals or families who owed the state various dues and in particular a certain type of service (*ilkum*): as simple corvée workers, as specialized soldiers, as craftsmen, etc. State servants could be paid salaries (during the period of their service), but as far as possible the Babylonian administration avoided having to make such payments by allotting them their own parcel of land. The average size of such holdings was 6.35 hectares, which was sufficient to maintain a family (Stol 2004, pp. 843–844). The nexus between landholding and active service was not always strictly upheld: sometimes the holder of the land allotment hired substitutes who undertook the required state service with the (tacit) benevolence of the authorities. The principal point here from the viewpoint of agrarian history is the fragmentation of domain lands and the substitution of the direct management of royal latifundia by a decentralized system of rents and service obligations. Increasingly, the crown even withdrew from the task of collecting dues incumbent on such land grants with its own administrative apparatus, bringing in private contractors (merchants) as tax farmers who also undertook to sell the dues that were collected in kind, paying the crown in silver (Kraus 1984; Stol 2004, pp. 919–948).

The Middle Bronze Age is remarkable for a wealth of information on private farming. In the third millennium, one hears little about land, especially arable land, in private hands (even though it existed); in the second millennium, this had changed. In an increasingly urbanized society, city-based landowners relied on rural holdings in the cities' hinterland. Transactions regarding arable land in private hands are abundantly attested in the northern part of southern Babylonia; in the deep south, however, the old disadvantage of small-scale private arable farming was still felt. Even in the north, the acquisition of arable land was not the preferred strategy of rich merchants and entrepreneurs to invest their wealth; fields remained relatively cheap. Instead, private wealth went into urban properties and especially into date gardens: horticulture was the agrarian activity of choice for well-to-do urbanites to invest in. This intensive form of agriculture, which could be pursued especially effectively on a small scale and which allowed achieving high returns, was ideally suited to the needs of an increasingly stratified society (Stol 2004, pp. 844–847, 854–855).

The final phase of southern Mesopotamian agrarian development to be discussed here is the Late Bronze Age – the Kassite period, after the ethnic origin of the dynasty that ruled the unified country (Babylonia) for much of the period. The Kassites had gained control over Babylonia after the collapse of the Middle Bronze Age political and socioeconomic order. When sources are again available after a hiatus around the mid-second millennium, Babylonia had been re-ruralized after a period of high population concentration in the cities of the Middle Bronze Age: in the Late Bronze Age, Babylonia was again a country of villages. In some urban pockets, however, the traditional institutions had survived the centuries of instability and political upheaval, and one encounters there a regime of labor and agrarian production that in many ways is reminiscent of the late third millennium: large numbers of unfree workers were compelled to toil on institutional estates which served the needs of a very thin urban elite and the crown (Tenney 2011). Outside these areas, we are in a thinly occupied region of villages. From relatively early in the Kassite period onward, the crown had an interest in reclamation of underused land and, at the same time, in extending its hold on these areas, possibly with the intention of counterbalancing the power of magnates and officeholders already active in the areas in question. These objectives were achieved through large-scale royal land grants (studied in Paulus 2014). The estates in question were of considerable size: in the early Kassite period, the mean is 850 hectares; in the post-Kassite period, i.e. at the very end of the Late Bronze Age, the mean is still 210 hectares (Paulus 2014, pp. 79–82). Most of the recipients were high officials, courtiers, military men, or priests; some members of the royal family and a few temples are also mentioned (Paulus 2014, pp. 148–163). The background of these transactions is not uniform (and neither is the social status of the recipient of these grants), but the texts frequently refer to tax and service obligations incumbent on the estates that the king waived in the interest of the recipient of the grant. It has sometimes been assumed that this led to a weakening of the monarchy, but it would seem more likely that the benefits of the extension of the royal network of patronage and the increased efficiency in land use through placing the estates in the hand of recipients capable of developing them outweighed a loss of income that may have in practice been uncollectable anyway (see the discussion in Paulus 2014, pp. 210–215). As the millennium progressed toward its end, the size of the grants shrank – a reflex of the progress of land reclamation and of the restructuring of landownership that eventually brought this episode of southern Mesopotamian agrarian history to its end. After an interim period of ecological and political crisis at the turn of the millennium, the Iron Age ushered in a new phase that would lead to fundamental change in southern Mesopotamian rural relations (Jursa 2010).

The Development of the Agrarian Regime in Northern Mesopotamia

For northern Mesopotamian agrarian history in the Bronze Age, Riehl et al. (2013) offer a concise narrative on the basis of archaeobotanical, geoarchaeological, and philological evidence. The former two categories of data allow fleshing out the sketchy picture offered by the latter: in comparison to the plethora of textual data from southern Mesopotamia, northern Mesopotamia has produced a less continuous stream of information (albeit with certain periods and regions of excellent coverage).

Throughout much of the third millennium, northern Mesopotamia was part of a network of city-states that extended through the entire region (Figure 8.7). Textual data (24th century BCE) from the city of Nabada (today's Tell Beydar), a small center under the influence of much larger Nagar (Tell Brak), gives detailed insights into the organization of agrarian production in this period and region. Farming was centralized and involved, at peak phases, the labor input of the entire population. Grain was stored centrally and allocated to the population as remuneration for labor service. Animal husbandry was organized by entrusting far-roaming shepherds with the management of the palace's flocks. In many ways, this form of organization corresponds to that of the contemporaneous and later southern Mesopotamia, demonstrating the existence of a socioeconomic continuum cutting across ecological distinctions (between irrigation and dry-farming areas) (Sallaberger and Ur 2004; Sallaberger 2004). Overall pride of place among the written sources from this period must be given to the archives of Ebla (today's Tell Mardikh, Archi 2015), whose contribution to agrarian history, however, still needs to be assessed in detail (e.g. Marchesi 2013, p. 275).The foundation of this city-state's success was attributed to wool production and the textile trade by some scholars, while others suggest overland trade in timber as the mainstay of its economy (Marchesi 2013, p. 274). The hinterland of the city is dotted with numerous smaller sites ('villages') subsisting on the basis of a dry-farming regime that was aided by wells and cisterns; their economy was clearly integrated with that of the dominant city (Mantellini et al. 2013). The palace had possibly at least some degree of control over the entire countryside – in any case, royal land grants include whole villages, and it seems likely that families generally held land conditionally from the crown, owing it labor service and dues. Details, however, are still elusive (Archi 2006).

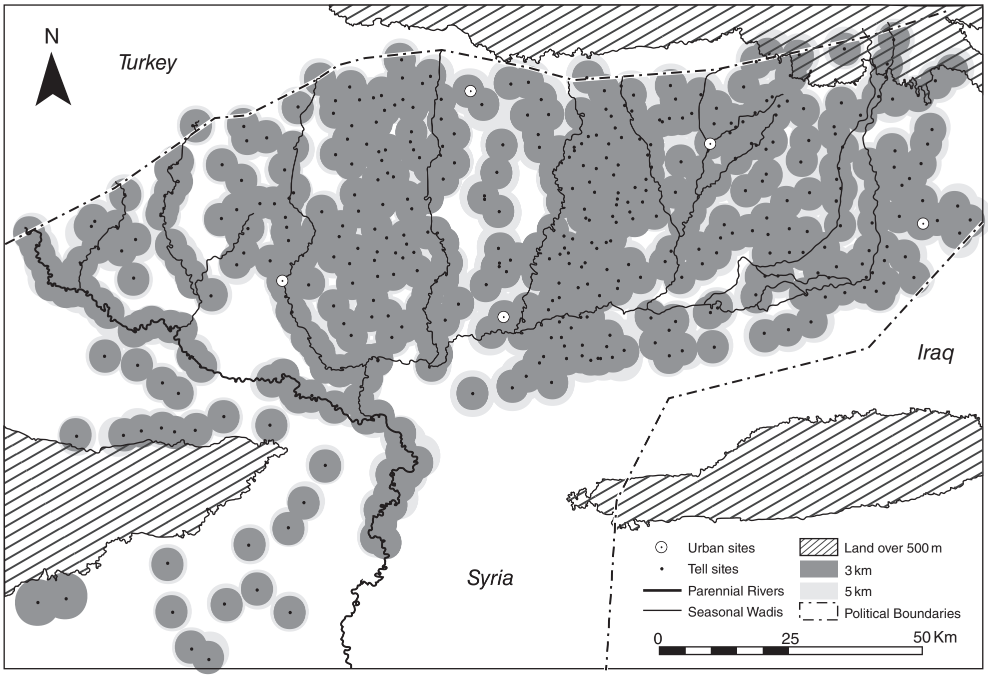

Figure 8.7 Reconstruction of land-use zones in the upper Khabur Basin of Syria. Shading indicates the likely cultivated areas around tells; the white areas between, the inferred pasture lands (by J. Ur and C. Hritz). Source: From Wilkinson (2003). Reproduced with permission of the University of Arizona Press.

The 'early city-state phase' in northern Mesopotamia came to an end around 2300 BCE, in part as a consequence of ever more intensive warfare between competing centers of power. Especially after the '4.2 ka event,' a strong tendency toward de-urbanization can be recognized in the region. Amorite groups appeared in the region and subsequently became its dominant socioeconomic and cultural element. The resultant mixed agropastoral economy of the Amorite Middle Bronze Age can be studied best in the case of the city of Mari on the Middle Euphrates. Irrigation agriculture in the river valley provided Mari its subsistence base, to which the proceeds of animal husbandry were added. The state drew its resources from royal estates and the estates of high officials; labor service – always a scarce commodity – was provided by the local population (and the military at times of a peak in demand) through a corvée system (Lafont 2000; van Koppen 2001; Mori 2007).

Finally, the Late Bronze Age saw the development of regional states in northern Mesopotamia which were united by a common socioeconomic and political culture. The king and palace elites as well as an urban upper class presided over a village-based subsistence-oriented economy. Peasant smallholding, both in dry-farming and irrigation conditions, was by no means rare. However, the tax and labor demands and other effects of political domination rendered the situation of peasants precarious. Throughout the Late Bronze Age, the tendency of city-based large-scale landownership (of palace, military, and/or merchant elites) to expand to the detriment of increasingly marginalized smallholders is visible. This could result in rural unrest. Indeed, sources describe this period's peasants as subject to corvée and military conscription, and as prone to rebellion (e.g. von Dassow 2008, pp. 102–105). Once having deserted their land, peasants could band together and form deracinated groups of landless 'bandits' who had a destabilizing effect on Late Bronze Age states (e.g. Pfoh 2016). The eventual collapse of

Late Bronze Age states was, if not caused, then accelerated by such internal tensions. A root cause of this collapse was certainly the climate change between 1200 and 900 BCE, which marks the transition between the Late Bronze Age and the Iron Age (e.g. Riehl 2013, pp. 118–120).

The textual data from northern Mesopotamia in the Late Bronze Age are rich, but heterogeneous. Of particular interest for agrarian history are the archives of Middle Assyrian provincial administrations and large-scale landholders which document many aspects of estate and labor management (Wiggermann 2000) and provide quantitative data for yields (Reculeau 2011). From Nuzi (close to Kirkuk) come rich archives of urban landowners (and a palace) from the fifteenth century which exemplify the process by which smallholders were increasingly marginalized and expropriated under a burden of debt. The texts allow also a micro-reconstruction of features of the rural landscape of the area with a level of detail that is hardly conceivable elsewhere (Zaccagnini 1979 and 1989; Maidman 2010). Finally, Emar on the Middle Euphrates has produced a corpus of documentation bearing on the rural landscape (Mori 2003): arable land (in small plots) and vineyards are amply attested. Perhaps the most striking characteristic in these texts is the evidence for communal landholding (land is said to belong to the city god "and the elders of Emar") that is being sold piecemeal to individuals.

Open Questions and Future Avenues of Research

In addition to providing an introduction to the basic parameters of Ancient Mesopotamian agriculture, the survey of the state of the question given above pointed out the principal bodies of evidence currently at the disposal of researchers. Bronze Age Mesopotamia is particularly rich in textual data which have been given pride of place since they provide unparalleled insights into agricultural practice and its social background. Much still remains to be investigated: to name just a few examples, there is as yet no comprehensive synthesis on Middle Bronze Age agriculture in southern Mesopotamia, much of the potential of the vast archives of the Ur III period of the late Early Bronze Age remains untapped, and an agrarian history of Ebla has yet to be written. Yet, all its potential notwithstanding, documentary coverage is always sketchy, necessarily incomplete and always leaves important questions unanswered – questions that typically involve quantification, model building and systemic generalization. In consequence, the value of the traditional text-driven approach to Mesopotamian agrarian history has been challenged. In developing a program for investigating agrarian change in northern Mesopotamia during and after the Akkadian period, i.e. around and after 2300 BCE, Harvey Weiss suggests that "… agricultural innovation" being "largely absent", "[i]mperial economic growth was not achieved by increases in per capita productivity but by increases in aggregate imperialized production. Understanding and explanation of the historical need or necessity for aggregate, imperial agricultural revenues in ancient West Asia is enhanced through the definition of the dynamic qualities of land, labor, and climate" (Weiss 2000, p. 92). Climate data, according to Weiss, now allow an understanding of the dynamics of "Holocene agro-production … Changing production functions can now replace the static, unverifiable relations drawn from ethnography and the instrumental record. Archaeological research, handicapped by labile variables, including those derived from the jejune epigraphic record, may now move into a long forestalled era of modeling" (Weiss 2000, p. 91). Monocausal climatological determinism may be as misleading as text-based positivism, however, and it would seem that the principal challenge that faces the agrarian historian interested in Ancient Mesopotamia is integrating textual information with science-based archaeological data on climate, settlement patterns, crop use, and so forth. Much recent work on northern Mesopotamia fits this brief (e.g. Riehl et al. 2013 and much of the secondary literature cited there). The case of southern Mesopotamia, on the other hand, is more difficult. The textual record is richer than in the north, and generally better known, but apart from some large-scale surveys made in the last century (Adams 1981), very little recent archaeological work has been done that allowed recovery of the type of complex data required for the multidisciplinary approaches commonly adopted for northern Mesopotamia. This is obviously a result of political circumstances, and may possibly change in the future. Nevertheless, as of today, research into the agrarian history of southern Mesopotamia in the historical periods is seriously hampered by the lack of specialized archaeological research on the ground.

FURTHER READING

General treatments of Mesopotamian agriculture and its social setting can be found, i.a., in Postgate 1994 and Potts 1997. The former is particularly recommended for the clarity of its exposition of the basic features of Mesopotamian socioeconomic history in the Early and Middle Bronze Age, while the latter gives more details on the physical environment. For early urbanism and its agrarian base, Liverani 1998 (in English 2006) is concise and yet authoritative. Readers of Italian should turn to Liverani's *Antico Oriente* (2017) for the currently most comprehensive one-volume presentation of Ancient Near Eastern history with a clear focus on socioeconomics, including agriculture. Two volumes of synthesis are particularly recommended for their archaeological approach: Wilkinson 2003 and, especially for the early periods, Nissen 1988.

There is a plethora of specialized studies, especially of a philological nature, but many are quite 'atomistic' in their approach; interdisciplinary studies striving to integrate textual, archaeological and climatological data are much rarer. The eight volumes of the *Bulletin on Sumerian Agriculture* (Cambridge: Sumerian Agriculture Group) contain numerous pertinent articles that remain a standard in the field. The encyclopedic presentation of the textual data on Babylonian socioeconomics in the Middle Bronze Age given by Stol 2004 (in German: there is no equivalent in English) is outstanding for the philological approach often adopted in Ancient Near Eastern studies. Reculeau (2011) is recommended also from the viewpoint of methodology as an excellent example of a study that draws on textual and archaeological data to great effect.

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CHAPTER NINE

Egyptian Agriculture in the Bronze Age: Peasants, Landlords, and Institutions

Juan Carlos Moreno García

Introduction

Pharaonic Egypt has been famous, since antiquity, for being one of the most fertile and productive agricultural landscapes of the world. The annual flood and the sediment it carried renewed the fertility of the soil and, according to Classical authors, produced considerable yields, especially by the standards of the more fragile and rain-dependent Mediterranean area. The myth of the prosperity of the country, not to speak of the industriousness of its peasantry, has thus obscured many aspects related to the actual conditions under which harvests were obtained and the resources of the Nile Valley exploited. Among these aspects, one must evoke the unbalanced documentary evidence at our disposal. Mostly based on administrative papyri, letters, and inscriptions produced by great institutions (temples, the crown itself, administrative departments, the Granary, etc.), as well as by officials and local potentates, this evidence provides a too "institutional" perspective on Egyptian agriculture. That is why it would be quite inaccurate to generalize from this limited set of sources. Thus extensive cereal production, the use of yokes and plows, a tight administrative control over agricultural activities, and the movement of cereals and other goods to and between institutions are privileged in these sources. On the contrary, domestic and small-scale agriculture, intensive production of vegetables on modest peasant allotments, the role of cash crops produced outside the institutional sphere (such as dates and horticulture), and the use of animals as well as grazing areas by peasants remain badly understood, most noteworthy because peasants rarely produced documents about their everyday activities (Moreno García 2006b, 2014). Also, with respect to the limited documentary evidence, important questions emerge, such as the role of commercialization and markets in the agricultural strategies of both peasants and institutions, the modalities of the organization of work, the resulting productive landscapes, and the impact of taxes on the productive choices of peasants (Moreno García 2008a, 2014). As for the documents preserved, their distribution is highly unequal between historical periods and

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geographic areas. Many papyri and inscriptions deal in fact with agricultural activities during the Ramesside period (1295–1069 BCE), usually related to temples and to a particular section of the Nile Valley, Middle Egypt (Gardiner 1941, 1948a, 1948b; Gasse 1988; Janssen 2004; Vleeming 1993). Later on, from the very end of the 2nd millennium, more than a hundred inscriptions refer to land donations made by individuals to temples, but they are mainly concentrated in Lower Egypt (Meeks 1979, 2009), while around 700 BCE private land leases become common, but most of the documents concern Upper Egypt (Moreno García 2016b).

Given the unbalanced nature of the documentary record, many questions remain open. In the case of land leases, they are occasionally evoked in late 2nd millennium sources, so their sudden importance around 700 BCE probably points less to agricultural innovation than to the expression in writing of otherwise customary oral agreements. In the case of private acquisitions of land, it was far from being a usual theme in private inscriptions. Hence, its sudden popularity in private sources from the very end of the 3rd millennium BCE suggests, quite probably, that a relative laxity in the composition and thematic choices in monumental texts made it possible to introduce private business as a "presentable" topic in formal inscriptions. As for isolated archives, such as those of Heqanakhte (1950 BCE: Allen 2002), Thutmose (1080 BCE: Antoine 2015), Tsenhor (late fifth century BCE: Donker van Heel 2014) and Djekhy (550 BCE: Donker van Heel 2012), they provide vivid details about the diversified agricultural interests and strategies of a "middle class" of private substantial landowners, sometimes in close contact with temples. In other cases, isolated references in administrative records and letters reveal the existence of wealthy peasants, even of agricultural "entrepreneurs," whose contribution was essential in the cultivation of institutional land (Moreno García 2013). However, this kind of tenant is hardly documented at all for the Bronze Age. Finally, documents relating to ordinary peasants are extremely rare. That is why an early archive, the Gebelein papyri (around 2500 BCE), provides invaluable evidence about small rural communities; the exploitation of natural resources (hunting, honey collecting, etc.) there played a surprisingly substantial role (Posener-Krieger 2004).

Because of the scarcity and unequal distribution (geographical, chronological, and social) of the written evidence, archaeology should have provided essential data to understand social and economic agricultural dynamics, the uses and transformation of landscape and the traces of the organization of agricultural work. Unfortunately, this has not been the case. On the one hand, it has been a common practice to consider pharaonic agriculture as tightly controlled by the state, a kind of "despotic" or "bureaucratic" regime in which individual and peasant initiatives were marginal at best. On the other hand, the alleged conservatism of the Egyptian peasantry and the apparently unchanged conditions under which they worked meant that the techniques, landscape, and forms of production remained essentially the same since antiquity. It was a conservatism only superficially altered by the introduction of limited irrigation technologies and some specialized crops by Greeks, Romans, and Arabs. Finally, the rich repertory of agricultural scenes found in the Egyptian tombs has been abusively interpreted as a direct, unbiased, and reliable source of information (Moreno García 2003, 2006b). Under these conditions, it has been common to consider Egyptian agriculture and landscape as essentially the same from antiquity until the 19th century CE, thus making it unnecessary to introduce, for example, extensive archaeological surveys like those commonly developed in neighboring regions (such as Mesopotamia). In all, any consideration of pharaonic agriculture as dynamic, subject to change over three millennia, has been marginal in Egyptology until very recently. The same is true with respect to the pharaonic peasantry, often depicted as an amorphous category of people with little internal differences (Mitchell 1990). As for topics such as the regional characteristics of agriculture and its productive specializations, the importance of pastoral activities, the role of crops such as pulses and fodder in the agricultural strategies of peasants, etc., our knowledge still remains very unsatisfactory (Murray 2000a, 2000b). For all these reasons, disciplines such as paleobotany, archaeozoology, archaeological hydraulics, archaeogeography, and the history of technology, to mention only a few, still have much to offer in order to gain a deeper understanding of Bronze Age agriculture (Moreno García 2006b, 2008a, 2014).

A final consideration concerns the relationship between the peasantry and the elites who ruled the country and its influence on agricultural practices. Temples, the crown, officials, and rural potentates employed, on a permanent or on an occasional basis, substantial numbers of workers on their estates. However, agricultural serfdom and slavery seem to have played a rather limited role there, even in periods of intense centralization of royal power. Instead, patronage and informal networks of authority made it possible for rural landlords and officials to mobilize much of the workforce needed to till their fields and, in so doing, to guarantee that their privileged social position prevailed within their communities. This position was recognized by the state, for instance, when these local elites provided the workers employed seasonally in the fields of the temples and the crown. Nevertheless, little is known about the impact of wage labor, migration to cities, or seasonal non-agricultural work as means of enabling peasants to escape these constraints and to gain more autonomy (Eyre 2004; Moreno García 2013, 2014). In any case, debts, internal family conflicts, and bad harvests exacerbated social inequalities and contributed to the accumulation of land and power in the hands of local landlords and institutions, such as temples (Moreno García 2008a, 2014). Temples appear thus as basic economic and social nodes that helped articulate the agrarian relations that tied the royal palace to the countryside, the crown to the local potentates and the peasantry. In many cases, they even administered the fields of the crown as true managerial agencies within an agrarian order formally dominated by the king. Not surprisingly, institutions, landlords, and peasants were the main actors of the agricultural life of Bronze Age Egypt.

Environmental Conditions and Physical Setting

The determinant factor in the agricultural cycle was the annual inundation of the Nile. Depending on the height of the flood, the resulting landscape, and the extent of the irrigated areas, the volume of the harvest experienced important variations from one year to the other. Given the crucial importance of the flood, it provided the basis for the Egyptian calendar with its three seasons: *akhet* "the flooding" (mid-July to mid-November), when the inundation covered the fertile riverbanks (the actual flood took place from mid-July to October) and canals could be opened to water higher land; *peret* "the coming forth" (mid-November to mid-March), when plowing, sowing, and germination took place; and *shemu* "harvest" (mid-March to mid-July), when the harvest was gathered. In fact, the annual flood had deeper effects on the agriculture, land use, and production system than the mere seasonal rise in level of the Nile. Minor watercourses and swampy areas – mainly at the bottom of the cliffs bordering the desert – dotted the Egyptian countryside long after the inundation had disappeared. The water, moisture, and fresh vegetation they provided allowed occasional pastoral, fishing, and agricultural activities to be carried out in areas relatively distant from the Nile, and for mounds, settlements, and fields to be found outside the riversides of the Nile (Alleaume 1992; Gillam 2010; Moreno García 2010a; Antoine 2011). Traces of any centralized control of the flood as well as of the irrigation system are absent for the period considered. Even irrigation canals and dykes are quite rare in the administrative and archaeological record

(Moreno García in press). As a consequence, land irrigation mostly depended on the flood with minimal arrangement of the natural basins in the floodplain, while natural wells and ponds contributed to the cultivation of fields in the immediate surroundings of settlements (Alleaume 1992; Trampier 2005–2006; Gillam 2010; Antoine 2011). Under such conditions, the possibility of exploiting a variety of ecological niches and natural resources remained an option for ancient Egyptians; extensive cattle breeding, fishing, and honey collection were activities important enough to provide substantial fiscal income (Moreno García 2014). So, extensive cereal production was never the "natural" dominant productive option. Its importance in the administrative records probably is due to the fiscal interests of the monarchy and the main institutions (such as temples) in the production of crops that could be easily stored, distributed, and commercialized.

The agricultural landscape of the country was quite differentiated. In the valley, it consisted of high land adjoining a watercourse that stood above the natural flood, dotted with trees, palms, and vegetable plots, partly developed as orchards and partly left undeveloped as scrub for pasturing flocks. Grain was cultivated beyond this area, on lower land flooded by the inundation. Beyond that were the margins of wild marshes and natural forest scrub (Eyre 1994, p. 59). Higher areas, irregularly flooded, were ideal for extensive cereal production, and it seems that it was common practice to leave these zones fallow one year in two. Perennially emerged areas, above the high point of the flood, free from full inundation, situated in a marginal non-arable area and cleared of the natural scrub vegetation were ideal for creating orchards usually planted with a mix of trees and vines, but a standing permanent water source was then necessary (Eyre 1994, pp. 60–61). In fact, ponds are usually associated with gardens and tree plantations in Egyptian inscriptions, and the administrative documents further reveal that ponds, swampy pools, and cisterns appeared in close proximity of fields (Gardiner 1948a, pp. 29–31), while small areas of marshland were part of many plots of cultivated land according to some papyri (Vleeming 1993, pp. 65–69; Moreno García in press).

The Delta and the western oasis depart somewhat from this picture. In Lower Egypt extensive areas of surface sands or thin mud accumulations occur in the central and southern Delta and remained above flood level; they were suitable only for grazing. The same conditions prevailed in the westernmost delta, where cattle breeding is widely attested in the epigraphic record. These numerous islands of dry land dotted a maze of distributary channels and naturally draining flood basins, but with an increasing proportion of marshland in the northern Delta (Butzer 1976, pp. 23–25). Under these conditions, the Delta was a land loosely settled, where fishing, horticulture, and extensive cattle grazing prevailed (Moreno García 2015). In the Old Kingdom, plant debris clearly documents cultivated landscapes, the corralling of livestock during part of the year, low-Nile pasturage at some distance from settlements, and the persistence of wetlands within the environmental mosaic. Specialized agricultural domains (vineyards, etc.) were founded by the crown on such islands, and the competition for the use of these areas provoked conflicts with pastoral populations in the quest for grazing land. The record thus exhibits the hallmarks of an established cultural landscape, rather than pioneer settlements within an "untamed" deltaic environment. But the settlement network was subject to changes over time, when the end of the 3rd millennium, for instance, saw the abandonment of many sites (Butzer 2002, p. 93). Later on, during the first millennium and especially after the Macedonian conquest, urbanism and agriculture spread over the region. As for the oasis, recent archaeological work reveals the importance of wells and ponds in earlier periods (especially at the oasis of Dakhla), while *qanats* were introduced following the Persian Period and were used together with wells at Kharga oasis. Not surprisingly, the control of water was essential there, and it figures prominently both in wills and contracts (Ritner 2009, pp. 173–178; Chauveau 2006).

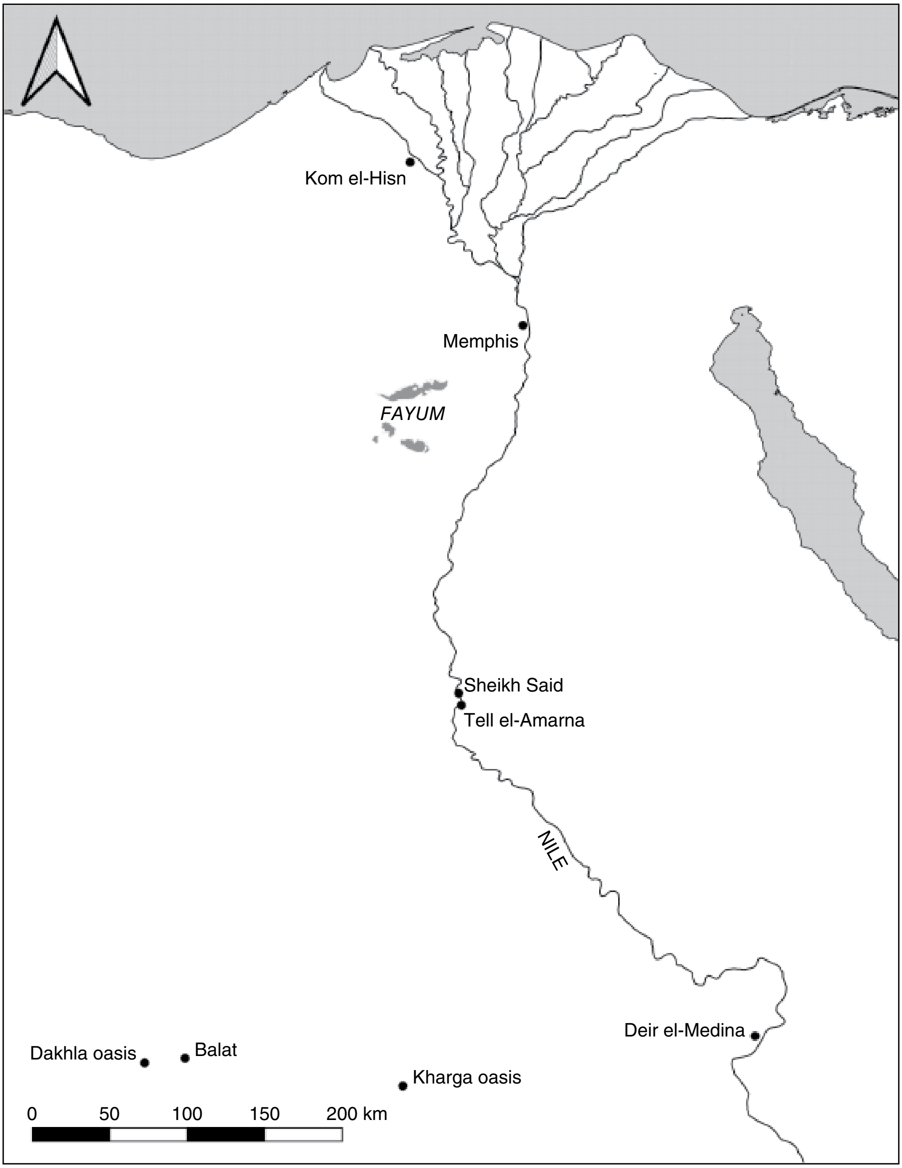

Figure 9.1 Map of Bronze Age Egypt. Source: Map by David Hollander with QGIS and map files from the Ancient World Mapping Center. "inland water.shx", "ba_rivers.shp", "coastline.shp", and "openwater.shp". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm]

As for the types of soil and their agricultural use, the land falls into two main categories: first-class land, free of vegetation, well irrigated, and producing high yields; and second-class land, usually to be cleared from bush, reeds, and weed, and where water posed a problem, by scarcity or by excess. Burning fields in order to eliminate scrub and weeds and to put land into cultivation was a practice well attested in Egyptian sources (Caminos 1954, p. 326; Wente 1990, pp. 127–128, 175–176, 180–181, 209). In other cases, the silt deposited once the annual flood passed over formed small islands and new tracts of cultivable ground. That is why ritual formulas dating to the end of the 3rd millennium evoke operations such as "flooding the riverbanks," "transporting sand," and "leveling the ground" in order to prepare land for cultivation. The new fields thus obtained apparently fell under the control of the crown, as several administrative and literary texts of the Late Bronze Age reveal (*Teaching of Amenemope*, Nauri decree and Papyrus Harris I: Lichtheim 1976, pp. 148–149; Kitchen 1969, p. 50; Grandet 1994, p. 261). Quite often, such new lands were cultivated by forced labor, be it criminals, soldiers, or serfs (Kitchen 1969, p. 260, 324–325).

The basic types of land were *khebes* "plowland," in the early 2nd millennium (Hayes 1955, p. 29; Moreno García 2006a, pp. 120–121) and, from around the middle of the 2nd millennium, *nekheb* "fresh" (Gardiner 1948b, p. 36) and, especially, *qayt* "high" in opposition to riverside land, called *kheru* "low" and *(iw) maw* "(island of) new land": "I was endowed with high and low land" was a common statement in private inscriptions then (Helck 1975, p. 16; Davies 2009, p. 34, 36). Judging from the sources, *maw*-land was reclaimed from the river once the annual flood passed over, when new agricultural areas, highly productive, were formed by the sediments deposited and by the constant changes of the riverbed. A specific type of soil was *bah*-land, an area with controlled watering, perhaps dyked to prevent free flooding and whose close association with fruit cultivation excludes the possibility that it was simply a flood basin (Eyre 1994, p. 70–71; Tallet 2004, p. 68). As for *idb*-land, it could correspond to basin lands distant from the riverbanks, areas combining high grounds and depressions sufficiently low to adjoin the water table (Antoine 2011, p. 14, 24–25; 2015, p. 113). Furthermore, small areas of "marshland" were part of many plots of cultivated land (Vleeming 1993, pp. 65–69). Archaeobotanical evidence indicates the presence of wet-loving species in many samples and may confirm the damp conditions found in some arable fields as well as a serious problem of land drainage (Murray 2000a, p. 516). Such a mixture of arable areas and surfaces to be cleared, drained, or laid out in order to be cultivated suggests that the basic form of cultivable land was a long tract perpendicular to the river in order to encompass both high and low ground. Finally, as the centuries passed, it is quite probable that some of these terms finished by evoking general aspects of the landscape and lost their original literal meaning. It has thus been suggested that *qayt* came to refer to the land usually inundated by the Nile while *maw* indicated the areas of higher elevation of the dams, above the flood level, the *geziras* and the islands of the Nile (Grieshaber 2004, pp. 47–58).

A question related to the qualities of soil is the importance of fallow in Egyptian agriculture. A passage from the papyrus Harris I (around 1150 BCE) states "I doubled their fields which had been left fallow in order to double the divine offerings (=income)" (Grandet 1994, p. 261). Many references to the *qayt*-fields in the Wilbour Papyrus, for instance, are introduced by the expression "total, *qayt* fields: *x* arouras, which makes *x*/2 arouras" (1 aroura = 2750 m^2), an accounting procedure that suggests that they were cultivated in a two-field system; furthermore, they were taxed systematically at a rate of five sacks/aroura (one sack = 76,8 liters of barley), in contrast with the first-class *nekheb*-fields (10 sacks/aroura), or the *teni*-fields (7,5 sacks/aroura). In Nubia, similar account procedures specify that several fields were to be "calculated at a quarter of arable land": Frood 2007, p. 216). As for *idb* "riparian land," it was not always in condition to produce grain and was then left fallow, while *pat* plots seemed particularly appropriate for gardening and horticulture (Antoine 2015). The Wilbour papyrus (around 1145 BCE) evokes, among the many types of plots to be subtracted from the grain producing land, *wesef* "fallow" fields (Gardiner 1948a, pp. 94–95; Katary 2006). In fact, medieval sources detail several modalities of fallow depending of the kind of soil, the crops planted, and the effects of the annual flood; *al-sharâqî* land shows many similarities with *qayt*-fields, as it was not reached by water, was left fallow for a year, and the next one was cultivated with cereals and then produced yields comparable to the most productive land (*bâq*) (Frantz-Murphy 1986, pp. 80–86; Alleaume 1992, pp. 38–39).

Ponds, wells, and cisterns are usually associated with gardens and tree plantations in Egyptian inscriptions, and frequently referred to in administrative documents as landmarks in order to locate fields (Gardiner 1948a, pp. 29–31). Wells are often evoked together with cultivated areas, usually planted with trees and vegetables, as in the Dashur decree of Pepy I (around 2300 BCE: Strudwick 2005, 104). The *Apanage* stela (early first millennium BCE) also describes the different kinds of land, trees, and cisterns being part of private tenures: "137 arouras of private cleared fields, 99 arouras of bushy and tired land, total: 238 arouras of field, 1 cistern, 8 sycamore trees, 6 date-palms" and "66 arouras of private cleared fields, 5 arouras of bushy and tired land, total: 71 arouras of field, 3 cisterns, 26 large date-palms, 50 small date-palms, 3 sycamore trees" (Ritner 2009, p. 275). Late 2nd millennium instructions for the cultivation of a landholding included clearing the land (lit. removing its grass), plowing and farming one aroura of land in vegetables "at this well" (Wente 1990, p. 209). An early demotic receipt also mentions growing flax close to a well (Donker van Heel 1995, p. 89), while a stela dated around 822 BCE mentions the donation of a field and a cistern (Jansen-Winkeln 2007, pp. 164–165). Not surprisingly, land close to wells was coveted and inspired strategies to control it; thus, Ikeni, apparently the owner of a well ("the well of Ikeni"), profited from a period of hard times to buy several small allotments (about 1400 m^2 each) surrounding it and belonging to several people (Parker 1962, pp. 49–52). Ritual texts echoed such association as they evoke together the grant of agricultural land and wells, as in formula 348 of the *Coffin Texts* ("farmlands are given and wells divided": Moreno García in press).

Another element of the landscape to be considered are trees. They were highly valued in a country where timber was so scarce, and they appear in real estate transactions as being part both of institutional and private tenures. In some cases as stabilizers of dykes and riverbanks and providers of fuel, in others as specialized plantations, the main species were sycamore trees, date palms, and dôm-palms. Documents such as the *Apanage stela* indicate the exact amount of date palms and sycamore trees in some of the plots transferred (Ritner 2009, p. 275), while the demotic papyri from the archive of Tsenhor reveal that plots of agricultural land also included a wooded area equivalent to 10% of the arable area (Pestman 1994, pp. 36–37, 82–84); under these conditions, trees were important enough to be explicitly mentioned in transfers of property, sometimes together with fields, meadows, and slaves (Théodoridès 1964, p. 47; Malinine 1953, p. 115; Manning 1994, pp. 48–49). In general, trees were reckoned by the administration together with hydraulic systems (Strudwick 2005, p. 104), and their preservation seems to have been a concern for the administration (Boorn 1988, p. 234, 236–238).

Crops and the Agricultural Cycle

Historically the Nile has provided a fairly predictable annual flood, when the country was regularly inundated between July and October. Water remained on the fields for between six to eight weeks and then was drained. Crops (cereals, pulses, and vegetables) were planted in the autumn and harvested in the spring, a single crop being grown on the land each winter in harmony with the natural cycle of the Nile. Only the development of water lifting, like the waterwheel, from the Ptolemaic period on, allowed for permanent irrigation on very limited surfaces, where a second crop grew during the summer season (Smith 2003, p. 21; Moreno García in press). Emmer wheat and hulled barley were the two most important cereals produced in Egypt until Greco-Roman times. Apparently barley was the predominant cereal during the Old and Middle Kingdoms, whereas by the New Kingdom and later periods emmer appears to have become the more important of the two (Cappers 2006, 2012). Pulses were also cultivated, and it can be inferred that they played an important role in domestic agriculture, but further research is still needed (Moreno García 2006b, p. 64). In any case, pulses were not alien to institutional food-preparing areas, as in a royal domain recently discovered at Sheikh Said (2575 BCE), where huge quantities of broad beans, peas, sorrel, and melons were eaten, as well as fish and meat from young animals (Willems 2009, p. 22). Green fodder crops were also produced and, together with pulses, were part of crop rotation, a common practice in order to regenerate the soil nutrients, especially in soils of mediocre quality or insufficiently inundated. Well attested in Greco-Roman times, crop rotation can be traced back to the Pharaonic period (Rowlandson 1994; Katary 2006, pp. 145–148).

In this respect, Heqanakhte, a prosperous tenant from the early 2nd millennium BCE, produced an invaluable set of letters addressed to his subordinates with precise instructions about the management of his fields. And what appears from them is that his agricultural choices were guided by purely private interests seeking to obtain the most profitable returns: a plot previously planted with flax was to be grown with barley unless a big inundation came, because in that case emmer would best suit the soil; another plot, left in pasture, had to be hoed; and more land was to be leased in order to be cultivated. Other accounts from his archive reveal that flax production was one of the main concerns of his agricultural activities. One of the letters states that a plot of pasturage of 14 arouras (about 3.5 ha) should be hoed, quite probably with the intention of being planted (Allen 2002). Later on, many texts refer to fields specifically devoted to "herbage" and "vegetables" or from which a rent could be alternatively paid in barley and in "vegetables" (Kruchten 1981, p. 118; Moreno García 2006a, p. 114; Wente 1990, p. 209; Kitchen 1970, pp. 804–806). In two letters from the end of the 2nd millenium BCE, an official orders a subordinate to sow the grain of a field and to plant "vegetables." The answer to this letter states that, according to the instructions given, "vegetables" had been planted. Another letter refers to a conflict about the confiscation of some fields actually planted with "vegetables" as well as about grain stored nearby, in all probability from a previous harvest (Wente 1990, p. 46, 186–187). In some instances, the "harvest" of beans from bush-like plants was recorded in monumental inscriptions (Spencer 1989, pl. 101A). Unfortunately, many administrative and agricultural documents employ quite frustratingly imprecise terms, thus making it impossible to know the particular species planted and the modalities of crop rotation used. In some cases, cereals may alternate with *semu* "herbage" (even "fodder"), while in others *wadj* "vegetables" appear as a more preferable option in well-irrigated small plots. Antoine has stressed that different verbs designated agricultural operations: *seka* "to cultivate" for grains and *dega* "to plant" for vegetables, which suggests different techniques (Antoine 2015, p. 109). In any case, deliveries of "vegetables" could be quite substantial (more than a thousand sacks: Gasse 1988, p. 98), thus implying that they could be stored (lentils, beans?). All this evidence reveals that crop rotation practices were common in Egyptian agriculture and that they probably helped regenerate the fertility of soils, especially on *qayt* land, which was irregularly flooded by the Nile (Moreno García 2018a).

From the middle of the 2nd millennium BCE, it seems that the introduction of the *shaduf*, a new irrigation device, made perennial irrigation possible on small gardens and favored the expansion of lucrative specialized crops such as dates, vegetables, fruit, and flowers. Papyrus Louvre 3226, for instance, mentions the delivery of dates (by private individuals?) to institutions in exchange for grain, at a constant rate of one sack of barley for a sack of dates. The global quantities exchanged were not very high: between 50 and 100 sacks per year in each individual operation, between the 28th and 35th years of the reign of Thutmose III (1451–1444 BCE); this represents between 3.8 and 7.5 tons of dates. How the dates were obtained is not specified, but similar later papyri reveal that small fleets sent by temples and royal institutions traveled around the Nile and collected dates and other goods from individuals, from cereals to flowers, from vegetables to wine (Janssen 1961). This means that in all probability the ships mentioned in the Louvre papyrus obtained the dates from individuals on a regular basis (Megally 1977; Moreno García in press). As date palm plantations were only affordable for wealthy Egyptians, given the specialized workforce they required (few archaeological traces of date consumption are available even on well-sampled New Kingdom settlement sites: Murray 2000b, p. 619), and dates were harvested around autumn, this means that they could get cereals in spring and dates in autumn, and the effect of a meager harvest of one of the two crops could be offset by an abundant harvest of the other, a possibility not available for poor peasants. A consequence is that grain loans were made at a high interest (50%) precisely because peasants would have more difficulties in paying them back (serfdom appears as a further consequence; from a comparative point of view, cf. van Leeuwen, Földvári, and Pirngruber 2012).

Gardens and plantations of trees are best recorded in the institutional and elite spheres, usually as providers of luxury, elite-oriented goods (fruits, wine, oil). Metjen, an official who lived around 2600 BCE, acquired a garden that measured about one hectare, set out with trees, a large pool, and planted with fig trees and vines (Strudwick 2005, p. 193). A similar garden (1.26 ha) has been found at Tell el-Amarna, and it has been estimated that it comprised about 1630 vines (Tallet 1998, pp. 244–245). New Kingdom dockets provide more information about institutional plantations of vines and olive trees whose production was devoted to the provision of temples and the royal palace; they were usually cultivated together in the same domains, quite often in basin land with large trees surrounding the plantation (Tallet 1998, pp. 245–247; 2004). It is also noteworthy that the institutional nature of such plantations explains why they appear preferentially in areas close to the royal capital, like the "West river" in Akhenaten's reign or in the eastern Delta under the Ramessides (Tallet 1998, p. 249). Nevertheless, growing vegetables and fruit on a large scale is still an expensive and difficult undertaking in Egypt today (Smith 2003, p. 21). So, as in the case of Metjen's, wealthy individuals, usually members of the ruling elite, devoted limited areas to gardens, as in the case of an aroura of land to be planted with fruit by the deputy of the temple Nessobek (Wente 1990, p. 176), or the field of five arouras of cucumbers, carobs, and other plants belonging to a villa mentioned in a Ramesside literary text (Caminos 1954, p. 165). In all, the use of the *shaduf*, first attested in the early New Kingdom, only had limited implications for irrigation because of its high labor costs and the very small area that could be watered directly (Eyre 1994, p. 63). That is why it was probably used in a context of elite exploitations oriented toward urban markets and providing fruit, wine, flax, and flowers (Wente 1990, pp. 92–93; Tietze 2011, pp. 202–228). Even in areas quite far away from the Nile Valley, as in the oases of the Western Desert, similar productive conditions prevailed. The discovery of an important archive of late 3rd millennium clay tablets from Balat, in the oasis of Dakhla, deals with institutional agricultural affairs. Not surprisingly, they focus on taxable storable and long-lasting goods, like cereals and linen, and only rarely on dates and garden produce (Pantalacci 2006, pp. 83–85). Given the harsh conditions prevailing there, water was the key element in the oasis agriculture, and wells and ponds were invaluable property transferred by will (Philip-Stéphan 2008, p. 261).

Distinct patterns of production and food consumption are also apparent with regard to beer and wine, the latter being, like meat, not a staple but a prestigious item. Beer was brewed at the domestic level for daily use and also delivered to workers in standard rations. By contrast, wine appears to have been largely produced for royalty, the upper classes, the funerary requirements of the elite, and religious rituals. It apparently became more widespread by the

New Kingdom (1550–1069 BCE), when non-royal officials, and on special occasions common people, also had access to it; some evidence even suggests that it was then produced not only in state vineyards but in private ones too, the main wine-making regions being the Delta and the western oases. Furthermore, vines were traditionally cultivated more in gardens and orchards than on purely agricultural lands, alongside fruit trees and vegetables, thus suggesting that they were originally intended to provide fruit, not wine; quite significantly, the term for vineyard (*kamw*) is the same as that used for garden and orchard. As for olives, their apparently late introduction, during the New Kingdom, and their complex horticulture would explain why they were restricted to elite contexts and why olive oil production remained rather more limited in Egypt than elsewhere in the Mediterranean. In contrast, other vegetable species provided the oil currently employed in the country (Murray 2000b). Fruit trees were also an important element of ancient Egyptian food production and included dates, figs, olives, persea, carob, Egyptian plum, and Christ's thorn (Murray 2000b, p. 616). As for vegetables, onions, garlic, lettuce, celery, and melon are well attested both in the written and the paleobotanical record. Finally, flax was an important product as the majority of ancient Egyptian textiles were of linen. Its production was one of the main concerns among the agricultural activities carried out by Heqanakhte (Allen 2002, pp. 172–178) and, in fact, flax appears as a coveted crop in private agricultural transactions (Wente 1990, p. 92; Donker van Heel 1995, pp. 101–103, 107–110, 236–239).

Nevertheless, any study of Egyptian crops should not be reduced to a mere enumeration of species. The plants and crops cultivated, their respective proportion in peasant allotments, and the landscape thus resulting were the consequence of the prevalent social relations of power and, consequently, of the degree of autonomy in peasant day-to-day decision making. Such conditions (and the possibilities they opened) imposed choices of production and patterns of consumption underlying alternatives like cattle versus pig (and fish), meat versus pulses, wine versus beer, cereal production versus horticulture, etc. (Barceló 1988; Sherratt 1999; Sigaut 2004). In fact, agricultural production was the result of the interaction of variables like intensive/extensive, domestic/institutional, autonomous/tax-oriented, and subsistence/market production, and its study would only be possible in the framework of detailed research programs of paleobotany and landscape and irrigation archaeology. Significant storage, for instance, was only possible for institutions and wealthy landowners (but about 10% of the harvest stored was lost because of spoilage: Adamson 1985), and storage facilities like large silos appear in the archaeological record related to houses belonging to the middle-high sectors of Egyptian society (Kemp 1991, pp. 309–310; Adams 2007).

Technical Aspects and Animal Use

Each possible combination of these variables resulted in a particular type of agriculture and affected the crops planted, the technical choices and animal use, the specific work processes implemented, particular social organizations of agriculture, and differentiated landscape morphologies. However, the biased nature of the written and archaeological sources prevents a thorough understanding about how these possible agricultures were organized, interacted, and evolved over time. In the case of the choice between the hoe and the plow, it corresponds to different agricultural strategies, and the contemporary Mesopotamian agriculture echoed such dichotomy in the popular literary *topos* of the "debate between the hoe and the plow" (Civil 1994, pp. 73–75). That the hoe and the plow were used in Egyptian agriculture is, of course, widely known. But the social and technical conditions underlying their use have been largely underestimated, especially in the case of the plow (Chadefoud 2007; Moreno García 2008–2009).

Unlike iconography and administrative documents, the plow was used only by institutions and landlords in very specific contexts like extensive agriculture as well as limited horticulture in artificially irrigated plots. Outside such particular conditions, its use was superfluous because of the characteristics of the flooded soil of the valley (where no preparatory labor was needed) and the costs of keeping a yoke (Moreno García 2008-2009). But on higher ground, where the effects of the annual flood were more limited, the plow or the hoe were required to cover the seed; the second option implied an intensive (and costly) use of work and, consequently, the plow was preferred and became indispensable in large tracts of land, in which smaller yields were compensated by the cultivation of sizable fields. The Egyptian sources show that *qayt*-fields produced half the harvest expected from good *nekheb*-land, but they represented nevertheless a great percentage of the institutional land held by the temples and the crown, usually as large domains. In many cases, they were cultivated by means of plow teams. According to this system, a cultivator (*ihuti*) was provided with a yoke by the institution in exchange for the obligation to farm a standard plot of 20 arouras (about 5.4 ha) and deliver 200 sacks of cereal (one sack = 76.8 liters of barley: Moreno García 2008a, pp. 123–129; 2010b; 2016b, pp. 228–232; Wente 1990, p. 131). Consequently, only institutions, wealthy peasants, and landlords could afford to keep a plow and plow teams; a good example is the well-off Heqanakhte, who possessed a substantial herd of cattle and was able to lend grain to many neighbors and/or clients (Allen 2002, p. 19). The prestige and symbolic importance of plows pervades iconography and private inscriptions, as in expressions like "one who farms with his yoke" and "I have farmed for him who was deprived of yoke and I gave seed to him who requested (it) from me" (Moreno García 2008-2009, p. 57). As for donkeys, they were also expensive and unaffordable for ordinary peasants. Evidence from Deir el-Medina reveals abundant transactions involving hiring donkeys. They were apparently employed in carrying water, firewood, grain, straw, dung, and only very rarely for plowing and threshing.

Given the scarcity of yokes and donkeys in the hands of ordinary peasants, pasturages were intended to supply fodder for temple herds (Katary 1989, pp. 75–76), for horse teams used in chariotry (Caminos 1954, p. 326) and for cattle in the hands of well-off Egyptians (Caminos 1954, p. 413). In some instances, herbages could even be requisitioned from the gardens of well-off Egyptians (Kruchten 1981, p. 118). A good example is a late 3rd millennium BCE cattle-raising center, Kom el-Hisn, that delivered little wood charcoal and animal bones but huge amounts of dung as well as of samples of fodder plants (Murray 2009, p. 258). It seems that it was a specialized cattle rearing domain founded by the crown in a rich grazing area in order to provide for the needs of the palace far away, at Memphis (Moreno García 2015; Wenke, Redding, and Cagle 2016). Pasture areas figured prominently among the possessions of temples (Strudwick 2005, p. 104; Moreno García 2006a, p. 104; 2010a, p. 54; Ritner 2009, p. 515).

If plows, yokes, taxes, and extensive grain producing were inseparable from institutional agriculture, the characteristics of domestic agriculture were probably quite different, but it is only possible to speculate from the reduced amount of written and archaeological evidence available. Hence gardening, horticulture and, in general, intensive labor on small plots might have been its main characteristics. Probably domestic agriculture produced higher yields because of the scarcity of cattle and donkeys (it was not necessary to produce fodder), the subsequent intensive employ of labor (typified by the hoe) and, perhaps, the use of manure from domestic waste (a Ramesside ostrakon mentions donkeys loaded with grass, manure, and straw: Wente 1990, p. 161; donkeys loaded with manure are also evoked in a second century CE agreement, whereby an individual agrees to convey dung to the vineyard of a landlord: Delia 1986). Pulses and vegetables, as well as pigs, fowl, and small flocks of sheep and goats, appear to play an important role in peasant production and diet together with cereals, a diet occasionally complemented by fishing, gathering of wild plants and fruits, and perhaps fowling; in this respect, it is quite significant that pigs and fish were symbolically considered inappropriate for elite and ritual diet, but they formed part of the diet of common people, even as rations delivered by the state (Moreno García 2003, 2006b, pp. 50–66). In fact, common Egyptians ate few cattle and dairy products, while fish was a widespread component of their diet (Thompson et al 2005). Also significant is that the villagers recorded with their occupations in the Gebelein papyri were often involved in hunting, honey gathering, and, apparently, fowling (Posener-Krieger 2004). The traces of such practices have been detected, for instance, in the Workers Village of Tell el-Amarna, where small vegetable gardens and plantations joined pens for pigs, and in Elephantine, where goats were raised in a domestic context (Moreno García 2006b, p. 64; Kemp and Stevens 2010). As meat was not a regular item in the diet of most Egyptians, pulses such as lentils, peas, chickpeas, and fava beans would have been an important and widely available source of protein for most of the population but, again, they are rarely mentioned or represented in official texts and iconography. The landscape thus resulting might have consisted of small plots surrounded by trees close to ponds and pools used by the community.

As for agricultural techniques, cutting cereals low on the straw leaves cereal stubble in the fields for livestock to graze and also leaves a long length of straw attached, a harvesting method well attested in the Old Kingdom (2686–2160 BCE). Reaping high on the straw is done when the harvester wants to cut only the ears of the cereal and as little straw as possible; if the straw is to be used later as fuel, stored fodder, or building material, it must be cut in a separate operation (Murray 2000a, p. 521). If not, it could be simply burnt. Reaping high seems to have prevailed in New Kingdom times, whereas Pliny the Elder (*Natural History* 18, XLV 161–162) reported that in Egypt wheat was cut twice (Murray 2000a, p. 524). As for threshing, trampling by animals was the method usually employed according to the iconography and the textual evidence (Wente 1990, pp. 122–123); another possibility was beating with a stick, a method prevalent when small quantities were processed but which has been hardly represented at all in Egyptian art, the Ptolemaic tomb of Petosiris being an exception (Murray 2000a, p. 524); nevertheless, it must never be forgotten that iconography deals mainly with the agricultural practices carried out in an institutional or wealthy milieu, and that any generalization to peasant methods is hazardous. Thus threshing floors are usually linked to institutional domains and to the delivery of taxes in cereal (many examples in Janssen 2004).

The Transformations of Institutional Agriculture Over Time

Bronze Age Egyptian agriculture knew many transformations over the centuries, especially in the institutional domain, the best-documented one. In the Thinite (3100–2686 BCE) and Old Kingdom (2686–2160 BCE) periods, the crown founded a network of agricultural domains and production centers (the most important were the *hut* and the "great *hut*"), each one in control of substantial tracts of land and provided with workers and, sometimes, cattle. At the same time, pharaohs endowed temples with fields, sometimes as large as 100 ha each (Moreno García 2001, 2007). The crisis of the monarchy at the end of the 3rd millennium was apparently followed by the disorganization of the prevailing model of institutional agriculture. On the one hand, pharaohs at the turn of the 3rd millennium had to rebuild the tax system of the crown, appoint governors of *hut*, and grant cattle herds to provincial officials with the obligation of delivering quotas of animals to the Treasury (Moreno García 1999, pp. 175–178; 2006a, p. 115; 2007, p. 327). On the other hand, inscriptions highlight private acquisition of fields, flocks, and serfs as well as the economic autonomy of their owners and their households (Moreno García 2000). One of those moderately wealthy landlords was Heqanakhte. He and his well-off neighbors could well be representatives of a provincial "middle class," owners of important tracts of land and flocks, who ran their agricultural "enterprises" in a rather rational way, seeking to maximize their income. It is quite significant that, at the same time, the old network of royal agricultural centers (the *hut*) was never restored, while a new class of royal camp works (called *kheneret*) flourished, sometimes in charge of clearing and preparing soil for cultivation. Temples still possessed substantial agricultural domains (Quirke 1988; Moreno García 2006a, p. 113–124). Large containers found in Nubia and the Levant could have been used for the export of agricultural goods (including grain), but the volume of these transactions cannot be ascertained.

Around 1600 BCE, important innovations were introduced. The *shaduf* made it possible to irrigate permanently small gardens and orchards. At the same time, new fruit trees were introduced: almond, pomegranate, and apple, while date palms and olive trees flourished. It was then that private gardens and institutional plantations expanded, when literary texts and iconography celebrated peri-urban gardens and the production of vegetables (sometimes for export) and that gardens and orchards were part of the luxury villas of the elite. Furthermore, many administrative papyri reveal a flourishing private agriculture, based on lucrative crops, oriented toward urban markets and institutions. Fleets of crown and temple ships collected wine, vegetables, dates, flowers, and fruits from private tenants, sometimes in exchange for grain. It seems that such agriculture was therefore based on intensive horticulture, whose labor costs were too expensive for institutions and thus left in private hands (with the exception of olive plantations and vineyards; Moreno García in press). Emmer began replacing barley as the main cereal crop, and it seems that huge amounts of Egyptian grain were being exported abroad (especially toward the Hittite empire, in Anatolia and northern Syria). In fact, Egyptian temples became enormous agricultural agencies, in control of more than one third of the land of the country (Katary 1989; Grandet 1994; Haring 1997). This circumstance is linked to the arrival in Egypt of foreign prisoners of war and serfs, whom the king often granted to the temples. This made possible the expansion of the "*ihuti* agrarian model," in which *ihuti*-cultivators, settled in temples and royal domains, were constrained to cultivate standard allotments and deliver fixed amounts of grain (Moreno García 2008a, 2010b, 2016b, pp. 228–232). At the same time, a network of state granaries collected, stocked, and redistributed grain, especially during the early New Kingdom (Megally 1977). Towns also delivered grain taxes to the royal administration (sometimes as *shemu* or harvest tax). However, no significant agricultural crown center then played a role similar to former *hut* or *kheneret*. Finally, the texts also evoke the importance of wealthy peasants and agricultural "entrepreneurs" in the cultivation of the land of temples and the crown, while land leases are occasionally mentioned in the texts.

The crisis of the New Kingdom interrupted the flow of foreign prisoners and confirmed the role of temples as the main organized economic power in Egypt, especially in the South. The shortage of imported manpower led to the gradual decline of the "*ihuti*-model," partly compensated by the resort to compulsory work and partly by a greater involvement of individuals (called *nemehu* or "free tenants") in the exploitation of the domains of the temples, as the first written land leases show (Gasse 1988; Vleeming 1993; Moreno García 2016b). Land donations to the temples, usually recorded in stelae, flourished where solid institutional powers were absent, especially in Lower Egypt and the area of Memphis and Fayum (Meeks 1979, 2009).

Current Debates and Avenues for Future Investigation

Currently, some ideas are subject to intense scrutiny. One of them concerns the history of the introduction and diffusion of different types of cereals in Egypt and the modalities of their cultivation (Cappers 2006, 2012), as well as the chronology and impact of date cultivation in the Egyptian economy (Newton et al. 2013). Palaeobotany also provides crucial information about the plants cultivated and consumed in particular settlements (Stevens and Clapham 2013), but much of the research is carried out at "atypical" sites, such as specialized settlements (inhabited by artisans, priests, or officials) instead of rural villages. In all, several major axes of research still remain largely underdeveloped in Egyptology and await in-depth studies. One of them concerns the role of pulses in diet, crop rotation, and in the exploitation of insufficiently irrigated areas. Another major axis concerns the history of agriculture itself, the transformation of agricultural landscapes over time and the interaction between pastoral and agricultural production in the strategies of rural population. In this respect, the modalities and organization of agricultural production in small-peasant land allotments remains poorly known given the predominance of institutional plots in the administrative record. This, of course, is inseparable from careful regional studies in order to detect specific agricultural practices, even potential productive specializations, in different parts of Egypt. The study of irrigation, both artificial and flood-based, has still to explore all the possibilities opened by the seminal studies of Alleaume, including the regime of the Nile and the changes in the morphology of the floodplain because of the continuous "migration" of the riverbed. Expansion and contraction of cultivated areas, internal colonization in particular areas, their interplay with wetland, marsh, and bush areas, and the impact of the creation of royal and temple domains on such areas also open promising perspectives (Moreno García 2010a; Bunbury 2013). The typology of soils, and the comparison between pharaonic and Islamic sources should be quite fruitful (Frantz-Murphy 1986). Oasis agriculture also emerges in recent times as a very promising area of research, including flows of specialized cash crops exported to the Nile Valley and elsewhere (Agut-Labordère 2016). The organization of peasant work process(es) and production strategies still awaits an in-depth study, and the contributions of the history of technology about agricultural tools, crop processing, storage, manure, etc. should also play a crucial role in the future. Such study should also include a better knowledge of seasonal work practices of the rural population and the possibilities for seeking jobs (corvée, sharecropping, day laborer, etc.). Animal use, farm animals and, in general, animal exploitation and the processing of animal by-products in the strategies of peasants and institutions (including hunting, fishing, leatherwork, etc.) should be better understood, sometimes as alternative and/or complementary activities to agriculture, an aspect that should include fish breeding and seasonal fishing (Nile perch, for instance, was broadly exported to the Levant: Linseele, Van Neer, and Bretschneider 2013). The role of markets and commercialization in domestic and institutional agriculture, their incentives and constraints, also deserves close scrutiny (Moreno García 2014, 2016a), as well as peri-urban horticulture oriented toward urban markets and the role played by investments in lucrative plantations (date palm, vines) and in artificial irrigation devices, such as the *shaduf* (Moreno García in press). Crops specifically planted for "industrial" purposes, even for export (such as specialized oils used in cosmetics, perfumes, dyeing, and leatherwork, particular fibers, etc.), should reveal regional specializations and internal circuits of exchanges (Moreno García 2018b). Finally, philology still has much to offer in domains as diverse as the identification of plants, types of land, tools, and agricultural operations. As for the social organization of agriculture and its dynamics over time (indebtedness, peasant stratification, rural "entrepreneurship," etc.), its study should definitely banish the still tenacious *topos* of the "eternal" Egypt and its not less "eternal" *fellah*.

FURTHER READING

An overall agrarian history of Egypt during the Bronze Age is still lacking, but some collective volumes include chapters devoted to specific periods or to single archives dealing with agricultural matters during this period (Bowman and Rogan 1999; Eyre 1994, 2004; Moreno García 2006, 2016b; Antoine 2015). Land possession and the modalities of access to agricultural land has also been the focus of intense research (Allam 1994; Katary 1989, 2000, 2012; Antoine 2014). Excellent syntheses analyze the role played by cereals and cereal processing (Samuel 1993, 1999; Murray 2000a, 2009; Bats 2018), but domestic horticulture, pulses, and small-scale irrigated agriculture await in-depth studies (Eyre 1994; Moreno García 2006b and in press). The same is true about the history of agricultural tools and the social conditions of their use (on plows, see Moreno García 2006a), as well as of crop rotation (Katary 2006; Moreno García 2018a) or the role played by commercial production (Agut-Labordère 2016; Moreno García 2016a). The contributions from ethnology (Cappers 2006) and from comparative history on the long *durée* are crucial in this respect (Ruf 1988, 1997).

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CHAPTER TEN

Agriculture in the Bronze Age Levant

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The term "Levant" describes the eastern Mediterranean region, which can be divided into the Northern Levant (parts of Turkey and Syria), the Central Levant (Lebanon), and the Southern Levant (Israel, Palestine, and Jordan). With regard to a combined chronology of the Levant (Sharon 2014), the Bronze Age includes the Early Bronze Age (ca. 3700–2300 BCE), the Early Bronze Age IV/Intermediate Bronze Age (c. 2300–2000 BCE; both terms for this period are used in this chapter), the Middle Bronze Age (c. 2000–1550 BCE), and the Late Bronze Age (c. 1550–1200 BCE). During this long time span of approximately 2700 years, major historical and cultural developments took place, namely: the first rise of urbanism (Early Bronze Age I; c. 3700–3000 BCE), the evolvement of the first urban societies (Early Bronze Age II–III; c. 3000–2300 BCE), processes of de-urbanization during an intermediate period (c. 2300–2000 BCE), the rise of flourishing city-states (Middle Bronze Age; c. 2000–1500 BCE), and the transformation of the city-state system into a network of city-states under vassalage of great empires (Late Bronze Age; c. 1500–1200 BCE). Agriculture was always the fundamental base of all Bronze Age societies in the Levant, and the agricultural dynamics during these 2700 years were closely connected to the historical and sociocultural developments in the Levant and in its various subregions.

Archaeological and Textual Evidence

Bronze Age agriculture of the Levant is reflected in archaeological as well as in textual sources. These sources are rich and manifold, which corresponds to the fact that agriculture was crucial for the Levant during the Bronze Age. However, it has to be stated that many aspects of Bronze Age Levantine agriculture are not reflected by archaeological remains or by ancient texts. This is firstly because ancient texts were generally not written by farmers and secondly because archaeological excavations are usually not conducted on agricultural terrain but inside of settlements. Only in rare cases do archaeological investigations focus on ancient cultivation areas (e.g. Hopkins 1985; Gibson 2001). Furthermore, ancient agriculture of the Levantine regions in general is only rarely considered as a main research topic (but see Klengel

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

and Renger 1999; Borowski 2009; Borowski 2013; Kamlah and Riehl, 2020). However, living conditions of ancient peasants and aspects of their agricultural activities did leave material remains: the size and the structure of ancient settlements are related to the agriculture of their inhabitants. Only in recent archaeological research is specific attention paid to rural settlements (e.g. Faust 2000; Maeir, Dar, and Safrai 2003; Schwartz 2015). Moreover, regional settlement patterns give evidence of agricultural strategies within the respective regions (e.g. Moyal and Faust 2015). Therefore, the change of settlement patterns in the course of time is an important source to reconstruct the dynamics of ancient agriculture.

The most significant archaeological finds to reconstruct Levantine field crops of the Bronze Age are the remains of the cultivated plants themselves. Likewise, animal bones are the primary source for Bronze Age animal husbandry in the Levant. Such remains can be gained and analyzed by archaeobotanical and zooarchaeological sampling inside of settlements. Furthermore, specific tools for agricultural activities are known from numerous excavations of Bronze Age settlements in the Levant. The most important tools are the plow (Hruška and Seidl 2003–2005) and the sickle (Müller-Neuhof and Schrakamp 2009–2011). Archaeological excavations have uncovered architectural remains which were constructed for agricultural purposes. In rare cases, such architectural remains like terrace walls or irrigation canals were excavated within ancient field areas. Extramural archaeological evidence for processing agricultural products comes from countless olive and wine presses which have been traced by archaeological surveys (Frankel 1999). Additionally, many relevant structures, installations, and objects which served for storing or processing agricultural products were excavated inside of Bronze Age settlements. Aspects like storing agricultural products in installations and vessels or processing agricultural products with stone tools are increasingly important for reconstructing ancient agricultural production (cf. Rowan and Ebeling 2008; Manzanilla and Rothman 2016). Bronze Age animal husbandry has left archaeological traces inside of settlements and houses as well. However, only little archaeological research has been undertaken until now to reconstruct Bronze Age animal husbandry by analyzing architectural remains like stables or animal troughs.

Iconographical approaches offer additional sources. Depictions of plants and animals on various media testify to the importance of the agricultural environment for Levantine Bronze Age communities. However, most of the iconographic media, like seals or decorated luxury items, are restricted to a limited social stratum and are connected with the elites of Bronze Age societies. In comparison with contemporary Egyptian wall paintings inside of tombs, agricultural depictions illustrating the daily life of peasants are relatively rare in the Bronze Age Levant.

A similar situation is offered by the written sources. In the Levant, many Bronze Age inscriptions have been uncovered which mention agricultural products, including livestock. Such texts were mostly found in archives, like the Early Bronze Age Ebla tablets and Late Bronze Age texts from Ugarit or from the Tell el-Amarna archive in Egypt. The latter contains cuneiform clay tablets written in the Levant. The literary genres of these texts consist mainly of letters, administrative texts, tax or tribute lists, and ritual sacrificial lists. While such texts do frequently mention agricultural products, they mention these products only *en passant*. Hieratic inscriptions from southern Palestine represent administration documents of the Egyptian-ruled colony of Canaan. The inscriptions date to the end of the Late Bronze Age and the beginning of the Iron Age, and they refer to crop deliveries in favor of the Egyptian administration. Regarding Old Testament texts, it has to be stated that their authorship date is not Bronze Age; yet Old Testament texts contain many references to realities and to symbolic meanings of agricultural activities in the Southern Levant during the Iron Age.

Next to archaeological, iconographical, and written sources, we have ethnological surveys, which are crucial for our understanding of Bronze Age agriculture in the Levant. Above all, the pioneer work of Gustav Dalman (1928–1942) has to be mentioned, followed and expanded by recent research (Halayqa 2014; al-Hroub 2015).

Geography and Climate

From a physical geographic perspective, the "Levant" describes the eastern Mediterranean region that borders the Taurus Mountains in the north and the desert regions in the east and south (Figure 10.1). As for other regions with a rich cultural and political history, the geographic extent of the "Levant" as well as the cognitive maps projected on southwest Asia changed throughout time, depending on ancient people's migration patterns, religion, commerce, and strategic networks (Scheffler 2003). While the term "Levant" is of common use in describing the prehistoric and historic eastern Mediterranean region, it is less applied in modern political geography, referring to Syria, Jordan, Israel, Lebanon, Cyprus, and the Hatay Province in Turkey. A comprehensive overview on the historical geography of the ancient Levant is provided by Suriano (2014), who includes Cyprus, Cisjordan, Transjordan, the Southern Levant, as well as the Northern Levant, which he distinguishes into an upper and lower part. The northern and southern part of the Northern Levant meet, according to Suriano's classification, in the area around Homs, which is geomorphologically characterized by an intersection between the Jebel Aansariye in the north and the Lebanon and Anti-Lebanon Mountains in the south. Modern Lebanon would thus belong to the southern part of the Northern Levant, while western Syria and the Hatay region are in the northern part of the Northern Levant. We follow this classification in keeping Suriano's trisection of the Levant, but refer to "Central Levant," replacing Suriano's term for the southern part of the Northern Levant.

Since prehistoric times Mediterranean landscapes have been shaped by a complex interrelationship of geographic parameters and human intervention that changed vegetation and water balance and thereby introduced considerable impact on the development of ancient agriculture. Investigating the nature of ancient agriculture is thus bound to an understanding of the characteristics of Mediterranean climate dynamics in general and throughout time. These main climatic features are the seasonal differences in temperature, the south-east increasing continentality and the distribution patterns of precipitation, which cause the specific spatial and seasonal differences in surface runoff, the water table, vegetation, as well as agricultural production (Wagner 2001). In detail, these features determine the NW-SE increasing length in summer aridity, resulting in a mean of six humid months in the Mediterranean-humid to -subhumid climate of the Hatay region decreasing to two humid months in the Mediterranean-subarid to arid climate of the Gaza Strip, complemented by a similar pattern from the coast to the inland regions. In the Mediterranean, six arid months are considered as the agro-ecological dry boundary, which does not correspond to the often cited 200–300 mm isohyet (e.g. Wilkinson 2003). The latter is based on the mean annual amount of precipitation and is the better marker for differentiating rain-fed from irrigation agriculture in the area of northern Mesopotamia, because of the more even relief there, accounting for a less steep decline of the isohyets. Furthermore, the total amount of precipitation accessible to plant roots changes along the NW-SE decline, although the effective water availability is massively influenced by the relief, which is particularly diversified along the Levantine coast. Additionally, the inter-annual variability in precipitation that increases in a north-south direction from 5% to 35% is responsible for a high degree of unpredictability in agricultural production in the southern regions (Wirth 1971).

Figure 10.1 Map of the Levant.

The particular climatic features that determine modern agricultural production probably did so in the past. Modern land use in our area of consideration includes specialized fruit tree culture, in particular, olive in the coastal areas of the northern and Central Levant, irrigation agriculture of selective crops in the Southern Levant and in the Jordan Valley, but also in the Hatay region, with dominant cereal cultivation branching out toward the southeast, and transhumant agriculture in the elevated and mountainous regions transforming into nomadic animal husbandry in the dry steppes (Wagner 2001; precise information on modern land use in the later 1970s is available from the TAVO A X maps commented by Richter 1979).

The natural sensitivity of Mediterranean ecosystems relating to the described natural differences influenced soil preservability particularly in relation with human interference with natural vegetation units, thus leading to extended soil erosion and negative feedback mechanisms on the water balance since prehistoric times (Butzer 2001, 2005; Chew 2001). While the degree and the consequences of human impact on Mediterranean geo-ecosystems can still be considered subject to fundamental research demand, numerous palaeoclimatological works, both on the global and regional level, have helped generate a relatively sound knowledge of ancient climate dynamics.

During the last decades, past climatic fluctuations have been a research subject for a wide range of palaeoclimatological and archaeological disciplines and have been recorded in sea and lake sediments, speleothems, river beds, tree rings, and ancient plant seeds, by applying diverse methods such as stable isotope geochemistry, palynology, dendroecology, and dendrochronology (Bradley 2015).

At least two major climate fluctuations have been discussed in relation with sociocultural changes in the Bronze Age Levant, and it is clear that human impact during this time period also played a considerable role in environmental and economic transformations. Palaeoclimatologists refer to these fluctuations as the 4.200 BP and the 3.200 BP events (Wanner et al. 2008; Staubwasser and Weiss 2006; Issar and Zohar 2004; Pustovoytov et al. 2007), roughly marking the transitions from the Early to the Middle Bronze Age and the Late Bronze Age to Iron Age, respectively, and being well reflected in Near Eastern local and regional paleoclimate proxy archives, such as Soreq Cave (Bar-Matthews and Ayalon 2011), Lake Van (Wick et al. 2003), and the Dead Sea (Frumkin and Elitzur 2002; Langgut et al. 2015). These climatic fluctuations are also documented in the geoarchaeological and plant stable isotope record and were causally related to a destabilization of the water balance and prolonged droughts associated with water stress on ancient crop species (Wilkinson 2003; Deckers and Riehl 2007; Riehl et al. 2014). The particular local environmental effects of the major climate fluctuations were diversified, however, with relatively clear patterns in the inland regions of northern Mesopotamia and a more complex picture in the Levant, in particular with notable differences between the northern compared to the central and Southern Levant, likely reflecting the relevance of the NW decline as a general geographic parameter (see above; for discussion of the differences between northern Mesopotamia and the Levant in general, see Pustovoytov and Riehl 2016).

The Major Crop and Animal Species

Knowledge of the presence and economic and cultural rank of Bronze Age crops and domestic animals derives from archaeobotanical and zooarchaeological studies, often with reference to the chronologically later textual information in the Old Testament. Although Bronze Age crop species slightly differ in their proportions within archaeobotanical assemblages depending on regional, local, environmental, and diachronic factors, they comprise the same taxa since the

Table 10.1 Maximum proportions of major crop species in Bronze Age sites of the Southern Levant. Note the uneven contribution of investigated sites for the different regions in brackets.

	Early Bronze Age			*Middle Bronze Age*			*Late Bronze Age*		
	Israel (21)	*Jordan (14)*	*Lebanon (1)*	*Israel (16)*	*Jordan (4)*	*Lebanon (3)*	*Israel (18)*	*Jordan (5)*	*Lebanon (3)*
Barley	36	50		25	7		97	56	96
FTW	20	5	P	19	6		99	38	P
Emmer	9	49	75	66	6	35	6	2	
Einkorn	1	10	P		6			18	
Lentil	99	20	5	2	2	P	2	P	P
Bitter vetch	5	P		14			P	6	2
Garden pea	5	3			1			15	
Grass pea		P	P						
Chickpea	19	P		P	1			P	P
Broad bean	10	P		P	P		P		
Linseed	4	5		2			P	8	
Olive	76	3	8	10	1	12	100	8	
Grape	8	6	4	24	1	3	56	P	P
Fig	1	14	4	16	7		P		
Punica	11	P		1			P		

Abbreviations: FTW (free-threshing wheat), Punica (pomegranate), P (present).

beginnings of cultivation during the Epipalaeolithic period. The cereal species barley (*Hordeum vulgare* L.), emmer wheat (*Triticum dicoccum* Schrank), and free-threshing wheat (*Triticum aestivum/durum*), as well as olive (*Olea europaea* L.), grape (*Vitis vinifera* L.), and lentil (*Lens culinaris* Medik.) reach particularly high proportions in the archaeobotanical assemblages of this region (Table 10.1), while the triad of cereals, vine, and olive oil is of major importance in the textual and iconographic record of agricultural products in the Old Testament.

Dominance in barley, as indicated in numerous Early and Late Bronze Age sites, has often been attributed to its high tolerance for drought and salinity, which is related with its comparatively short life cycle. As in many Bronze Age sites of Upper Mesopotamia, free-threshing wheat is a ubiquitous cereal find, reaching very high proportions in the Southern Levant during the Late Bronze Age and Iron Age, while the hulled tetraploid emmer wheat is particularly numerous in Early Bronze Age sites, but remains important in the coastal Levant at least until the Middle Bronze Age (Riehl 2014). Einkorn (*Triticum monococcum* L.), a diploid hulled wheat species, occurs only sporadically, which has been explained by its agronomic properties, i.e., relatively low water-holding capacity causing its drought susceptibility (Oleinikova 1976; Kishitani and Tsunoda 1981). As a crop species which has been taken into domestication in northern Mesopotamia, it was probably introduced to the South only with the establishment of agricultural societies.

Although nutritionally enhanced, and with their high protein value complementing a diet mainly based on cereals, pulse crops are generally among the rarer finds in archaeobotanical assemblages, which may in part be due to taphonomic factors (Riehl 2014). Lentil is by far the most widespread pulse crop and surely represented an important food plant throughout the whole Bronze Age. Many of the more water-demanding pulse crops, such as garden pea (*Pisum sativum* L.) or broad bean (*Vicia faba* L.) become strongly reduced in proportions during the Middle Bronze Age, which has been linked with climatic fluctuations toward the end of the Early Bronze Age (Riehl 2009; Riehl et al. 2014). Grass pea (*Lathyrus sativus* L.) occurs only rarely in Bronze Age sites, possibly because ancient people may have been aware of its comparatively increased toxicity (Kislev 1986).

Despite the olive being considered as one of the most important crop species of the circum-Mediterranean region, it occurs in relatively low proportions in the archaeobotanical record, which contrasts its role as indicated in the textual evidence. One explanation may be that olive oil was produced at a central location outside the individual household area, which has been suggested at least for the Iron Age phases (Borowski 2009), and thus reduces the chance for olive pits to be found through archaeobotanical sampling. Furthermore, if by-products such as the olive cake were used for animal feeding – a utilization that has been demonstrated to increase the content of mono-unsaturated fatty acids in milk of modern sheep and goat (Molina-Alcaide and Yáñez-Ruiz 2008) — they may have been deposited only in minor amounts within the settlement. During the Bronze Age, olive oil production is assumed to have been technically very similar to vine production, while the processing steps and instruments became more sophisticated mostly during the Iron Age (Frankel 2013).

Similarly, another oil crop, linseed (*Linum usitatissimum* L.) tends to be underrepresented in the archaeological record — jointly responsible is the particularly fragile nature of its seed. Besides its use as an oil crop, the fibers are raw material for linen production. As the species is intolerant to arid growing conditions, its presence in the Southern Levant was heavily impacted by the two major climatic fluctuations during the Bronze Age, i.e. in the final Early Bronze Age phase and at the end of the Late Bronze Age, surely co-related to shifting cultural preferences (Riehl 2009; Orendi 2019).

Since the Early Bronze Age, grape (*Vitis vinifera* L. ssp. *vinifera*) was probably the fruit tree of most significant agricultural value, and is together with its main product vine, the most frequently discussed Mediterranean crop species (e.g. McGovern et al. 2003). While grape was cultivated in the Near East over a large geographic area, higher proportions of the archaeobotanical remains occur mainly in areas with modern mean annual precipitation above 400 mm (Riehl 2014). As with olive, the find and distribution patterns do not representatively reflect the role of grape, because the main processing step in the use of its fruits, i.e. the production of wine, mostly took place in the vineyards (Borowski 2013), thus providing little chance for the deposition of large numbers of grape seeds within the settlement, while direct consumption of the fruit or the raisins reflect the main source of origin in archaeobotanical assemblages.

Other seeds of fruit trees, like fig (*Ficus carica* L. and *Ficus sycomorus* L.), pomegranate (*Punica granatum* L.), or date (*Phoenix dactylifera* L.) are even more inconsistently found in Bronze Age sites, which also can be explained by a highly reduced chance of deposition, compared to the cereals. For these species, much more is known on their agricultural production from the textual evidence.

The multiplicity in usefulness of domestic animals determines their extraordinary valuation in many sectors of ancient economic and sociocultural systems. Apart from the use of meat and milk products for human diet, they provide multiple resources for producing textiles, and for increasing the efficiency of agriculture and transport. Furthermore, they were of considerable importance in ancient ritual practice. Traded agricultural products always provide knowledge on the economic emphases of ancient societies, beyond reflecting the required mechanisms of technology and labor organization in agriculture. As with olive oil and wine trade, traded animals would require their previous surplus production in some regions. Unfortunately, analytical overviews of the zooarchaeological record in the Southern Levant are limited, and most of the information comes from a few systematic analyses of individual sites, and from the textual sources of the Old Testament. A major study on economic strategies in animal husbandry has been published by Sasson (2010). He analyzed 70 Bronze and Iron Age faunal assemblages from this region for sheep-goat ratios, mortality profiles of caprines, and caprine-cattle ratios to consider different strategies of animal production, i.e. self-sufficient production and consumption, consuming economy, and producing economy.

Small ruminants, i.e. sheep (*Ovis aries* L.) and goat (*Capra hircus* L.) are the most abundant finds of Near Eastern zooarchaeological assemblages, and it is assumed that they were kept as mixed flocks. With 67% of sheep as a mean of a large number of investigated assemblages, the subsistence strategy points to a compromise between low-risk goat husbandry and higher-risk sheep herding with a primary focus on wool production (Sasson 2010), which was surely an important sector of economy in the Near East since the beginning of the Early Bronze Age. Through their breadth in grazing on different components of the vegetation, goats have a more detrimental effect on the vegetation cover than sheep, which may be an additional reason for keeping them in smaller numbers than sheep. Dominant goat proportions, on the other hand, may indicate drier and hotter environmental conditions, as they are more tolerant than sheep (Maher 2013).

Domestic cattle (*Bos taurus* L.) ranges at third place in terms of abundance of its bones in zooarchaeological assemblages. Cattle were important for their meat, but also for pulling the plow and carts and as beasts of burden. Occasionally, the drought-resistant zebu (*Bos indicus* L.) is represented in Bronze Age sites, which also provides some environmental information. Dairy production is likely to have played a role long before the metaphoric use of the term "milk" in the Old Testament, referring to ancient Palestine as the "land flowing with milk and honey," particularly when we consider the fact of regular contacts with Mesopotamia and Egypt, where milk production is already documented in the iconographic record with the beginning of the Early Bronze Age.

The donkey (*Equus asinus* L.) and the horse (*Equus caballus* L.) are represented in much smaller amounts, and while the donkey was a useful pack animal, horse remains reflect the elevated social status of their owner (Maher 2013). In a few sites the dromedary camel (*Camelus dromedarius* L.) and the two-humped camel (*Camelus bactrianus* L.) are recorded. Both are ideally suited transporting animals in arid environments.

The most discussed issue of animal husbandry in the Bronze and Iron Age Southern Levant is the extent of pig (*Sus scrofa domestica* L.) breeding and consumption (see numerous references in Maher (2013)). In the Bronze Age, its presence in faunal assemblages is less than 5% (Maher 2013), and with increasing percentages often interpreted to represent Philistine ethnicity, similarly as suggested for the consumption of dog (*Canis familiaris* L.). However, this is a matter of debate, and alternative interpretations argue for the necessity of particular environments for pig husbandry (Albarella 2007), for increasing sedentism, or for the limited secondary products pigs provide, which would have led to reduced economic interest in breeding them (Maher 2013).

As with wild plant species, the presence of wild game indirectly reflects agricultural conditions in terms of the subsistence situation, but also as concerns environmental conditions for ancient agriculture. Species such as the beaver (*Castor* spp.) may indicate the presence of open water sources in the closer environments (Doll 2010). Although the hippopotamus (*Hippopotamus amphibious* L.) occasionally represented by finished ivory products may be considered as deriving from Egyptian import, the occurrence of unmodified postcranial hippopotamus bones from a number of sites in the Southern Levant suggests the exploitation of local herds (Maher 2013), thus indicating the presence of sufficient water resources to offer an adequate living environment to these large animals, and thereby providing a perspective of ancient hydrological conditions for agriculture.

Agricultural Calendar

Although direct written sources are missing, it is possible to create a general idea of the agricultural calendar in the Levant during the Bronze Age. No uniform agricultural calendar existed during the Bronze Age, probably because of the geographical and climatic diversity of the Levant. In fact, it can be deduced that a variety of agricultural calendars were available for the different subregions and that this kind of regionally fitting accuracy was fundamental for the agricultural wealth of the Levant.

Presumably the new year started traditionally in autumn (September) in the Levant. Early rainfall occurs during October and November. The rainy season covers the months of December and January, while late rainfall prevails in February, March, and April. The summer period from May to August is the time of the major harvest activities, from barley and wheat to grapes and olives.

A unique inscription regarding the agricultural calendar of the Southern Levant was found in Gezer: the so-called Gezer calendar, which contains a seven-line Hebrew inscription dating to the end of 10th century BCE. The text reads (translated by Borowski 2009, p. 38):

1. Two months of ingathering (olives) / two months
2. of sowing (cereals) / two months of late sowing (legumes and vegetables)
3. a month of hoeing weeds (for hay)
4. a month of harvesting barley
5. a month of harvesting (wheat) and measuring (grain)
6. two months of grape harvesting
7. a month of ingathering summer fruit

This inscription was most likely a writing exercise for the instruction of scribes. Nevertheless, it gives important insights in the time course of agricultural production in the Southern Levant, presumably not only for the Iron Age but also for the Bronze Age. The year was divided into twelve months. It began, according to the text, in September-October with the olive harvest and continued in November-December with the sowing of the cereals and in January-February with the late sowing. According to line 3, the flax harvest took place in March (translated by Browoski as "hoeing weeds"). April-May was the time for harvesting barley and wheat. In June-July, grape harvest took place and finally in August the summer fruits were gathered.

Development of Agriculture Throughout the Bronze Age

Archaeological evidence in the Levant implies that agriculture was practiced in the form of rural, small-scale family-based farming at the beginning of the Bronze Age (Early Bronze Age I; c. 3600–3000 BCE). A new subsistence mode emerged in the Levant (Miroschedji 2014, p. 308) that was characterized by an agropastoral economy including agriculture (mainly cereals and legumes), horticulture (olives and grapes), and animal husbandry (sheep and goats as well as cattle). Not much is known about agricultural practice during Early Bronze Age I from archaeological sites of the Northern Levant (Cooper 2014, p. 280), which partially also applies to the archaeobotanical record. The latter is particularly scarce in the Central Levant (compare tab. 10.1).

The general settlement pattern in the North was characterized by small villages with a low degree of social stratification (Akkermans and Schwartz 2003, p. 226). Furthermore, it appears that these small farming or pastoral communities existed independently of any form of political centralization. In the Central Levant, several settlements of the Early Bronze Age I period have been partially excavated: Byblos ("Énéolithique récent"), Tell Fadous-Kfarabida, and Sidon (Dakkerman district; Genz 2014, pp. 293–297). These settlements consist of more or less equally sized houses without exceptional buildings. In contrast to this, some burials within the settlements indicate a certain kind of social stratification. In summary, even if more research is needed, it seems that, just as in the Northern Levant, also in the Central Levant small-scale family farming was dominant during the Early Bronze Age I.

Generally speaking, this is true for the Southern Levant as well. In this region, many excavations of small rural settlements from the Early Bronze Age I period were undertaken in the areas west of the Jordan (Miroschedji 2014, pp. 307–313) as well as in Transjordan (Richard 2014, pp. 334–338). Such villages consisted of 5–20 equal-sized houses. On the base of the inventory of those houses, it can be deduced that they served as family dwellings for 5–10 people and that the families practiced small-scale agriculture. A specific situation is given in the southwestern parts of the Southern Levant during the Early Bronze Age I. Here, a number of settlements show clear evidence of Egyptian influence and presence (Miroschedji 2014, p. 312). It seems that Egypt regarded southwestern Palestine as a colonial territory and that the main interest of the Egyptians was to gain agricultural products like olive oil and wine from this region. As a consequence, the local farming communities must have produced a certain surplus. Further evidence for agricultural surplus production derives from a few very large settlements in the Southern Levant like Megiddo in the Jezreel-Valley and Beth Yerah at the Sea of Galilee. In Megiddo, recent excavations have brought to light a monumental temple dating to the Early Bronze Age I which was much greater than all temple buildings from the later periods (Adams, Finkelstein, and Ussishkin 2014). As the center of the fertile Jezreel-Valley, Megiddo did develop already during the Early Bronze I period a complex society producing monumental architecture and urban-like structures which must have required a significant intensification of the agriculture in the region.

Diachronic archaeobotanical syntheses for the region indicate for the Early Bronze Age as a whole a major focus on barley production (Riehl 2009), which is particularly homogenous in the Northern Levant, while in the Southern Levant emmer wheat also played a central role, probably corresponding to the Egyptian influence in this region. Current research for the Southern Levant also allows a high-resolution consideration of the archaeobotanical record for the different Early Bronze Age phases, suggesting a very diverse regional pattern, resulting from complex feedback mechanisms between environmental conditions, economic goals, cultural preferences, and their temporal dynamics (Kamlah and Riehl 2020). Some general diachronic developments can, however, be recognized throughout the Early Bronze Age phases in the Southern Levant. The overall emmer proportions even increase from the Early Bronze Age I to the Early Bronze Age II–III, almost reaching the same proportions as barley. Emmer then decreases rapidly in the subsequent phase of the Early Bronze Age IV, the Middle Bronze, and the Late Bronze Age sites, in favor of free-threshing wheat, which is the dominant wheat species from the Late Bronze Age onward. In the North, emmer wheat is already replaced by free-threshing wheat during the Middle Bronze Age. As with olive finds, the proportions of emmer wheat are much higher in the Southern than in the Northern Levant. Similarly, flax seeds appear with considerably higher frequency in the Southern Levant, while the pulse crops are supraregionally less distinctive in terms of differences in presence and proportions of their archaeobotanical remains (Riehl 2009).

The Early Bronze II–III periods (c. 3000–2300 BCE) have to be considered as urban cultures. All over the Levant, urban settlements were established. These cities share common elements, like fortifications, public administrative buildings (so-called palaces), and public temples. In the Northern Levant, the cities of Ebla, Hama, Qatna, and Tell Nebi Mend stand out (Cooper 2014, pp. 280–283). The main urban centers of the Central Levant were Tell Arqa, Byblos, Sidon, and Tyre (Genz 2014, pp. 297–304). Finally, in the Southern Levant, Dan, Megiddo, Beth Yerah, Beth Shean, Khirbet ez-Zeraqon, Ai, Tell Yarmuth, Tell es-Sakan, and Arad are the best known excavated urban settlements (Miroschedji 2014, pp. 313–322). From the settlement patterns in the various regions, it appears that such urban settlements were the center of a city-state with a "Hinterland" comprising smaller cities, villages, and arable land. Agriculture was the economic base of these city-states (Genz 2012, p. 615).

The socioeconomic developments of this Early Bronze Age urbanization in the Levant were connected with major agricultural changes. The rise of urbanism would not have been possible without expansion and intensification of agriculture. On the other hand, the increased demand for food and secondary products, which was a result of growing populations in the Early Bronze Age cities, led to a further intensification of agricultural production. Due to the lack of relevant written sources, the details of these intensification developments remain obscure. It might be that an extensive use of cattle for pulling the plow was one of the essential improvements during the rise of Levantine urbanism. Also, an increasing Egyptian influence, as mentioned above, may have played a role in setting the core areas in agricultural production. All in all, it seems that long-term mutual processes of improving agricultural strategies and developing social specializations paved the way for the successive transformation of the proto-urban subsistence mode to an agricultural system which was embedded in the more complex societies of the Early Bronze II–III cities. Such social specializations are visible in certain architectural features of Early Bronze Age urban centers. At Tel Yarmuth in the Southern Levant, a huge palace dating to the Early Bronze Age III was excavated (Palace B2; Miroschedji 2014, pp. 317–318). It covered an area of approximately 6000 m^2 and included more than 40 rooms, among them more than 10 storerooms filled with large pithoi for storing agricultural products. A comparable capacity for storing agricultural surpluses existed in the Early Bronze Age III city of Beth Yerah, where a monumental granary was excavated (Genz 2010). These buildings testify that the Early Bronze Age II–III cities were able to store and to redistribute large quantities of agricultural surpluses under the control of the local elites.

Despite such common general developments in the Levant during the Early Bronze Age, there are also considerable regional differences (Greenberg 2002). In comparison with the Northern Levant, which was the center of Early Bronze Age Levantine urbanism, the Southern Levant appears as periphery. The size of typical Early Bronze Age cities in the south ranges between 5 and 10 ha (Miroschedji 2014, p. 314). With great caution, the population size of these cities can be estimated between 1000 and 2000 persons. In contrast, the Northern Levantine city of Ebla covered an area of 60 ha and had probably more than 50 000 inhabitants (Matthiae 1981). This Bronze Age megacity was the core of an impressive city-state based on a well-organized and strictly centralized agricultural system.

During the Early Bronze Age IV/Intermediate Bronze Age period (c. 2400/2300–2000 BCE), Ebla reached the peak of its early urban development. The administrative center of the city was a huge palace (Palace G) containing a large court, a ceremonial wing, royal apartments, kitchens, workshops, storerooms, and an archive (Cooper 2014, p. 284). In the latter, more than 17 000 cuneiform clay tablets were found. According to the tablets, the royal palace owned several thousand sheep and pasturelands both close to the city and at great distance from it. Other examples of flourishing cities in western Syria during this period are Tell Afis, Hama, Tell Nebi Mend, and Qatna (Cooper 2014, pp. 283–285). At Qatna, excavations have unearthed a domestic quarter with many installations for storing and processing agricultural products, indicating an extensive surplus production (Morandi Bonacossi 2007, pp. 67–71). It seems that the prosperity of Qatna during this period was based on a large-scale exploitation of its hinterland, including well-organized agriculture and pastoralism. Even in some marginal regions, like the Hawran region in southern Syria, intensification of settlement activities took place. Khirbet el-Umbashi is an example of a settlement in this region. Its inhabitants constructed a system of dams, canals, and water reservoirs in the vicinity (Braemer, Echallier, and Taraqji 2004). From archaeozoological finds, it appears that pastoralism, especially sheep and goat keeping, was the economic base of the settlement. All in all, in western Syria, the Early Bronze Age IV/Intermediate Bronze Age period appears to be a time of continuation without any major disruption of the Early Bronze Age urbanism and agriculture (Cooper 2014, pp. 288–289). The chronological resolution of the archaeobotanical record into different phases of the Early Bronze Age is currently insufficient, and does not allow a conclusion to be arrived at on general agricultural developments in the Northern Levant during the Early Bronze Age IV.

In north-central and eastern Syria, there are clear archaeological indications of discontinuation forced by climate change (Weiss 2014), which are supported by the archaeobotanical and stable isotope evidence when comparing the Early Bronze Age as a whole to the Middle Bronze Age (Riehl 2008). Levantine communities responded to this climate change (the 4200 BP event) in different ways, like political change, nomadism, regional depopulation, and migration. The region that was seemingly most affected by these events was the Southern Levant. During the Early Bronze Age IV/Intermediate Bronze Age period, only very few settlements with architecture existed, like Khirbet Iskander and Tell Iktanu in Jordan (Prag 2014). Within these settlements, ground stone tools confirm the economic significance of harvesting and food processing. Apart from such very rare exceptions, most of the people in the Southern Levant lived in temporary campsites during this period. From these campsites, not enough archaeobiological remains are known to draw conclusions about their agriculture and pastoralism. However, looking at cereal proportions of the very few investigated sites, an increase in proportions of barley becomes recognizable during the Early Bronze Age IV/Intermediate Bronze Age, whereas the less drought-tolerant wheats are decreasing. It will be an important task for future research to investigate the agricultural changes during this period in the Levant.

With the beginning of the Middle Bronze Age (c. 2000 BCE), a rapid process of re-urbanization took place in the Southern Levant (Burke 2014). In contrast, the transition from the Early Bronze Age IV/Intermediate Bronze Age to the Middle Bronze Age in the Northern Levant involved only minor sociocultural changes. Excavations at Ebla have shown that the Middle Bronze Age culture evolved directly out of the preceding period. The urban culture of the Middle Bronze Age (c. 2000–1550 BCE) and of the Late Bronze Age (c. 1550–1200 BCE) can be considered one continuous cultural period, in which a system of city-states covered the entire Levant. Major urban centers were Aleppo, Alalakh, Ebla, Ugarit, Hama, and Qatna in the Northern Levant, Tell Arqa, Byblos, Kamid el-Loz, and Sidon in the Central Levant, and Hazor, Kabri, Megiddo, Beth Shean, Shechem, Jericho, Jerusalem, Lachish, and Ashkelon in the Southern Levant. Compared to the Early Bronze Age IV, the Middle and Late Bronze Age Levantine urban culture was supported by social stratification and specialization as well as by agricultural intensification. Long-distance exchange played an important role in these periods. From the location of the major settlements in relation to land and shipping routes, it has been claimed that already in the Middle Bronze Age agricultural surplus (probably mainly olive oil and wine) was transported from the Levant to other regions (Stager 2001; Burke 2014, pp. 406–407). The archaeobotanical record for the Middle Bronze Age is not supportive of this assumption. Only the cereal assemblages indicate some regional differentiation. In the southernmost Levant, except in the southern Jordan Valley and Dead Sea region, cereals show a decreased productivity, whereas further north no such pattern is visible, and in contrast, even higher proportions in drought-susceptible free-threshing wheats are documented. For the Late Bronze Age, several sources illustrate that agricultural products were transported systematically from the Levant into other regions, which is also suggested by the increased presence of archaeobotanical finds of olive in Northern Levantine sites and an increase of proportions of grape seeds in archaeobotanical assemblages of the Southern Levant. The so-called Canaanite Jars, transport amphora for agricultural products, were found in many regions outside the Levant. Agricultural products are mentioned in written documents regarding the impact of the Egyptian Empire on Canaan (i.e. the Central and the Southern Levant during the Late Bronze Age): letters of the Amarna archive and hieratic inscriptions from the southern part of the Southern Levant (Panitz-Cohen 2014, pp. 547–548). A similar situation was seen in the Northern Levant, first with the economic interest of Mitanni (1550–1350 BCE) and later with that of the Hittite empire (1350–1200 BCE) reflected in various written documents (Pfälzner 2012, pp. 771–774).

The Levantine agricultural production during the Middle and in particular during the Late Bronze Age was integrated into the palace economy of the city-kingdom — a combination of redistributive mechanisms, commercial activities, and gift exchange (Pfälzner 2012, p. 783). The economic base of each city-kingdom was a regional, village-based agricultural production, and the palaces were supplied with a certain amount of this production. As a consequence, agriculture in the Levant during the second millennium BCE was carried out with the need to produce surplus first for the palace economy (Middle Bronze Age) and later for the palace economy as well as for the great empires to the north and the south.

Perspectives for Future Research

For future research on agriculture in the ancient Levant, it is essential for systematic archaeobotanical sampling to become a generally accepted standard for all excavations. Furthermore, zooarchaeological investigations of faunal remains from excavations need to be improved by analyzing the full spectrum of animal categories to enable the reconstruction of ancient environmental conditions as a prerequisite to understanding ancient agriculture. In most of the excavations, bones get collected by hand-picking. However, hand-picking reveals only a part of the faunal remains from each excavation site and should be complemented by sieving or flotation of sediment samples. Besides intensifying archaeobotanical and zooarchaeological research, it will also be essential for future research to put stronger efforts into multidisciplinary approaches, combining all available sources. A specific field for future research could be that of gender studies related to ancient agriculture, for instance, by investigating the role of women in agricultural production (cf. Ebeling 2016) or by conceptualizing an archaeology of family-based agriculture. Of particular interest will be to connect future research on ancient Levantine agriculture with environmental questions (cf. Lawrence et al. 2016; Marston 2017). These perspectives, as many others which could be developed, all show that the study of agriculture is crucial for a comprehensive and profound understanding of the Levantine past and present.

GUIDE TO FURTHER READING

For a short overview on major topics in agriculture of the ancient Southern Levant, including landscape conditions, cultivation practices of the main crop species, factors of yield, and agricultural laws, see O. Borowski 2013. The pioneer work of G. Dalman (1928–1942) provides a comprehensive collection of seven volumes on the ethnographic documentation of traditional farming in Palestine (in German). A. Killebrew and M. Steiner have edited a useful handbook (2014) which contains a number of valuable review chapters on the archaeology of the Northern, Central, and Southern Levant. A recent article by D. Lawrence et al. (2016) represents an interesting research output using multiple lines of evidence to demonstrate chronological change of interrelationships between climatic conditions and cultural development in the Near East, including the Levant. A so far unique review of the zooarchaeological record of Levantine settlements is presented by A. Sasson (2010).

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CHAPTER ELEVEN

Agriculture in the Chalcolithic and Bronze Age of Asia Minor

Andrew S. Fairbairn

Introduction

Covering an area of 400 000 km, Asia Minor forms the western and central Asian regions of the modern state of Turkey, bounded by the Black, Aegean, Marmara, and Mediterranean seas to the north, west, and south, and in the east by the high country east of a line running from the Gulf of Iskenderun on the Mediterranean to the city of Trabzon on the Black Sea (Figure 11. 1; Düring 2010). Contiguous with regions to the east that have close connections with the northern Levant, Greater Mesopotamia, and the Caucasus, and separated by a short water crossing from Europe, Asia Minor has long been an important communication and migration route, including for the first hominins into Europe. As well as being "a bridge between Asia and Europe," Asia Minor was also a major center for cultural innovation in its own right and not merely a conduit for people and ideas moving through it from other regions (Greaves 2007). As well as innovations in metal technologies and, later, in town planning and art, the region contributed to the first development of farming, which appeared there from c. 8300 cal BCE (Baird et al. 2018) and was subsequently carried into Europe from its shores as a colonial package after 7000 cal BCE (Omrak et al. 2016). 10 000 years later, Asia Minor is part of one of the world's most productive agricultural economies, one that dominates global markets in several agricultural commodities and runs consistent production surpluses, providing a key pillar of Turkey's economy.

While most interest concerning early farming societies in Asia Minor, as elsewhere in southwest Asia, is focused on the first appearance of farming in the Neolithic, here we look at what happened once farming was established in the Chalcolithic (c. 6000–3000 cal BCE) and Bronze Age (c. 3000–1200 BCE). This brief overview aims to use archaeological and historical accounts to identify the key characteristics and developments in farming systems as Asia Minor underwent significant social, economic, and cultural transformations, including the emergence of urbanized state societies. All of these changes relied on stable food production systems resilient and adaptive in the face of both unpredictable climate change and increasingly turbulent political events. As discussed below, Asia Minor's primary data record for ancient agriculture is extremely patchy, though at the time of writing several new studies

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promise to make significant additions to the existing state of knowledge. This summary, including information in Tables 11.1 and 11.2, aims to provide a snapshot of current knowledge, but does not claim to be comprehensive and recognizes that many aspects of this story will change as new studies are published.

The Cultural Sequence

Major cultural change is evident in Asia Minor during the Chalcolithic and Bronze Age with significant population growth and fundamental shifts in social, political, and economic organization paralleling those in adjacent regions (see Steadman and McMahon 2011; Sagona and Zimansky 2006; Düring 2010; Yakar 2011). All of the societies documented in Asia Minor during this period relied on farming – arable production of crops and pastoral production of animals – as the economic bedrock for their sustenance and stability. Cultivated plants and herded animals were the mainstay of the diet, but secondary products, such as traction, skins, straw, and chaff, provided power, building and craft materials, as well as forming commodities that were bought, sold, and used both to generate and discharge debt. Yet the evidential coverage and depth of knowledge concerning each period and subregion of Asia Minor varies greatly – generally being less well studied than the Levant and Mesopotamia – and the long-term agricultural histories of many regions and periods are poorly understood.

In broad terms, the Chalcolithic (6000/5500–3000 BCE) has the least well-known history and saw a continuation of Neolithic traditions, at least in its initial centuries, society consisting of autonomous small-scale settlements lacking obvious centralized authority, though some regions have evidence for a mix of larger- and smaller-sized settlements (De Cupere et al. 2015). In contrast to the Levant and Greater Mesopotamia, evidence for the development of urbanism by the end of Asia Minor's Chalcolithic is weak, most settlements being small in size and lacking clear evidence for centralized authority. Increasing scale and specialization in the use of copper and widespread trade in ceramics with increasingly regional styles are elements of a trend toward economic specialization as is the increase in both the volume and scale of trade. Isotopic evidence suggests populations were generally more mobile (Welton 2014) and interregional trade networks extended earlier trade systems, taking in the Aegean, Europe, Mesopotamia, the Levant, and Transcaucasia, the latter perhaps aided by nomadic societies dominant in that region and reaching into the Black Sea littoral. Halaf/Ubaid and Uruk influence from Mesopotamia appears to have been largely confined to the trade sphere on Asia Minor's southern coast and did not effect widespread social and political change, though there is some evidence from Mersin-Yumuktepe for the development of monumental architecture and centralized authority (Steadman 2011; though see Düring 2010). In the Aegean, trends toward urbanization have been identified in the 5th millennium (papers in Horejs and Mehofer 2014) emphasizing the long development of the new ways of living that came to dominate the Bronze Age.

A marked increase in the number and size of settlements in Asia Minor's Early Bronze Age (hereafter EBA, c. 3000–2000 cal BCE) is indicative of a significant increase in population, and by the mid-third millennium, medium-sized settlements emerged, controlling local settlement networks, in contrast to territories in the northeast and southeast (Çevik 2007; De Cupere et al. 2015). More recognizable forms of urbanism and state formation are increasingly clear in Asia Minor's later EBA and Middle Bronze Age (hereafter MBA) when larger urban centers with long-distance trade networks developed greater control over their hinterlands, as in the Aegean and Mediterranean coasts, at Liman Tepe and Hısarlık/Troy, as well as inland, as seen at Beycesultan, Çadir Höyük, and Kültepe. Trade also intensified across the region, continuing patterns seen in the Chalcolithic, with evidence for globalizing trade systems indirectly linking the Eastern Mediterranean and Europe to India and China (Boivin et al. 2016).

Ancient trade in Asia Minor saw its apotheosis in the MBA (2000–1600 cal BCE) when cuneiform tablets record the first local primary histories, mainly from the archives of Assyrian traders based at Kültepe/Kanesh. At the end of this period, and dominating the Late Bronze Age (hereafter LBA), Anatolia's "upper lands" spawned the Hittite kingdom, whose hegemony from its capital at Boğazköy/Hattusha waxed and waned yet dominated much of Anatolia and the northern Levant, rivaling the power of ancient Egypt and Assyria. Again, this period saw trade and exchange across the whole region with shipwrecks bearing witness to the extent and richness of that trade (e.g. Bass et al. 1967). The Hittite kingdom was among several great powers to disappear from history around 1200 BCE in a period of abrupt cultural change that signaled the end of the Bronze Age world. Whether prompted by climate change, invasion, civil war, or a mix of many factors (see Knapp and Manning 2016), flourishing urban centers were greatly diminished across Asia Minor, and only in the southeast did centralized urbanism persist in the Neo-Hittite/Luwian states.

Geography, Climate, and Vegetation

Farming practice and potential in Asia Minor is strongly influenced by its complex and dissected environment. The geography is dominated by mountain ranges, most prominently the Pontic Mountains, running parallel to the Black Sea coast, and the Taurus Mountains, running parallel with the Mediterranean. Both ranges of mountains rise steeply from the sea and increase in height from west to east, reaching peaks of over 3000 m. Breached by relatively few passes to the central plateau, they have formed considerable barriers to communication throughout human history. Beyond the ranges, the central plateau sits at approximately 1000 m elevation and is formed from a series of plains, mountains, and river valleys, with the Great Salt Lake (Tuz Golu) and water bodies of the southwestern Lake District formed in areas where drainage to lower altitudes is impeded. Soils reflect the complex and varied lithology with considerable variation in texture, pH, and depth, the better arable soils being concentrated in the valley floor and alluvial plain environments. Significant regions are unsuited to the plow, being best suited for grazing or woodland cover.

Climate is also a major influence of farming, and Asia Minor's current climate can be split into three broad zones, with the between them characterized by mixed climate conditions. The Black Sea coast has a warm temperate climate with high rainfall (over 1000 mm per annum) and temperatures averaging between 10°C and 25°C. The Mediterranean and Aegean coasts have a Mediterranean climate with higher temperature ranges and precipitation of around 1000 mm concentrated in the cooler months with almost no rainfall in the summer. The central plateau (Figure 11.1, E) has a harsh continental climate, well known as a fickle influence over a farmer's fate, being both drier and cooler than adjacent regions, with half to one third of their rainfall and temperatures often extending well below 0°C in winter. Altitude is, of course, a major determinant of temperature, and some high mountains have permanent snow cover, the spring melt being a major source of water. Approximately 250 mm of rainfall is considered the minimum for reliable crop growth, and many regions of the central plateau are close to that threshold. Asia Minor has relatively few large rivers for a land area of its size, many of which have been dammed for irrigation in the last century. High ground water is also commonly used for irrigation, as seen in several of the inland basins such as the Konya Plain that are otherwise water deficient.

Table 11.1 Summary of economic plants found at sites in Asia Minor (numbers refer to Figure 11.1) from c. 6000–1200 cal BCE. +++ = dominant; ++ significant exploitation; + minor presence; * present; R = Resin; ? identification uncertain
Source: Adapted from Riehl and Nesbitt (2003) and Riehl (2014).

Period	*No*	*Site*	*Einkorn wheat* (Triticum monococcum)	*Emmer wheat* (Triticum dicoccum)	*"New-type" wheat*	*Free-threshing wheat* (Triticum aestivum/durum)	*Spelt wheat* (Triticum spelta)	*Hulled barley* (Hordeum vulgare)	*Naked barley* (Hordeum vulgare *var* nudum)	*Pea* (Pisum)	*Lentil* (Lens culinaris)	*Bitter vetch* (Vicia ervilia)	*Grasspea* (Lathyrus cicera/sativus)	*Chickpea* (Cicer arietinum)	*Horsebean* (Vicia faba)
Late Neo-Chalco	25	Ilıpınar	+++	+++				+++	+++	+++	++	+++	+++	+	
	30	Hacilar	+	+		++		+++		+	+	+			
	4	Canhasan I						+++		+++					
	5	Çatalhöyük West	++	+++	+++	++		++	++	++	++	++	+		
	25	Ilıpınar	++	+++				+++	+++		+++	+++	+++	+++	+
Mid-Late Chalco	2	Mersin-Yumuktepe	++	+++		+		++			++			+	
	29	Çamlıbel Tarlası	++	+++	++	++		++			++	++	++	++	
	28	Kümtepe	++	++		++		++							+
	22	Kuruçay	+	+++		++		+++		++	+++		+++		
	10	Alışar Höyük				*									
	11	Çadır Höyük	*	*				*		*	*	*			
	15	Ikiztepe	++	+++		+		+++		+	+++	+++	+	+	
Early Bronze Age	15	Ikiztepe	+	+++						++	++	+++	+	+	
	8	Kültepe/Kanesh	++	++		+++		+++			++	++			
	12	Kaman Kalehöyük	++	+		+++		++			++	+		+	
	27	Hısarlık/Troy	+++	+++				+++				+			
	1	Kinet Höyük	++	+++		+++					+++	++	+		
	2	Mersin-Yumuktepe	+	++		+		+			+	+			
	25	Ilıpınar	+	++				+?	+	+	+	+	++		
	21	Hacılar Büyük Hüyük	+++	++		++		+++		+	++	+++	+	++	
	20	Bademağacı	+++	++		+		+			+++	+	++	++	
	15	Ikiztepe	+	+++		++		+++			++	+++	+		
	17	Küllüoba	+++	++		+++		++				+++			
	26	Limantepe	++	+++		+		++		+	+++	++	+		
	24	Demircihöyük	+++	+++		+++		+++			+	+		+	
Middle Bronze Age	27	Hısarlık/Troy	+++	+++				+++		+++	+	++			
	1	Kinet Höyük	+++	+++		++		++			+++				
	16	Yassıhöyük/Gordion	+	+		++		++				*			
	8	Kültepe/Kanesh	++	++		+++		+++		+	++	++			
	13	Büklükale	++			++		++		+	+	+			
	3	Kilise Tepe						*							
	12	Kaman Kalehöyük	++	++		+++		+++		+	++	++		++	
Late Bronze Age	30	Boyalı Höyük													
	9	Kuşaklı	++	+++		+++	+	++		++	++	++	++		
	3	Kilise Tepe	+++	++		++	+++	+++		++	++	++	++		
	14	Boğazköy/Hattusas	+++	++	++	++		+++	++	++	++	++	++		
	12	Kaman Kalehöyük	++	++		+++		+++							
	27	Hısarlık/Troy	++	+++		++		++				+++	+	++	
	11	Çadır Höyük	*	*		*		*		*	*	*			
	1	Kinet Höyük		++		+++		+++			++	++	++	+	++
	16	Yassıhöyük/Gordion	++	++		+++		++			++	+++		+	
	23	Beycesultan	++	++		++		++	+		++	++			
	19	Ulu Burun				*		*							

Flax (Linum usitatissimum)	*Grape* (Vitis vinifera)	*Fig* (Ficus carica)	*Olive* (Olea europaca)	*Pomegranate* (Punica granatum)	*Hazel* (Corylus avellana)	*Almond* (Amygdalus spp.)	*Walnut* (Juglans regia)	*Apple/Pear* (Malus/Pyrus)	*Oak acorns* (Quercus *sp.*)	*Pine nuts* (Pinus *sp.*)	*Plum* (Prunus *sp.*)	*Hackberry* (Celtis *spp.*)	*Terebinth* (Pistacia *spp.*)	*Melon/cucumber* (Cucumis *spp.*)	*Sesame* (Sesamum indicum)	*Coriander* (Coriandrum sativum)	*Dill* (Anethum graveolans)	*Sumac* (Rhus coriaria)	*Black cumin* (Nigella sativa)	*Gold of pleasure* (Camelina sativa)
+++	+	++																		
						+		+												
											*	*	*							
	++	++			+															
	+	+	+																	
++								+												
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Table 11.2 Summary of the remains of managed animals found in sites from Asia Minor (numbers refer to Figure 11.1) from c. 6000 to 1200 cal BCE (for notation, see Table 11.1; H = horse, D = Donkey/Ass; for sources, see references in Arbuckle 2014 plus other papers cited here). Source: Adapted from Arbuckle (2014)

Site	*Period*	*Site*	*Cattle* (Bos taurus)	*Sheep/goat* (*Ovis/ Capra*)	*Pig* (Sus *sp.*)	*Equid* (Equus caballus/Equus asinus)
21	LN-EC	Hacilar	+++	++	+	
25	LN-EC	Ilıpınar	++	+++	++	
25	EC	Ilıpınar	++	++	+++	
33	EC	Menteşe	+++	+++	+	+
34	EC	Ulucak	++	+++	++	
5	EC	Çatalhöyük West	++	+++	+ W	+
32	EC	Köşk Höyük	+	+++	+	++
32	MC	Köşk Höyük	+	+++	+	+
6	MC	Güvencinkayası	+	+++	+	+
17	LC	Küllüoba	+	+++	+	+
29	LC	Çamlibel Tarlasi	+++	++	+++	+
11	LC	Çadır Höyük	+	+++	+	+
11	LC/EB	Çadır Höyük	++	+++	++	++
30	EB	Yarrıkaya	+++	+	+++	+
12	EB	Kaman Kalehöyük	++	+++	++	+ D
3	EB	Kilise Tepe	++	+++	++	
20	EB	Bademağacı	+++	++	+	
21	EB	Hacılar Büyük Hüyük	++	+++	++	
31	EB	Karataş-Semayuk	+++	++		
28	EB	Hısarlık/Troy	++	+++	++	
17	EB	Küllüoba	++	+++	+	+
14	MBA	Boğazköy/ Hattusas	+++	++	+	+
12	MBA	Kaman Kalehöyük	++	+++	++	+H/D
16	MBA	Yassıhöyük/ Gordion	++	+++	++	+
7	MBA	Acemhöyük	++	+++	++	+
8	MBA	Kültepe/Kanesh	++	+++	+	+
3	MBA	Kilise Tepe	++	+++	++	
31	MBA	Karataş-Semayuk	+++	+++	+	+
14	LBA	Boğazköy/ Hattusas	++	+++	+	+H/D
11	LBA	Çadır Höyük	++	+++	++	+
12	LBA	Kaman Kalehöyük	++	+++	++	+
16	LBA	Yassıhöyük/ Gordion	++	+++	+	++
3	LBA	Kilise Tepe	++	+++	++	+H/D
28	LBA	Hısarlık/Troy	++	+++	++	

Dog (Canis familiaris)	*Goose* (Anser anser)	*Duck* (Anas platyrhynchos)	*Dove* (Columbia livia)	*Fowl* (Gallus domesticus)	*Wild mammal*
?					?
+					+
+					++
+					+
++					++
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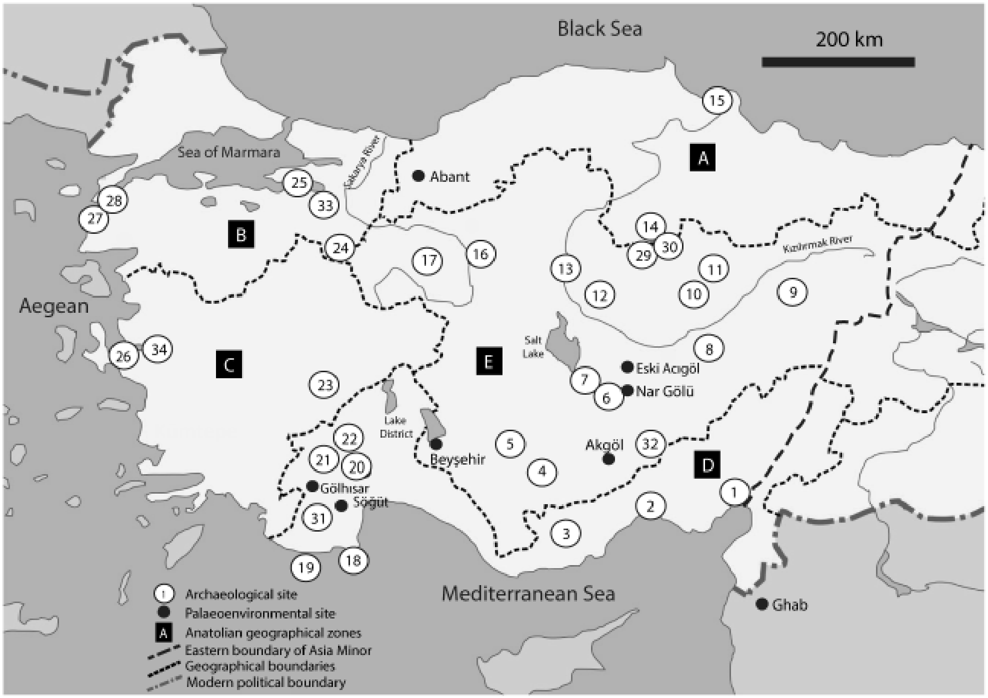

Figure 11.1 Map defining Asia Minor showing relevant palaeoenvironmental sites (black dots) and archaeological sites with archaeobotanical (see also Table 11.1) and/or zooarchaeological (see also Table 11.2) data or other finds relevant understanding ancient agriculture: 1. Kinet Höyük, 2. Mersin-Yumuktepe, 3. Kilise Tepe, 4. Canhasan I, 5. Çatalhöyük West, 6. Güvencinkayası, 7. Acemhöyük, 8. Kültepe/Kanesh, 9. Kuşaklı, 10. Alışar Höyük, 11. Çadır Höyük, 12. Kaman-Kalehöyük, 13. Büklükale, 14. Boğazköy/Hattusha, 15. İkiztepe, 16. Yassıhöyük/Gordion, 17. Küllüoba, 18. Cape Gelidonya, 19. Ulu Burun, 20. Bademağacı, 21. Hacılar/Hacılar Büyük Hüyük, 22. Kuruçay, 23. Beycesultan, 24. Demircihöyük, 25. Ilıpınar, 26. Limantepe, 27. Hısarlık/Troy, 28. Kümtepe, 29. Çamlıbel Tarlaşı, 30. Yarrıkaya, 31. Karataş-Semayük, 32. Köşk Höyük, 33. Menteşe; 34. Ulucak. Anatolian geographical zones are as follows: A. Black Sea; B. Marmara; C. Aegean; D. Mediterranean; E. Central Plateau. Source: Base map adapted from Wright et al. 2015a.

Vegetation across Asia Minor has been affected by millennia of farming and forestry practice, including clearance for cultivation, large-scale herding, and plantation development. Rather than the open, treeless landscape seen over much of Asia Minor today, remnant vegetation and palaeoenvironmental data suggest that in the absence of a human presence much of the region would be covered in a mosaic of woodland, grasslands, and wetlands (see Van Zeist and Bottema 1991). Deciduous woodland characterizes the Pontic zone, evergreen forest in the Mediterranean zone, and a mix of grasslands and oak woodland in the central plateau (Zohary 1973), though recent research suggests that the oak-park woodland often hypothesized as a natural formation in that region may be an artifact of long-term human management spanning the Holocene (Asouti and Kabukcu 2014). Permanently dry areas, such as the Konya Plain, developed shrubby steppe, now largely converted to agricultural ends, while rivers, lakes, and coastal environments would have sustained rich wetland and littoral environments ranging from open water to drier forested environments.

Human influence on the environment is increasingly well understood, with palaeoenvironmental and archaeological studies allowing this phenomenon to be understood in its historical context beyond modern analogues (Roberts et al. 2011; Asouti and Kabukcu 2014). The adoption and spread of farming, with increasing numbers of stock animals and clearance for arable plots, had significant long-term effects on environments and led to new forms of anthropogenic landscape. Human disturbance intensified during the "Beyşehir occupation phase" of pollen deposition around after c. 1500 BCE (Van Zeist and Bottema 1991; Eastwood and Roberts 1998). When forest clearance and the expansion of grazing into high-altitude regions was seen for the first time, probably as an outcome of increasing population and urbanization (Roberts et al. 2011; Asouti and Kabukcu 2014), though forest cover was maintained through the Bronze Age in some regions (Wright et al. 2015a).

The later EBA also saw a significant reduction in rainfall, as shown by multi-proxy records, forming part of a regional pattern of drying that produced extended drought and is thought to have contributed to a significant phase of settlement change and depopulation in the Levant (Roberts et al. 2011). Eastern Mediterranean climate records, including those from Gölhısar and Eski Acıgöl in Asia Minor, show that climate between 6000 and 4000 BCE climate was relatively wet, followed by a 3000-year long period of generally declining rainfall, ending in the late Holocene dry period, punctuated by dry phases at 4500 BCE, 3500–3000 BCE, 2700–2200 BCE, and 1100–800 BCE and wet phases at 4300–4000 BCE and 2000–1400 BCE (Roberts et al. 2011). In general, wetter conditions promoted more productive, reliable growth of crops and fodder, while drier conditions promoted less productive and reliable plant growth. Records also show changing intensity of wet and dry events which would have added to inter-annual unpredictability in agricultural production, potentially critical in highly populous societies living near the carrying capacity of their farming systems. The precise impact of fluctuating climate on crop productivity and reliability varied with the regional environment, the central plateau typically having low rainfall, being potentially more heavily affected than other regions in dry phases that would easily have pushed the region closer to drought. Isotopic studies in the Levant and Mesopotamia show a clear correlation between water stress in crop remains and climate proxies at 3200 cal BCE and 2200 cal BCE (Riehl et al. 2014b), though such evidence is still being compiled for much of Asia Minor, and it remains uncertain whether the same pattern of change affected the region.

Cultivated Plants

Asia Minor's history of plant use is based on the recovery of plant remains including macrofossils (seeds, wood, fruits) and microfossils (starch, phytoliths) from archaeological sites, complemented by available historical records. While many excavations have produced archaeobotanical remains (Figure 11.1, Table 11.1), sampling at many sites is opportunistic – collecting concentrations of plant remains when noticed in storage contexts, etc. – and relatively few have systematic flotation and microfossil sampling programs, especially in the later periods. Ultimately this reduces the comparability and representativeness of the data produced and limits the inference achievable from the archaeobotanical record. Research has established that by 6000 cal BCE, Asia Minor saw the cultivation of all the Old World's founder crops (einkorn and emmer wheat, naked wheat (hexaploid and tetraploid forms), naked and hulled barley, lentil, pea, bitter vetch, chickpea, and flax; see Riehl 2014). Table 11.1 summarizes published crop records for Asia Minor from 6000 to 1200 cal BCE, using a subjective assessment of abundance to provide unity to a very uneven dataset and providing the basis for the rest of this discussion, with available historical records.

Cereal Crops

Early Chalcolithic evidence is rare in the study area, with the best records from Ilıpınar (Cappers 2007; Figure 11.1, site 25) and Çatalhöyük West (Stroud 2013; Figure 11.1, site 25), and Middle-Late Chalcolithic studies are only marginally more common. Glume wheat species and hulled barley dominate cereal production through this period, especially emmer wheat (*Triticum dicoccum*) and hulled six-row barley (*Hordeum vulgare*), with einkorn (*Triticum monococcum*) generally less abundant, though its use persists until the LBA. Çatalhöyük West records the continued use of "New Type" glume wheat, similar to *Triticum timopheevi* (Jones et al. 2000), from the Neolithic into the Early Chalcolithic, with Late Chalcolithic finds at Çamlıbel Tarlası (Schachner 2012, pp. 123-137) and a single Late Bronze Age store at Boğazköy/Hattusha (Dörfler et al. 2011) the only other recorded examples in Asia Minor. At face value, published records suggest that "New Type" glume wheat was mainly a Neolithic phenomenon in Asia Minor, perhaps with regional importance in the central plateau, though as this crop only recently been distinguished it may have simply been missed in earlier research, and its presence into the Chalcolithic and Bronze Age requires review. Another rare record at Boğazköy/Hattusha is spelt wheat (*Triticum spelta*), also found in large quantity at LBA Kilise Tepe (Bending and Colledge 2007). Very rare in southwest Asia, it probably derives from Transcaucasia (Zohary et al. 2012), and its presence may reflect the availability of new crops through LBA trade.

Grain crops continue to be dominated by emmer wheat through the EBA, though there is increasing tendency for free-threshing wheat, mainly hexaploid bread wheat (*Triticum aestivum* and related species) where distinguished, to be preferred and for glume wheat species to decline in abundance, a pattern that is supported by formal statistical analysis and matches seen in other regions (see Riehl 2014). Free-threshing wheat has an inconsistent record in the Chalcolithic, and may have not become a widely grown crop until the EBA, though its certain identification requires fragile rachis segments to be preserved. The detailed record from Çatalhöyük suggests that the transition from glume wheat to free-threshing wheat began in the Late Neolithic (Bogaard et al. 2017). Some finds, such as the "short grain" wheat at Ilıpınar, may have derived from free-threshing wheat or represent puffed grains of emmer (Cappers 2007, pp. 123–124). Einkorn wheat is also present and clearly formed a pure crop, as seen at numerous sites including LBA Boğazköy/Hattusha and EBA Kaman-Kalehöyük. Historical records also give us names for grain (in Old Assyrian *uṭṭutum*, in Hittite *halkiš* (represented by the logogram ŠE)), including barley (in Old Assyrian *še'um*, in Hittite *halkiš* (represented by the logogram ŠE)) and wheat (in Old Assyrian *aršātum*, in Hittite *ZÍZ-tar*), among other names that may indicate other cereals or wheat/barley varieties, including *kanza* for einkorn (Hoffner 1974, Chapter 2). It is noticeable that the Hittite generic for grain is the same word used for barley (also used for several cereal-fostering gods) in the LBA as its prevalence in archaeobotanical assemblages (see below) increases, showing a pleasing concordance between archaeobotanical and historical evidence.

A pattern of reduction in glume wheat species from dominance in the Neolithic/Chalcolithic to selective abandonment from the Bronze Age, and disappearance in recent decades, is well established (see Nesbitt and Samuel 1996). Potential explanations include productivity concerns, with glume wheat species being disadvantaged to free-threshing wheat in requiring additional labor to release the grain from its chaff, taste and, in the case of einkorn, high susceptibility to drought (*ibid.*; Riehl 2009). In tandem with the decrease in use of glume wheat species is a great increase in the use of barley (Riehl 2009, 2014), almost exclusively from the EBA hulled barley – a crop with high drought resistance – especially two-rowed forms. Naked barley is uncommon after the Neolithic and represented at only a handful of sites, a pattern that concords with recent work at Çatalhöyük suggesting that its substitution with hulled forms started in the Late Neolithic (Bogaard et al. 2017). Within that general pattern of change, some regional patterning is apparent, with Kaman-Kalehöyük, Yassıhöyük/Gordion and Kültepe/Kanesh in the central plateau using free-threshing wheat from the terminal EBA, while other regions maintained a significant focus on glume wheats, as seen at Hısarlık/Troy, Kinet Höyük, and Kilise Tepe. Crop choice appears to have been determined in part by economic utility and productivity, but also may have been driven by taste and the demands of elites that were to come to increasingly control production systems in the Bronze Age (Riehl et al. 2012).

While wheat and barley species dominate Asia Minor's Chalcolithic and Bronze Age crop repertoire, other crops were present including common millet (*Panicum miliaceum*), foxtail millet (*Setaria italica*), rye (*Secale cereale*), and oats (*Avena sativa*). With the exception of common millet, none appear to have been anything other than exotic imports or contaminants in crops derived weeds. Common millet initially appears in small quantities and is thought to have been a crop at Hısarlık/Troy and Kilise Tepe by the LBA (Riehl 1999, p. 43; Bending and Colledge 2007). It is an irrigated summer crop, and its uptake signifies a new phase of crop diversification that continued into the first millennium BCE (Riehl and Nesbitt 2003).

It is worth noting at this point that cereal grain, chaff, and straw are found in the archaeobotanical record, mainly in the mixed remains of burnt refuse, with grain common in stores found in burnt buildings throughout the periods covered here. Chaff is less commonly found in store, though there is one record of free-threshing wheat chaff storage from MBA Kaman-Kalehöyük (Fairbairn 2004). These products, and the processing techniques used to produce clean grain and turn it into food, are also recorded in Old Assyrian and Hittite texts, many of which focus on crop raising and food production consumption as part of religious beliefs and rituals (Dercksen 2008a; Hoffner 1974). Cereal food products are found rarely in archaeological sites, including bread and flour, and the historical record provides examples of malt and beer, accompanying wine as liquid commodities in the Old Assyrian economy (Hoffner 1974).

Legumes/Pulses

Pulses are less well preserved than cereal crops, with the seeds usually only surviving and being prone to loss of testa and fragmentation, making their identification difficult. Across Asia Minor, archaeological assemblages are dominated by lentil (*Lens culinaris*) and bitter vetch (*Vicia ervilia*), both becoming more common later in the periods as pea (*Pisum sativum*) declined in abundance (Table 11.1; Riehl 2014). Chickpea (*Cicer arietinum*) is present inconsistently and may have been grown rarely in the Bronze Age or only in some regions, such as the Lake District where the presence of preserved stores (De Cupere et al. 2015) continue a strong record for that crop, established there in the Neolithic. With the exception of pea, these legumes are all recorded in Hittite texts (Hoffner 1974). Grasspea (*Lathyrus cicera/sativus*) is common in many sites in small quantities and is often thought to have been a weed, at Hısarlık/Troy associated with bitter vetch (Riehl 1999). Other finds confirm that it was grown in the Chalcolithic at Kuruçay and Ilıpınar, with pure stores at the former. Horse bean/broad bean (*Vicia fava*) has an inconsistent record, present in a few sites in the Chalcolithic. It is present in larger quantities at Kinet Höyük in the LBA, when it is recorded historically (Hoffner 1974, pp. 98–99). It is also found, not strictly within our study area, in voluminous stores from EBA Yenibademli Höyük in the northern Aegean island of Gökçeada, confirming its regional presence from that time alongside Spanish vetchling (*Lathyrus clymenum*) and clover (*Trifolium*), also found at Liman Tepe, both probably used as animal fodder/forage (Oybak Dönmez 2006).

Oil and Fiber

Oil-seed crops are known in Asia Minor from the Neolithic, mustard (*Descurainia sophia*) found in stores at Çatalhöyük East (Fairbairn et al. 2007). Flax seed is also found sporadically in large quantities from the earliest millennia of farming as seen at Ilipinar (Cappers 2007), though as their seeds are prone to explode when exposed to fire they are underrepresented in archaeobotanical assemblages (*ibid.*). Stores of seeds at Kuruçay and large quantities at Kinet Höyük and Hısarlık/Troy show that flax was used through the Chalcolithic and Bronze Age, probably as an oil source. Flax is also the source of linen, known from the Neolithic at Çatalhöyük (Burnham 1970). Another potential oil-seed crop is gold-of-pleasure (*Camelina sativa*), a well-known oil crop in Europe, whose seeds were grown with flax in MBA and LBA at Hısarlık/Troy, and stored with flax seed in an LBA flask (Riehl 1999). Safflower (*Carthamus* spp.) is well evidenced as a crop from the EBA in the Levant, but does not have strong evidence for its use in Asia Minor (Marinova and Riehl 2009). Sesame is another oil crop, known from Akkadian and Hittite sources (Hittite *šapšama*), which only has one verified archaeobotanical find at Büklükale from an early second millennium BCE palace (Fairbairn et al. 2019).

Orchards and Vineyard Crops

Orcharding and viticulture are important elements of Eastern Mediterranean food production, and Asia Minor's complex environment has great potential to produce a variety of tree and vine fruits as reflected in Turkey's leading position in production of hazelnuts, figs, and apricots, among others, all of which require different environmental conditions. Evidence demonstrates that these and many other fruits have long been exploited in Asia Minor (Table 11.1), though the separation of cultivation and gathering as well as local production and trade is complicated by the low archaeological visibility of many species and difficulties in identifying management practices. Evidence from the few Chalcolithic sites explored shows a continuation of Neolithic practices in which locally available, probably wild trees, were exploited for their fruits and nuts, though management is thought probable in some regions (see Asouti and Kabucku 2014). This is seen in the Black Sea coast and Marmara, the natural home of grape, fig, and hazelnuts (Cappers 2008; Van Zeist 2003), and in the Konya region, where wild almond, hackberry, and terebinth exploitation (Stroud 2013) continued a tradition of exploiting oil and protein-rich fruits from the Early Holocene (Fairbairn et al. 2014). While probable, cultivation is not unequivocally demonstrable for any of these taxa in Asia Minor before the EBA, though earlier cultivation of olive and fig is evidenced or suspected in the Levant and grape in Iran (e.g. Miller 2008; Areshian et al. 2012; Kaniewski et al. 2012; Dighton et al. 2016). Ethnographic evidence suggests that acorn use was widespread in eastern Turkey in the recent past (Mason and Nesbitt 2009), potentially providing a rich and important food resource from managed woodlands. While oak acorns are present at several Neolithic sites including Çatalhöyük East (Fairbairn et al. 2005), almost certainly used for food, but evidence from later sites is lacking, and so far there is no evidence to support widespread use in Asia Minor's past.

The EBA appears to be a major point of departure for orcharding and viticulture across the region, with the ubiquitous presence of grape and fig from the EBA suggesting their cultivation in sites of the Aegean and Cilicia, with probable cultivation of olive at Troy. During the Bronze Age, products such as oil and wine became important commodities for trade and generating wealth, and their production was underpinned by the development of successful cultivation methods, including vegetative propagation methods required for the maintenance of varieties with desirable traits (Barjamovic and Fairbairn 2018). While the early development of such techniques is contested, evidence suggests that by the LBA in the Levant, cultivation techniques for at least olive were producing standardized, large fruits from cloned trees (Dighton et al. 2016). The LBA has strong evidence for olive exploitation along Asia Minor's coastal zone, where they could be cultivated along with other trees found in regional pollen diagrams (Eastwood et al. 2007), but remain rare in most other sites, perhaps reflecting their primary use for oil (see Riehl 1999 for discussion). Historical evidence supports the presence of olive groves during this period in *Kizzuwatna*, the Hittite name for Cilicia (Bryce 2003), and pollen analysis suggests olive translocation into new environments in the same period (Van Zeist and Bottema 1991). Grape and fig seeds were also common at sites outside their natural distribution by the EBA, such as Kaman-Kalehöyük and Kültepe/Kanesh in the central plateau, probably from the operation of widespread trade, and probably cultivation in the case of grape, which tolerates the region's climate and whose use (Hittite *wiyana*), cultivation in vineyards (Old Assyrian $^{\textit{giš}}$*KIRI*$_6$*.GEŠTIN*), and bureaucratic control is recorded in both Old Assyrian and Hittite texts (see Smith 2008). Historical records and the remains of complex drinking equipment demonstrate that it was clearly consumed with gusto by the Asia Minor's Middle and LBA elites, perhaps providing the spur to local cultivation and production (see Miller 2008). Fig's ability to be dried and survive for long periods may have aided its emergence as a trade item that may extend to the Neolithic, when it is found at Çatalhöyük (Fairbairn et al. 2005), and burnt figs on a drying rack from LBA Kilise Tepe show evidence of early processing techniques (Bending and Colledge 2007, p. 592), in a region still renowned for the quality of that fruit.

Hazelnut and pomegranate are also thought to have been traded into the central plateau from at least the EBA and MBA (Fairbairn and Wright 2017), the latter being high-status trade items with symbolic significance into the Classical period (Ward 2003). Finds of hazelnut at Kültepe/Kanesh from the MBA city helped to confirm the plausibility of an otherwise contentious interpretation of the Akkadian word *allānū* as hazelnut (Fairbairn et al. 2013). In the case of both of these trees, their cultivation history remains unclear, though pollen evidence suggests hazelnut was cultivated in western Asia Minor from the first millennium BCE (Kaniewski et al. 2007), and historical records evidence the presence of pomegranate and apple orchards somewhere in the Hittite lands (Bryce 2003, p. 74). Texts also record the presence of fruit tree cultivars that have yet to be identified such as "mountain apple" (Hoffner 1974, p. 115), hinting at a diversity of orchard practices by the end of the Bronze Age that remain obscure.

Vegetables and Leafy Greens

Production of vegetables and herbs is not well represented in the Chalcolithic and Bronze Age archaeological evidence from Asia Minor, biased as it is toward the seed crops, especially those produced in large volumes, accompanied by durable chaff. Obviously leafy greens, herbs, and softer vegetables are not commonly preserved archaeologically unless their seed had a specific use or stores of seed were burnt. Evidence from elite deposits at Büklükale confirms the presence of some herbs and spices in the MBA (Table 11.1), but their absence from other sites suggests that these were rarities for the tables of the elite (Fairbairn and Wright 2017). Historical records clearly record gardens (^{giš}KIRI$_6$), gardeners (*nukaribbum*), and a palace official "chief of the vegetables" (*rabi warqē*) with sacks of onions (*šumkū*) recorded at MBA Kültepe (Dercksen 2008a) and records of herbs in Hittite texts (Hoffner 1974). Terminology for gardens and gardeners covers both vegetable and fruit production, thus taking in orchards. Somewhat unsurprisingly, the historical evidence demonstrates that a broader range of crops may have been grown than the archaeobotanical record would indicate, though references to some herbs and other greens may concern gathered wild plants rather than cultivated ones, as gathering is a well-recorded practice that continues in many areas of Asia Minor to this day (see Ertuğ 2000).

Trade, Cultivation, and Innovation

While there is no compelling evidence for long-distance trade in staple crops, with the possible exception of famine relief recorded in Hittite archives (see Bryce 2003), trade in exotic and high-value goods was clearly happening from at least the MBA and probably the EBA, when the diversity of economic plants increases significantly. A number of rare finds in storage contexts, burnt ceramic vessels, a shipwreck, and even a cesspit provide evidence for the presence of a range of fruits, spices, and plant resins (Table 11.1) that were almost certainly traded into Asia Minor from other regions. Most unambiguous are the finds from the Ulu Burun shipwreck, found off the Lycian coast, whose cargo included a remarkable haul of fruits, spices, nuts, and large blocks of terebinth resin (Haldane 1993). Other resins in historical trade records include asafetida, produced from the roots of *Ferula foetida*, recorded as being grown in the Hittite Lower Lands (Hoffner 1974, p. 110), a rare example of geographical specificity in Hittite texts demonstrating the cultivation of an otherwise unevidenced plant. These records, and archaeobotanical finds of new exotic goods, such as walnut (*Juglans regia*) appearing at ports such as Kinet Höyük, and passing through the ledgers at Kültepe/Kanesh's trade center, are clear evidence that Asia Minor's developed trade network circulated new plants and plant products, serving to open up the palate and mind to new foods from elsewhere in the region (see Boivin and Fuller 2008). That these finds are rare and often found in high-status settings indicates that, with the possible exception of grape and fig, most of these foods were not widely consumed and may have been accessible for consumption only by the elites or those aspiring to that status. Their use certainly extended beyond the mundane with clear historical records for ritual and medicinal use (Hoffner 1974; Salih et al. 2009) and being of central importance for elite participation in social and ritual settings. Evidence for these goods increases in third millennium Asia Minor, as in adjacent regions, and the high value of commodities such as olive oil and wine could have been a key spur in the uptake of cultivation both within the natural habitat of these plants and, where possible, in other regions.

Animals Husbanded

The husbandry and exploitation of animal products was another of the pillars on which ancient societies of Asia Minor were founded, animals producing primary product from their slaughter, such as meat, skins, bone, sinew, and fat, as well as secondary products from their live exploitation, such as milk, traction, transport, and manure. Understanding of many aspects of this complex of exploitation practices is rapidly improving with the increasing resolution of archaeological data available, especially the revolutionary impact of ancient DNA and chemical residue analyses complementing more traditional forms of research such as zooarchaeology (analysis of animal remains from archaeological sites – see Table 11.2) and textual evidence from cuneiform archives.

Stock Animals

Stock animals including sheep, goats, cattle, and pigs, were domesticated and herded in Asia Minor from at least the 8th millennium cal BCE, if not earlier (Stiner et al. 2014) animal lineages that were taken to Europe by the first farming colonists (Troy et al. 2001; Larson et al. 2007). Chalcolithic Zooarchaeological evidence from Asia Minor shows initial continuity with the Neolithic in that sheep and goats formed the most abundantly preserved remains with cattle secondary. At this point it is worth pointing out that while sheep/goat are more common at most sites throughout the period discussed here, cattle were much larger in body size and were most important in terms of meat production (Arbuckle 2014). Domestic pig was also an important presence in most sites, in some equaling sheep in numbers. This broad pattern persisted through the Bronze Age, though quantitative analysis has suggested in increasing focus on cattle in the Bronze Age as part of a focus on high-status animals by elites (Arbuckle 2014; De Cupere et al. 2015, p. 7). Sheep (Old Assyrian *emmerum*), rams (Old Assyrian *etūdum*), and goats (*ṣēnēšunu)*, including possible breeds such as sheep "from Zitluni" (qualifier *ṣuppum*, see Dercksen 2008b, p. 153), were recorded historically in the MBA, along with words for shearing (*buqūnum*) and various terms around the organization of herding and its control by the palace including the chief shepherd (*rabi rē'i'im/rē'i'ē*). Less is known historically about cattle (Old Assyrian *alpum*) at Kültepe, though it has been suggested they were primarily draft animals with their flesh eaten by the wealthy (Dercksen 2008a) or at the end of their working lives (Arbuckle 2012a).

As with plant products, animals and their products were key commodities in Bronze Age cities and used for trade, debt incursion, and payment, being fully integrated into the urban economies of the region (Dercksen 2008b). Among those commodities, were meat, skins, wool, and dairy products. The latter are commonly recorded in the historical record and are increasingly identified from residues in ceramics from the Neolithic period (Evershed et al. 2008; De Cupere et al. 2015), confirming its long-suspected presence on the basis of culling patterns, with cheese evidenced in Europe soon after (Salque et al. 2013). Unfortunately, residue studies in Asia Minor outside the Neolithic are rare, and the development of this central focus for animal husbandry remains obscure, though zooarchaeological evidence and ceramics suggest dairy was a major focus for many economies in western Asia Minor from that period (De Cupere et al. 2015). Milk is recorded in ancient texts (logogram GA, Hittite *pankur*), harvested from many animals, including goats and sows, with cheese produced (logogram GA.KIN.AG), and at least one "festival of milk" recorded in those sources (Hoffner 1974).

Dogs

Morphologically domesticated dogs are a consistent feature of zooarchaeological assemblages throughout the Chalcolithic and Bronze Age (Table 11.2), present as both part of the faunal assemblages and as taphonomic agents responsible from gnawing and destruction of bones in many sites (Atici 2006). Recent consensus suggests that the dog was domesticated from the wolf after 15 000 BP, following a long association with humans, though most other aspects of dog domestication remain controversial (Perri 2014). As hunting companions, guard dogs, and pets, dogs adapt well to human company, having a key economic role in protecting and herding livestock, one that continues to this day. Hittite pictorial evidence also suggests they were literal as well as symbolic participants in ancient hunts, and historical records show that dogs were valued, their killing being punishable by fines (Dörfler et al. 2011). Hittite records also show that dogs were important in rituals, especially puppies, whose powers extended to curing illness through licking the afflicted, protecting from harm through their presence, and purification through sacrifice (Collins 1992).

Pack and Traction Animals

Animals provided the key source of power for industrial processes, terrestrial transport, and traction before the invention of mechanical engines. Greater exploitation of that power has long been hypothesized as a significant advance during the Bronze Age, allowing the expansion of agriculture and trade networks as part of Sherratt's (1981, 1983) Secondary Products Revolution. The domesticated horse (*Equus caballus*) and donkey/ass (*Equus asinus*) were present from at least the Late Chalcolithic at Çadır Höyük, perhaps obtained from exchange with nomadic peoples of the Pontus (Arbuckle 2009). A problem in identifying domesticated animal remains in Asia Minor is that its central areas are the native home to wild horses and their relatives, so distinction of domesticated populations can be difficult. It is in those areas where equid remains are a constant presence, commonly hunted from the Paleolithic, where the best evidence for domesticated stocks lies. Interestingly, only in the LBA are the remains of the domesticated horse/ass found beyond that region. Of course, horses and donkeys are unlikely to be routinely slaughtered and eaten if mainly used as pack and traction animals, so the zooarchaeological record probably underrepresents their presence (Atici 2014a). Historical records confirm the presence of donkeys from the MBA, the black donkeys providing the means enabling the Assyrian trading system linking Assur in Mesopotamia to Kanesh/Kültepe in the central plateau and used for routine drawing of wagons (Dercksen 2008a). Horses are better represented historically from the LBA, used for personal transport. More important through much of the period discussed here for everyday agricultural labor and short-term haulage were cattle, more correctly oxen when used in traction, powering the plows and wagons that kept urban societies fed and supplied from their catchments. Archaeological evidence for draft oxen comes as early as Late Chalcolithic Çadır Höyük, where many males were slaughtered late in life once they were no longer fit for traction (Arbuckle 2009). Bronze Age finds of traction pathologies at sites including Bademağacı and Kaman-Kalehöyük (Arbuckle 2014) provide material evidence to support numerous historical references to cattle used in plowing and drawing wagons (see Dercksen 2008a; Atici 2014a).

Birds

Domestic birds are present in zooarchaeological assemblages, including the goose (*Anser anser*), duck (*Anas platyrhynchos*), dove (*Columba livia*), and fowl (*Gallus domesticus*), though as the first three are closely related to some of Asia Minor's native wild birds, some zooarchaeological identifications remain uncertain. Wild varieties of these animals were hunted from the Epipalaeolithic, and continued to be so through the periods discussed here, though avifauna are underreported, not always subject to detailed zooarchaeological study. Furthermore, the lack of fine-scale sieving at many sites means that the remains of eggs, a major product of birds as well as their flesh and feathers, are rarely if ever reported, and understanding of the history of egg eating remains uncertain for these periods. Domestic fowl/chicken was introduced from other regions and is known from a single EBA specimen. Domestic duck has a single record in the MBA, with better evidence from LBA Boğazköy/Hattusha and Kilise Tepe, both of which have particularly rich and well-studied avifauna, for the exploitation of the domestic duck, goose, chicken, and possibly domestic dove (Baker 2008; Dörfler et al. 2011). This fits regional evidence for the appearance of domestic bird keeping in the Middle and LBA in eastern Turkey (Boessneck and von den Driesch 1974), Mesopotamia (Peters 2014), and Egypt (Gilbert and Shapiro 2014).

Beekeeping

Hittite texts demonstrate that beekeeping was well developed in Asia Minor by the Middle and LBA with bees (Hittite NIM.LAL) producing honey (Hittite *milit*) and beeswax in beehives. Indeed, beekeeping is well evidenced in the third millennium in Egypt and Mesopotamia (Crane 1985; Hoffner 1974), but its development before this time remains a mystery. Chemical residues confirm that bee products were exploited from the Neolithic at Çatalhöyük in the central plateau and Çayönü Tepesi to the East (Roffet-Salque et al. 2015), though it is not possible to establish whether the residues came from collected honey or farmed hives. Honey/beeswax residues have not yet been explored in later periods.

Wild Plant and Animal Exploitation

While this account is primarily focused on farmed crops and stock, they were not the only source of foods and other resources in the period under discussion. A wide range of plants and animals were gathered, hunted, and fished from Asia Minor's increasingly depleted environment. As noted above, there is evidence for significant human modification of biota from early in the Holocene, with both pollen and wood charcoal evidence concurring that anthropogenic modification of vegetation (locally seen in the "Beyşehir occupation phase"), including deforestation, increasingly affected Anatolia from the third millennium cal BCE onward (Roberts et al. 2011; Wright et al. 2015a), though not to the same extent as in Mesopotamia (see Miller 1985). Wild plants and animals, common in the Neolithic, declined in archaeological visibility in most regions during the periods under study from the Chalcolithic to LBA, though in some site phases, such as Late Chalcolithic Çadır Höyük (Arbuckle 2009, p. 203) and the EBA of the Lake District (De Cupere et al. 2015), wild game was higher than the overall trend, and in the latter, tree fruits continue to be exploited from the Neolithic to Chalcolithic. The overall pattern of decline could reflect reduced availability of wild resources in a depleted environment increasingly given over to farming and/or changing tastes and cultural mores with a move toward the foods of the farm (for a discussion of a first millennium BCE example, see Miller et al. 2009), with patterns of enhanced use during certain periods in some regions reflecting local economic, cultural, or environmental factors. However, recent studies question the simple division of wild and domestic plant exploitation, and it is probable that woodland was managed from the Neolithic (Asouti and Kabukcu 2014), though the range and intensity of management practices increased over the millennia, as would the tension between maintaining woodland for fuel and other resources and clearing it for arable land. This history remains to be understood, though recent evidence supports the emergence of woodland management or protection during the Hittite occupation of Kaman-Kalehöyük, prefiguring evidence for more structured management practices in the Iron Age (Wright et al. 2015b).

Tools and Technology

Farming uses a range of tools in its many tasks, and technological transformation can have significant impacts on its practices and efficiency. Many traditional tools and technologies employ organic materials, which are poorly represented in archaeological sites, therefore tracing the history of technological change also requires critical use of historical records, ethnography, and experiment.

Ground preparation is the first stage in the cultivation of crops, and both plows and hand tools are well evidenced by the Bronze Age, with hoes and shovels found in the LBA wrecks at Ulu Burun and Cape Gelidonya, and a rare plowshare found in the former (Pulak 1998; Bass et al. 1967). The plow is thought to have been an early element of farming technology, with the ard/scratch plow accompanying the spread of farming across Europe. Old Assyrian *epinnum* is the generic word for plow, or may refer to the seeder plow (Dercksen 2008b, p. 145), both of which were drawn by pairs of oxen at Kültepe/Kanesh (*ibid*, p. 146).

Irrigation is an important technology, yet its early development is poorly understood in Asia Minor as it is hard to unambiguously identify from the archaeological record. The sum of archaeological and historical evidence suggests that it was used selectively on crops from at least the MBA in Asia Minor, evidenced historically and archaeobotanically at Kültepe/Kanesh (Dercksen 2008b; Fairbairn 2014), though isotopic analysis of crops indicated it was available earlier, being applied to emmer wheat just to the east of our study area at EBA Arslantepe (Masi et al. 2014). Hittite historical records suggest irrigation of fruit trees but not cereal crops (Hoffner 1974, pp. 22–24), while evidence from Kaman-Kalehöyük suggests that irrigation was not practiced at all throughout its Bronze and Iron Age history (Üstünkaya 2015). Many regions simply may not have required irrigation due to their climate (see Riehl 1999) and, while patchy, evidence suggests irrigation was available from the EBA and applied when circumstances required, or state actors could organize it (see Miller et al 2009). Its use was perhaps driven by politics or demand and not necessarily aridity, farmers clearly having the foresight to change crop selection to deal with increasing climatic uncertainty and drought during the period (Riehl 2009).

Pruning, harvesting, and *processing* tools are again well evidenced in Bronze Age sites. Bronze sickle blades and knives are known from Ulu Burun and Cape Gelidonya shipwrecks (Pulak 1998; Bass et al. 1967) as well as from sites with destruction levels, such as Kültepe (Kulakoğlu 2010, p. 288–289), the latter also preserving bronze pitchforks used in moving hay and straw. Parallel-sided stone blades are commonly found in the Chalcolithic and earlier sites, often identified as sickle blades on the basis of their shape and presence of polish from cutting crop stalks. Crop processing after harvest involved a series of stages, well identified in ethnographic and historical records (Hoffner 1974; Hillman 1984; Dercksen 2008b, p. 146–147) and involved many tools, though ethnographically most are made of wood and fibers. Among the lithics with the longest history of use are threshing sledge blades, still manufactured in the recent past, thought to have been developed in the EBA (Anderson et al. 2004) and whose use was identified archaeobotanically at LBA Kilise Tepe (Madella 2007).

Storage is a key farming technology to allow long-term curation of products, food security, and wealth. Many animals would have been stored "on the hoof," but such approaches were not possible for grain and other plant resources. Crop products and by-products, including fully processed grain, grain in the spikelet and chaff, were stored in sacks, pots, and installations, all of which have been found archaeologically. Evidence from Bronze Age stores and residues suggests many crops may have arrived at urban centers partially processed (Bending and Colledge 2007; Fairbairn and Wright 2017).

Storage in sacks was probably widespread if the incidence of sacks recorded in Old Assyrian texts is indicative of their use, with occasional archaeological finds also recorded (Fairbairn 2004). Such storage allowed transport of grain and daily access to stored food, as did the use of ceramic vessels and modest-sized aboveground clay storage bins, often found within Chalcolithic sites such as Köşk Höyük and Kuruçay, continuing Neolithic traditions. Earthen silos located outside buildings – pits dug into the ground with or without clay or straw linings – have been identified through the comparison of archaeological examples to historic and ethnographic records (Fairbairn and Omura 2005). Preserving grain by means of an earthen seal, such facilities are not suitable for regular access for food and were probably reserved for storage of surplus production for trade or future shortfalls. Their presence seems to be increasingly common in some agricultural production sites, such as Kaman-Kalehöyük, from the EBA onward, and their proliferation could be indicative of the development of surplus-based economies. While estimates of crop volume suggest many examples were domestic in scale, extremely large examples of earthen silos have also been found at several Bronze Age sites including Boğazköy/Hattusha, Kaman-Kalehöyük, and Kuşaklı, indicative of episodes of centralized storage of grain, probably for contingent strategic reasons including army provisioning and/or famine relief (Fairbairn and Omura 2005). Outdoor aboveground stores are known, for example, the communal storage seen at the center of EBA Demircihöyük. Large-scale magazines of wide-mouthed jars (*pithoi*) are also known from elite buildings/palaces in several sites from the EBA, probably representing more permanent and planned centralized storage of agricultural wealth.

Crafts and processed foods. Craft items and processed foods, such as cloth and cheese, appear to have been produced mostly in domestic settings with no clear evidence for centralized processing and production of crop and animal products during the relevant period. Specialist terms such as baker and butcher do not appear in ancient texts (Atici 2014b), perhaps supporting that domestic-scale production and distribution of farming products was the norm. Spindle whorls and loom weights made of clay and stone attest to the production of wool and linen fibers and cloth in many settlements, again at a domestic scale, though specialization may have developed from the Late Chalcolithic (Schoop 2014).

Transport is recorded in Old Assyrian and Hittite documents (Dercksen 2008a; Barjamovic 2011; Atici 2014a), including wagons drawn by donkey and oxen, used for moving goods from grain to straw, chaff, and fuel wood. While long-distance transport of trade goods was facilitated by donkeys, the humble wagon provided the mainstay of transport in Bronze Age cities. It is probable that such transport became common in the Late Chalcolithic when increased numbers of draft animals are evidenced.

The Agricultural Calendar

Asia Minor's agricultural calendar is fundamentally influenced by the seasonal cycle in which cool, relatively wet winters giving way to moist spring conditions and dry, hot summers. The Black Sea region has more summer rainfall than other regions, and the arid central plateau, with its long cold season and short growing period provides the most challenging region for farmers. The growth cycles of the core group of domesticates, mostly from a temperate Mediterranean climate, are timed to take advantage of these conditions. Many seed plants, including the major arable staples, have growth timed to occur during the wetter seasons, germinating in autumn, growing slowly through winter, and taking advantage of precipitation and warmth to complete their growth and set seed before they die as arid, hot conditions hit in summer. Stock animals also time their reproduction to birth in late winter or spring, providing offspring with enough access to food to gain weight and survive the next winter. Management cycles have traditionally been timed to make the most of these natural cycles with planting, harvest, slaughter (traditionally before winter), and storage carefully planned to limit risk and maximize system returns. Introduction of new crops and animals, especially summer crops, requires genetic strains that are able to cope with such conditions or the development of management strategies to overcome them.

Archaeological investigation of the seasonal round is afforded by analysis of mortality information from stock animals, including season of death, and also seasonality indicators in plant assemblages where identifiable. The traditional autumn sowing period appears to have been the norm through much of the Chalcolithic and Bronze Age, though spring sowing is recorded historically (Hoffner 1974). Where a determination can be made, Chalcolithic and Bronze Age records suggest that, as in the modern day, most of Asia Minor's grain and legume crops were sown on the traditional autumn sowing schedule, though they have increasingly been accompanied by spring-sown crops dependent on irrigation today including cotton (late or post-Medieval), maize (post-Columbian), and sugar beet (nineteenth century), as well as temperature-sensitive vegetable crops. Archaeologically, spring-sown wheat and barley are thought to be a relatively recent innovation globally. While some millet cultivation is found in the Bronze Age, solid evidence, as with sesame, is seen in Asia Minor only in the first millennium BCE (Riehl and Nesbitt 2003; Miller 2010), the latter, with olive oil, probably replacing the flax (linseed) as a source of oil (Riehl and Nesbitt 2003, pp. 306–307).

Matching the traditional cycle, Hittite records give us an unusually vivid view of the ancient farming year, most eloquently explored in Hoffner's masterwork *Alimenta Haetheroum* (1974). Starting in spring (*hamešhaš*), the season of flowers, floods, and thunderstorms running from April to June, the Hittite year had a summer (BURU$_x$-*anza*) lasting from July to October during which a myriad of activities was undertaken from harvesting and processing grain and fruits to tending orchards and readying the harvest for the coming winter. Autumn (*zenaš*) is thought to have lasted approximately two months from October to December, during which time plowing and seeding of the next year's crop was undertaken, attendant with numerous rites and festivals. A three-month winter saw the end of most agricultural activities beyond tending livestock and attending the birth of the new year's animals. This yearly cycle would have been familiar to any farmer from the Neolithic to recent decades.

Transhumant pastoralism, the seasonal movement of herd animals between pastures in complementary environmental regions, is a long-term feature of Asia Minor's farming system, allowing effective use of resources and increasing biodiversity by entire social groups or subsections of communities (Ocak 2016). Archaeological evidence for nomadic pastoralists in Asia Minor is sparse, unlike in the east (Hammer 2014), with some possible Later Neolithic records (Baird et al. 2011). Better evidence comes from the Chalcolithic and Bronze Age, where at Acemhöyük, transhumant pastoralists are inferred from patterns of meat supply (Arbuckle 2012b), and at İkiztepe from isotopic evidence of human diet (Welton 2014). Evidence suggests parts of the Black Sea littoral and much of northeastern Anatolia were home to largely nomadic pastoralist societies through much of the Bronze Age, if not earlier, part of the Early Transcaucasian Culture (ETC), and Asia Minor may well have been within their transhumant rounds (Hammer and Arbuckle 2017). Transhumance is clearly an ancient practice which varied in scale and presence depending on socioeconomic circumstance and is a long-standing element of provisioning.

Organization, Scale, and Management of Agropastoral Systems

Farming is a flexible and adaptable system of managing plants and animals for food and other resources, and evidence suggests long-term changing patterns of organization and management. Mixed farming combining integrated crop and animal exploitation is well evidenced in sedentary settlements throughout the Chalcolithic and Bronze Age with the core range of crops and stock animals changing to suit economic and cultural demands. Cattle was the dominant meat animal at most sites alongside, sheep/goat, and pig, which may have attained local dominance. Much of the arable production based around wheat, barley, and several legumes, though there are clear historical trends toward naked wheat, hulled barely, lentil, and bitter vetch with a reduction in glume wheat, naked barley, pea, and flax. Evidence points toward a modest development of viticulture and arboriculture in this period, pollen evidence in the Aegean only picking up signatures suggestive of larger-scale practices in the first millennium BCE. Cultivation of many garden vegetables/fruits, herbs, and spices is noted historically but is very difficult to trace archaeologically, and the few examples of exotic spices/herbs probably derive from trade only later taken into cultivation (Riehl and Nesbitt 2003) as appropriate stocks, technologies, and markets were available. As ever, the archaeological record is heavily skewed toward the commonly preserved, distinguishable elements of past lives with practices such as vegetable gardening, beekeeping, and bird keeping hard to verify beyond written records. From a modern perspective, the range of plants and animals grown in the Chalcolithic and Bronze Age is very narrow, yet it is clear in pastoral and arable domains that the diversity of exploited species and systems of production both increased during the Bronze Age, in many ways prefiguring the further developments of the Iron Age/Classical world. Viewed in the *longue durée*, these developments form part of a pattern of widening diversity of foods and exotic items circulating in society as urbanism emerged and as its new forms of production and trade increasingly transformed the world.

While this pattern is clear, the scale, intensity, and organization of agriculture in the Chalcolithic and Bronze Age is still poorly understood. Neolithic systems across western Eurasia are thought to have been intensively managed in systems of "garden agriculture," at least in the first millennia of their presence, with manuring and careful tending of fields located close to settlements maximizing returns (Bogaard 2005) and variously integrated with animal herding. This insight has overturned the assumption in western Eurasia that ancient farmers were involved from the start in broad-scale agriculture of the kind seen in the recent past, emphasizing the diversity of potential ancient farming systems as solutions to producing resources. It is uncertain when broad-scale arable systems of the type seen in the recent past were developed during the pre-Classical period', though evidence from Mesopotamia suggests that extensive agriculture was established by the 3rd millennium BC (Styring et al. 2017).' Detailed evidence for Kaman-Kalehöyük suggests that expansion of cultivated land, reduction in manuring intensity, and reduction of tree cover was seen toward the end of the Bronze Age, perhaps signaling the development of imperially driven broad-scale agriculture by the Hittite kingdom (Üstünkaya 2015; Wright et al. 2015b). This broadly fits with the timing of the Beyşehir occupation phase, a phenomenon that could be indicative of the transition to such broad-scale, less input-dependent systems in Anatolia. Such change could explain a pattern seen on the Aegean coast where increase in the seeds of ryegrass (*Lolium temulentum*), a pernicious weed, peaked in the LBA, perhaps indicating soil overuse and exhaustion during that period (see Riehl and Nesbitt 2003).

Evidence for pastoralism from Asia Minor's Chalcolithic shows continuity with the Neolithic, in that sheep/goats are numerically dominant, with cattle secondary, though this changes over time with increasing focus on cattle production through the Chalcolithic and into the Bronze Age (Arbuckle). Cattle are initially dominant in the temperate forest regions of northwest Anatolia, associated with dairying, and their increasing use in other regions reflecting a value in traction and also as a status symbol deployed by emerging social elites (Arbuckle 2014). Traction was also facilitated by donkeys and horses, known from the Late Chalcolithic at Çadır Höyük, and perhaps obtained from contact with nomadic pastoralists in the Pontic zone. Evidence for specialized pastoralism for wool/hair production and increasing evidence for weaving suggests that textile production was emerging as an important part of Asia Minor's economy during this period, perhaps driven by ritual demands (Schoop 2014). Recent studies at Acemhöyük have suggested the presence of a centrally controlled production system in the MBA with a focus on sheep wool production running in tandem with a meat supply provided by transhumant pastoralists (Arbuckle 2012a). At Kaman, the EBA system shows management for herd maximization, not specialization (Atici 2005). Clearly quite different economic strategies were followed in different settlements depending on socioeconomic structures, risk strategy, and system demands. And this example illustrates that, while regional patterns of agricultural practice are plausible, evidence is increasingly questioning the idea of uniform, normative agricultural systems changing across broad regions in time. Better fitting the evidence, from both plant and animal sources, is that farming practice was extremely diverse across Asia Minor for much of the past, reflecting cultural, social, and environmental difference.

Andrew Sherratt famously hypothesized that animals were initially mainly exploited for meat with exploitation of their secondary products (wool, milk, traction) becoming important later, with the transitional period in the 4th millennium BCE seeing the "secondary products revolution." Evidence from ceramic residues has shown that dairy was utilized from at least the 7th millennium cal BCE in Asia Minor, thus predating Sherratt's model. Zooarchaeological research has confirmed that Central Anatolia at least saw the use of animal traction and exploitation of wool by at least the MBA at Kültepe, and as early as the Late Chalcolithic at some sites, including Acemhöyük and Çadır Höyük, driven in part by the emergence of commodity-focused economies. Evidence is, however, uneven and, like many other prehistoric revolutions, that of secondary products was a rather drawn-out affair with commitment to secondary products varying with local economic circumstance and strategy (Atici 2014a).

Those economic circumstances and strategies were affected by a number of large-scale factors outside any individual farmer's control, including climate change (dry and wet phases), imposed sociopolitical structures, war, and trade. Provisional analysis of crop selection in Anatolia (Riehl 2014) shows, as in other areas of southwest Asia (Riehl 2009), that farmers moved away from more susceptible crops (pea, einkorn wheat, flax) to more drought-resistant crops (barley, lentil, bitter vetch) as the climate became more arid. In the Aegean, a move from pulses to cereals may have provided a more reliable base for increasing population demands (Riehl et al. 2014a). Such evidence indicates that arable farmers were responding contextually to risk and opportunity throughout the period and does not fit with the notion of significant direct control of agricultural production by the elites that emerged during the Bronze Age, as seen in some Mesopotamian polities (Paulette 2016).

Historical records show how farming was associated with the Hittite state by the LBA, sustaining farming productivity through ritual participation being a core kingly responsibility in the Hittite world, yet there is little evidence to support direct attempts at management. Agricultural lands and estates were given out by the king, though there is no evidence for direct intervention in their operation. Hittite historical records show attempts by the later kings to avert famine through requests for grain from adjacent lands (Bryce 2003), an event that would have caused suffering to the people and undermined the state's claims on authority. Earlier, Kültepe's MBA palace appears to have been actively involved in farming and included bureaucrats with oversight in many of its component areas, but rather to make sure the palace's financial interests were served and grain supplies maintained rather than providing direct instruction to farmers about what to grow. Archaeobotanical evidence from Kültepe/Kanesh shows significant, consistent differences between the upper and lower cities for consumption of agricultural products and fuel, but it is difficult to square that with centralized control; rather, evidence could indicate differential access to land or markets by sectors of the population (Fairbairn and Wright 2017). Herd animal selection has not been successfully associated with climate change, but increasing focus on cattle exploitation through the Bronze Age may have been linked to the animals' value as an indicator of social status (Arbuckle 2014), and centralized influence over provisioning may have occurred at MBA Acemhöyük, complemented by provisioning by non-state actors in the form of nomadic herders operating outside centralized control. Evidence also suggests influence over landscape use, if not conservation, in some regions with possible proscription of pine exploitation at Hittite Kaman-Kalehöyük (Wright et al. 2015a). In conclusion, the Chalcolithic and Bronze Age of Asia Minor sees evidence for state interest in economies, but little evidence for direct centralized control with variation in the mode of production and how everyday farming interacted with different forms of authority.

Future Research

Asia Minor's agricultural history is emerging from relative obscurity as a result of increasing primary archaeological investigations, including the study of animal and plant remains, plus a rich historical record which is becoming better known outside the philological world. While this overview attempts to bring together those records, it should be recognized that the state of knowledge for Asia Minor is less detailed than that for Mesopotamia and the Levant, largely due to very patchy primary data. Entire regions and periods remain poorly sampled, with few or no records, and in many areas convincing regional histories accounting for variability across Asia Minor's diverse environments remain to be completed. At the time of writing, a new generation of archaeobotanical and zooarchaeological scholars is producing new primary records that are sure to refine further the overview of the region provided here and address the many areas of uncertainty concerning ancient agriculture. A key priority for future research in this area is more systematic collection of archaeological data from a wider range of excavations. Well-tested recovery processes and strategies exist but are applied at too few sites, with the opportunistic collections at many simply not allowing robust analysis. This is particularly the case for the Chalcolithic, a period in which urbanism has its roots and where there is so much to learn concerning economic and cultural transformations, though the record from Bronze Age itself is only marginally better.

A key issue remains in understanding the transformation of farming with urbanism, including the development of broad-scale approaches to farming that could have been present by the Late Bronze Age and the role of transhumance trade and crop innovation in alleviating the problems caused by new ways of living. As larger-scale climate records continue to develop, local-scale research is required to understand the extent to which Asia Minor's climate tracks larger-scale patterns and affects agricultural production and to further refine understanding of the move toward more drought-tolerant crops. Furthermore, local histories of landscape management, deforestation, and the link to farming decisions remain unclear over much of Asia Minor, with integrated seed, charcoal, and local climate studies required to improve understanding. Of high significance is understanding agricultural management responses to risk in periods of aridity, as seen in the 2nd, 3rd, and 4th millennia, including the role of agricultural problems in the LBA collapse. There is still a lack of clarity regarding the introduction and use of summer crops in the Bronze Age, and understanding in-field management and changing farming strategies during the development of urbanism and centralization of power remains obscure from the Chalcolithic onwards. Furthermore, the development of tree management, cultivation, and domestication remains uncertain and a key focus for future research.

FURTHER READING

Much of the literature concerning ancient agriculture in Asia Minor is dispersed through scholarly journal and monograph articles, especially site excavation reports, many of which are directly cited here. One of the most recent critical overviews of the archaeology of Asia Minor is provided by Düring (2010), with palaeoenvironmental trends and data summarized most recently by Roberts et al. (2011). Key archaeological overviews for the use of key animal species have been produced by Arbuckle et al. 2009, Arbuckle (2014), and Hammer and Arbuckle (2017), with plant agriculture most recently discussed by Riehl (2014) and Mark Nesbitt's 1995 paper "Plants and People in Ancient Anatolia" continuing to provide the most concise overview of archaeobotany's contribution to understanding ancient farming. Hoffner's *Alimenta Haethorum* also provides an unsurpassed overview of agriculture from the Hittite historical view, with Dörfler et al. providing an archaeological summary to complement it and the upcoming volume *Hittite Landscape and Geography* (Weeden and Ullmann 2016) promising to bring new focus to this area of scholarship.

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CHAPTER TWELVE

Bronze Age Europe: Revolutions in Agricultural Adaptation

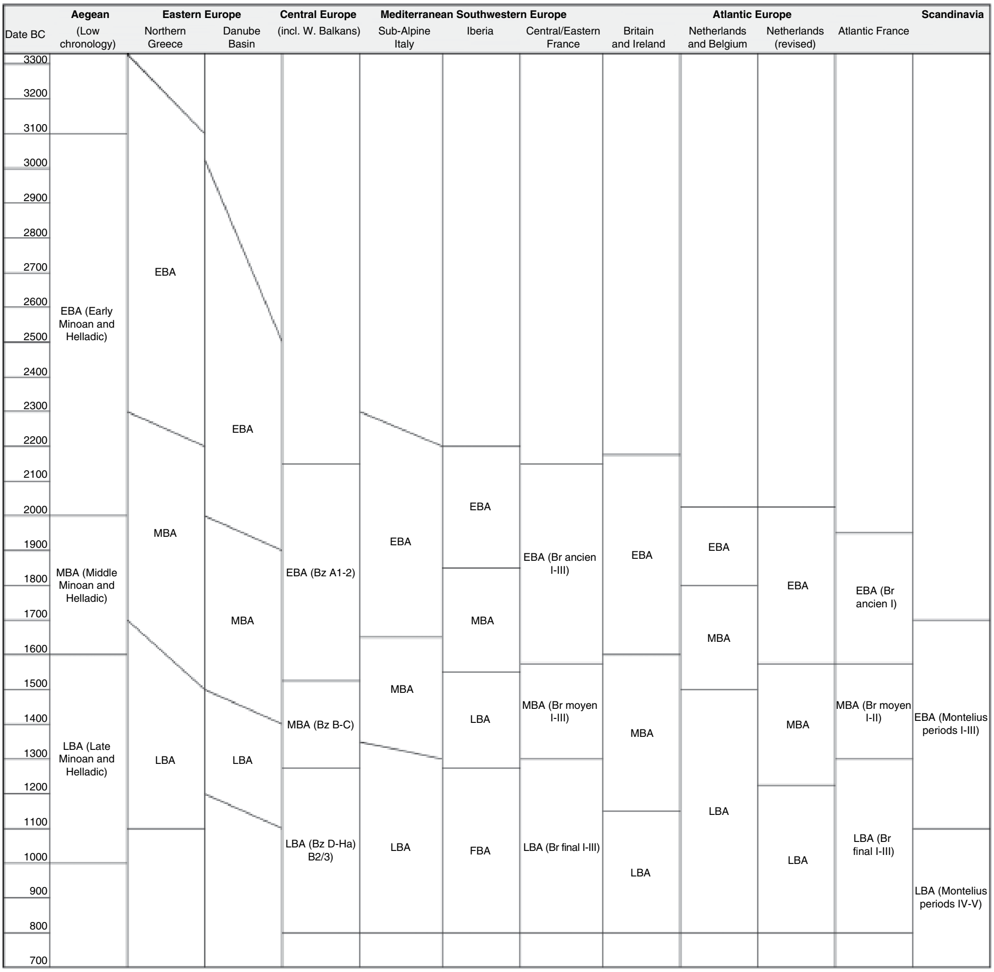
Lynne A. Kvapil

What can be said about Bronze Age agriculture in the wake of the major advances of the Neolithic period? It may not be particularly flashy, but the Bronze Age in Europe sees a revolution in agricultural control and management that reflects increasing levels of adaptability. Assemblages of cultivated plants and animals were carefully chosen according to geography, climate, and societal demands, whether it was for subsistence, risk buffering, or surplus to support other industries. And when that was not sufficient, the landscape was altered. The adoption of metal tools enabling more intense forest clearance and the use of the ard plow began to transform marginal land into productive fields. Soils that once would have been quickly over-farmed or were not naturally suitable for cultivation were replenished through crop rotation and fallowing, the application of manure, or irrigation. Early terraces made the vertical landscape fruitful, and field systems organized the landscape for both animal and plant husbandry. These slow revolutions were, in many ways, rooted in earlier traditions. In the late or final Neolithic and Chalcolithic periods, the household began to emerge as a self-contained economic unit, marginal arable land was colonized by loosely connected independent households or small communities, and new exchange and trade networks amplified differential access to precious materials and knowledge, all of which were developments that supported the formation of ranked societies and the early states that emerged in Aegean Greece.

The following chapter examines these revolutions in more detail, beginning with Aegean Greece, where the Bronze Age occurs earlier than most other parts of Europe, and moving throughout Europe by geographical region. Bronze Age chronology is complex for this reason and because terminology and subperiods are usually determined by the scholarship of a particular region. For ease of discussion, this chapter will refer to the tripartite division of the Bronze Age into Early (EBA), Middle (MBA), and Late (LBA). Table 12.1 outlines the approximate dates for these periods in each region.

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

Table 12.1 Major chronological divisions of the Bronze Age for regions of Europe discussed in this chapter. Compiled by the author after Andreou, Fotiadis, and Kotsakis (1996); Bietti Sestieri (2013); Boroffka (2013); Harding (2000); Nicolis (2013); Roberts, Uckelmann and Brandherm (2013); Shelmerdine (2008); Teržan and Karavanić (2013).



Aegean Greece

The Aegean, consisting of the southern Greek mainland, Crete, and the Cycladic islands (Figure 12.1), is often excluded from discussions of the European Bronze Age and prehistoric agriculture, in part because scholarly discussion relating to the agriculture economy tends to focus on the formation of the Minoan and Mycenaean palace states. Here, the Mediterranean climate as we understand it today, with hot, dry summers and cool, wet winters, seemed to develop during the transition between the Neolithic and Bronze Ages, at the same time as land-use intensity increased (Atherden, Hall, and Wright 1993).

Agricultural expansion at the beginning of the EBA, which included the settling of marginal areas or farming of larger fields, was aided by the introduction of the ard plow and draft animals. The use of bovines for traction dates back as far as the Early Neolithic period in Crete

Figure 12.1 Map of Europe showing sites discussed in sections on the Aegean, the southwestern Mediterranean, and Eastern Europe. Source: Lynne A. Kvapil.

(Isaakidou 2006), but it intensifies in the EBA. There are multiple lines of evidence for this, beginning with localized but severe episodes of erosion attributed to the destabilization of soils from deep plowing (Van Andel, Runnels, and Pope 1986; Van Andel, Zangger, and Demitrack 1990; Wells, Runnels, and Zangger 1990). Terracotta figurines resembling oxen from Tsoungiza preserve traces of attachments that seem to represent yokes (Pullen 1992, 2011). A bovine bone with an enlarged articulation at the distal end of the metacarpal, found at the same site, has also been interpreted as evidence for the use of draft animals (Halstead 2011). Finally, barley, which was dominant among an array of cultivated cereals in the EBA Aegean that also included emmer and einkorn wheat (Hansen and Allen 2011; Stika and Heiss 2013), would have been good fodder for livestock that were working rather than grazing (Jones 1987), and it was hardy enough to thrive on the marginal soils of newly colonized land (Renfrew 1966).

The presence of pulses among botanical remains suggests that perhaps they were rotated with cereals, which would have been a necessary defense against soil depletion. Not only are pulses regularly present, several pure deposits of stored legumes have been found, including deposits of field beans from Lerna and Thebes (Hopf 1961; Jones and Halstead 1993b). So, while it is uncertain whether cereals were grown as maslins (Hansen and Allen 2011), the discrete storage of pulses indicates that they were grown as single crops and supports the possibility that they were rotated with cereals.

The cultivation of cereals and pulses was balanced with the rearing of sheep, goats, cattle, and pigs. Skeletal remains show that these animals were harvested for meat as juveniles or subadults; but, the increasing age at harvest for cattle and ovicaprines indicates an emphasis on the production of secondary products, including traction, milk, and wool (e.g. Gejwall 1969). There was not a "Secondary Products Revolution" per se (see below), but secondary products were an integral part of subsistence practices as well as being instrumental to the production of textiles, as confirmed by the discovery of weaving implements, such as loom weights and spindle whorls. These objects are not uncommon finds at EBA sites in the Aegean (Barber 1991), although it is important to note that there is not good evidence for large-scale textile production until the MBA (Halstead 1996).

During the MBA, early archaic states, referred to as the "First" or "Old" Minoan palaces, develop on Crete. These were followed by the Mycenaean palaces of southern mainland Greece in the LBA. In seeking to explain the development of Minoan and Mycenaean palace states, Renfrew proposed that changes to the organization of agricultural production resulted in the "emergence" of Minoan and Mycenaean civilizations (Renfrew 1972). His model focused on the specialized cultivation of grapes, olives, and cereals, crops which have alternating growing and harvesting seasons and which would have thrived in various growing environments. Although there are very fertile parts of southern Greece and Crete, arable land is not necessarily widespread. A focus on what Renfrew called Mediterranean polyculture would have allowed for a diversification of cultivars, the colonization of marginal land, and the intensified use of land in general, all innovations which were instrumental to the surplus production that eventually supported the palace states (Renfrew 1972, 1982).

While the Mediterranean polyculture model has been extremely influential, it does not obtain in light of evidence showing that neither olives nor grapes were domesticated prior to the development of the Aegean palaces (Halstead 2004; Hansen 1988). Moreover, recent reassessments of the nature of Minoan and Mycenaean palace states stress that these difficult-to-define entities likely did not exert total political, religious, and economic control but rather that they were hugely instrumental in integrating ceremonial, administrative, and corporate aspects of society. Elites of the palaces would thus have been far more interested in mobilizing raw materials for the production of prestige goods and in distributing subsistence goods as rations for corvée labor or through large communal banquets (Nakassis, Galaty, and Parkinson 2010; Schoep 2010). Of course, agricultural goods would have been integral within these systems of resource mobilization and food distribution.

Consideration of botanical and faunal remains along with texts written in the early Greek script known as Linear B allowed Halstead to offer a model of agricultural production as organized by Mycenaean palace states (Halstead 1987, 1992a, b, 1995, 1999, 2001, 2004). He suggests that, under a palace-organized agricultural regime, wheat and barley, important grains since the MBA (Forstenpointner et al. 2010; Kroll 1991; Sarpaki 1992a; Shay and Shay 1974), would have been cultivated in an extensive way with little human labor. Oxen, also recorded in Linear B texts, would have thus been a valuable source of labor for plowing as well as the threshing of grain, a process made more difficult with the harvest of straw for fodder; seeds would have been broadcast in the late winter so that more land could be covered in a short period of time, and grains harvested in the spring prior to the dry Mediterranean summer; and, to return nutrients to the land, fields would have been left fallow on a biennial basis or rotated with pulses, which survive in the archaeological record but do not appear in any texts (Sarpaki 1992b).

Although this model focuses on the extensive, labor-saving aspects of cultivation, there is botanical and textual evidence for the cultivation of labor-intensive crops. A handful of plants, such as safflower, coriander, and cumin, are listed in Linear B documents in a way that suggests regular planting and predictable harvests (Kvapil et al., 2019); and, macrobotanical remains of melon and pomegranate were found at the Mycenaean palace at Tiryns (Kroll 1982). Palatial gardens of both edible and decorative plants may thus have existed at Mycenaean palaces like Tiryns, and they have been proposed for Minoan palaces (Day 2006), but it is not certain to what extent the palaces may have administered horticulture or if these labor-intensive crops would have been paid to palatial elites as taxes, traded, exchanged, or even sold in market settings (Killen 2008; Kvapil et al., 2019).

Other, more labor-intensive crops, such as flax, grapes, and olives, are also mentioned in Linear B texts. Texts from the palace at Pylos record the lease of palatial land in return for a levy of raw flax for the production of garments (Foster 1981). Cultivation of the grape is sometimes assumed by the LBA in southern Greece based on the presence of domesticated seeds from sites in northern Greece (Hansen 1988), but there is no certainty that grapes were domesticated even by the LBA (Sarpaki 2012). Olives, on the other hand, likely were domesticated and cultivated by the LBA. Not only is there botanical evidence (Halstead 2004; Hansen 1988; Zohary, Hopf, and Weiss 2012), but pollen diagrams from near Pylos also suggest intensified olive production possibly related to the production of perfumed oil (Zangger et al. 1997).

Linear B texts also make extensive mention of the palatial administration of stock, mostly sheep. The production of woolen textiles on a significant scale seems to have begun at the Minoan palaces in the MBA as attested by large deposits of loom weights that have been found in palatial contexts, although these textiles may have been produced strictly for internal consumption (Schoep 2010). Linear B documents indicate that the Mycenaean palaces continued the Minoan tradition of keeping large palatial flocks, which were raised for primarily for wool used for the production of prestige goods but seem to have been managed and utilized differently by different palaces (Halstead 1992b).

Recent work on agriculture in the BA Aegean also sheds light on practices at settlements or households which may have interacted with palatial society but largely functioned beyond the palatial sphere. Faunal remains from a well at Petsas House in the settlement outside the palace at Mycenae suggest that the domestic pig was the most directly available source of meat as opposed to caprines, which appear much more abundantly in palatial contexts (Meier, Price, and Shelton *forthcoming*; Price 2015). Since pigs would have been easier to keep in an urban setting than sheep, goats, or cattle and because the nitrogen levels found in the pig bones suggests that they were feeding on domestic refuse, they must have been provisioned independently at the household level (Meier, Price, and Shelton *forthcoming*).

The harbor town of Korphos-Kalamianos in the southern Corinthia illustrates the variety of growing environments available to a non-palatial settlement. The karstic landscape surrounding the settlement was filled with arable basins good for extensive cereal and pulse cultivation and terraced hills useful for either arable farming or arboriculture. Scatters of ceramic sherds on terraces suggest that nearby fields and urban gardens were manured with domestic refuse, while underground sources could have supplied water for small-scale irrigation. The variety of available growing environments suggest that agricultural production outside the palaces ranged from intensive to extensive and from specialized to diversified depending on subsistence needs and participation in trade and exchange networks (Kvapil 2012; Kvapil et al. 2019).

Mediterranean Southwestern Europe

Like Aegean Greece, the Iberian Peninsula, sub-Alpine Italy, and southern France (Figure 12.1) belong to the Mediterranean climate zone and generally experience hot, arid summers and cool, wet winters that made an autumn sowing of cereals preferable (e.g. Bouby 2000); but there is variation from this standard with greater distance from the Mediterranean sea and with greater elevation. Here, the onset of the BA was accompanied by both cultural continuity and change. In southern France, Neolithic Beaker culture continued, but Argaric and Castrejo cultures developed on the Iberian Peninsula and Apennine groups on the Italian peninsula. Settlements once primarily coastal shifted inland, and land use intensified as the plow allowed heavy alluvial soil to be more easily cultivated. Analyses of pollen and charcoal confirm that deforestation begun in the Neolithic period continued throughout the BA in this region (Figueiral 1995; Figueiral and Bettencourt 2004).

Agriculture in this region throughout all periods of the Bronze Age can by and large be portrayed as mixed subsistence farming, characterized by the cultivation of grains, legumes, and other plants and the rearing of sheep, goats, cattle, and pigs depending in some cases on the surrounding landscape. The most common preference was for sheep and goat or cattle (De Grossi Mazzorin 2013; De Grossi Mazzorin and Tagliacozza 1998; Maini and Curci 2013), but pigs appear to have been raised in large numbers in areas with mixed oak forest, as attested by archaeozoological data from sites in northern Italy like Poggio Rusco and Noceto (Stopp 2015).

The dominant types of cereals chosen for cultivation also differ regionally, particularly in the EBA and MBA. In southern France and much of Italy, emmer wheat was preferred followed by naked and hulled barley. However, cereal pollen from sediment samples collected at the terramare settlement of Fondo Paviani suggests that more barley was cultivated in the Po River valley along with wheat and oats (Dal Corso et al. 2012). Over time, there was a shift in preference from naked to hulled varieties of barley that might reflect the increased use of cattle as work animals since hulled barley was more suitable for animal fodder. This transition begins on the mainland in the EBA and is not visible on nearby islands, like Sardinia or Menorca, until the MBA (Bouby 2000; Hopf 1991; Ucchesu et al. 2015). On the Iberian Peninsula, barley was dominant among cereal varieties, but the changing preference for hulled over naked barley is less apparent. Buxó i Capdevila et al. (1997), looking at sites including Bòbila Madurell in Catalonia, argue that cultivation of hulled barley was a key feature of Argaric culture in the southeastern part of the peninsula. Delgado-Raack and Risch (2015) even go so far as to propose that Argaric dependence on barley monoculture resulted not only in malnutrition but also in a decreased tolerance for crop failure so severe that the ensuing social conflicts may have contributed to the collapse of El Argar society.

Evidence for the cultivation of other plants during the EBA and MBA is slimmer, although Uzquiano et al. (2011) do note that hulled barley and naked wheat form a common grain assemblage throughout the peninsula at this time, and they interpret the discovery of a mix of naked wheat and germinated hulled barley in a storage pit at El Llano de la Horca as the remains of food or fermented drink preparation. Evidence for millet and spelt, on the other hand, have been found in northern Italy and Tuscany (Bellini et al. 2008; Hopf 1991; Tafuri, Craig, and Canci 2009), and new glume wheat (see below), while not present in large amounts, is ubiquitous enough in samples from southern France to suggest that it was widely cultivated if not grown in large quantities (Toulemonde et al. 2014). Although there is evidence for the presence of the field bean, grass pea, and lentil, there is little indication of significant pulse cultivation (Mercuri et al. 2006; Stika and Heiss 2013). Flax and poppy have also been found, but in very small amounts (Stika and Heiss 2013), although it is important to note that the small quantity of botanical remains, especially for oil plants, may not always preclude cultivation (Valamoti 2011).

Agricultural production in the LBA is characterized by an increasing diversity of cultivars. Emmer remains the dominant cereal, but broomcorn and foxtail millet, spelt, oats, and new glume wheat are now found with much greater frequency (Hopf 1991; Mercuri et al. 2006; Toulemonde et al. 2014). Millet cultivation becomes much more widespread in the LBA, although adoption of broomcorn and foxtail millet may have lagged behind in the Iberian Peninsula (Moreno-Larrazabal et al. 2015; Stika and Heiss 2013). Einkorn and free-threshing wheats decrease substantially in popularity, although it has been argued that macroremains of these particular grains do not survive well in the archaeological record, particularly if grains were parched in preparation for human consumption (e.g. Bellini et al. 2008). The earliest evidence for the presence of rye is found at Terramara di Montale, in the Po Valley, but it is not clear whether its cultivation was intentional (Mercuri et al. 2006).

A much wider variety of legumes and other plants were also cultivated at this time. The presence of field bean, bitter vetch, chickpea, grass pea, and lentil suggest not only a broader diet, but also the possibility that grains and pulses were being rotated to replenish the soil with nutrients and that more fodder was being produced to support livestock (Bellini et al. 2008; Bouby, Leroy, and Carozza 1999; Stika and Heiss 2013). Poppy and flax also continue to appear among macrobotanical remains. Both may have been cultivated as oil plants, although flax could certainly have been cultivated for linen as it was in Alpine settlements (see below). Hemp may also have been cultivated for oil and fiber, as well as food or fodder, in the Po Valley (Mercuri et al. 2006), while at the lagoon site of La Fangade in Languedoc, substantial remains of dyers rocket or weld hint at the production of yellow dye, possibly related to textile production (Bouby, Leroy, and Carozza 1999; Chabal et al. 2010; Zohary, Hopf, and Weiss 2012).

The isotopic composition of cereals from Terlinques in southeastern Spain indicates that irrigation may have been practiced earlier than previously suspected (Mora-González et al. 2016). Such an innovation would not be inconsistent with similar developments in the Aegean (see above). Crops, at least by the LBA, seem to be sown separately, based on several sites that have produced evidence for the discrete storage of grain types. At the cave site of Baume Layrou in Languedoc, barley, millet, emmer, and spelt were found stored separately in bags, wooden containers, and ceramic vessels (Bouby, Fages, and Treffort 2005). There are still, however, signs that wheat and barley were sown and stored together in places like Menorca, where some agricultural advances were slow to be adopted (Moffett 1992). The presence of pollen in other storage sites indicates that at many sites the cultivation and processing of grains were carried out in close proximity to living quarters (Bellini et al. 2008; Mercuri et al. 2006).

Eastern Europe

Northern Greece, the Balkans, the Pannonian Basin, the Transylvania Plateau, and the Romanian lowlands (Figure 12.1) fall mostly into the climate of continental Europe, although coastal areas in the west are at the edge of the Mediterranean zone. This region is bounded by mountains including the Carpathians in the east and the Dinaric Alps in the west; but, the interior is defined by broad plains and river valleys, foremost of which are the Danube and its tributaries. The cultural groups that inhabited this region during the BA are numerous and often difficult to define distinctly. Northern Greece is a sort of cultural crossroads between Anatolia, southern Greece, and cultures to the north, like the Ezero of Bulgaria; while further north, a diverse array of regional groups were influenced by the Únêtice, Bell Beaker, Corded Ware, and Tumulus cultures (Boroffka 2013; Marková 2013; Teržan 2013).

Land in the plains and valleys was cleared early in the BA. Charcoal from cores excavated at Tarnowiec in the fertile Jasło-Sanok depression of the Polish Carpathians indicate that field clearance was achieved in parts of this region by the use of fire (Harmata 1995). Along with deforestation, there was a reorganization of settlements from tells on the edge of woodlands to hilltop settlements overlooking grasslands that were good for pasture but not naturally suited to cultivation (Barker 1985). The presence of small-seeded legumes and the invasive grass *Cynodon dactylon* in deposits of animal refuse suggest that, throughout the BA, land may have suffered from over-farming in the absence of efforts to replenish soil (Valamoti and Jones 2003), although excavations at Pupićina Cave in western Croatia suggest that there may have at least been some attempts to fertilize soil using animal refuse in the MBA (Miracle and Forenbaher 2005).

Einkorn, emmer, and hulled barley are the dominant triad of cereals throughout this region in the earlier BA, although regional preferences are apparent. Einkorn is better represented than emmer at Százhalombatta-Földvár, a MBA tell site along the Danube River in Hungary, where Taylor (2015) suggests open areas of the settlement were devoted to the final stages of processing grains that also included spelt, barley, and perhaps even some wild plants. Einkorn was also preferred at Mandalo in northern Greece, where discrete storage implies that einkorn and emmer were sown separately (Valamoti and Jones 2003). Maslin sowing was not unknown, however, as oats were found mixed with emmer at Plateia Magoula Zarkou (Jones and Halstead 1993a). In the Pannonian Basin and Romania, hulled barley is found with greater frequency, most likely because it was better suited to cooler temperatures (Wasylikowa et al. 1991), but also because there was a general increase in herding that relied to some extent on the foddering of livestock (Barker 1985). The heavy presence of einkorn chaff in storage deposits as well as in animal dung also suggests that it was used as fodder, while emmer was used as food (Valamoti and Jones 2003). The need for fodder may also have inspired the cultivation of pulses, such as bitter vetch, garden pea, and lentil (Jones and Halstead 1993a; Kroll 1991; Stika and Heiss 2013; Wasylikowa et al. 1991).

Flax cultivation, which began in the Neolithic period, continued throughout this region, but, because olive cultivation did not take hold in the Balkans and areas further north in the way that it did in southern Greece, a much more diverse array of oil plants was cultivated, including gold-of-pleasure, poppy, and safflower (Stika and Heiss 2013). Lallemantia, a newly adopted oil plant distinctive to northern Greece, may have entered Europe along with imported tin (Jones and Valamoti 2005). It is difficult to know with certainty the primary reason for the cultivation of oil plants. The discovery of a vessel filled with gold-of-pleasure at Kastanas provides primary evidence that seeds of that plant were used for the derivation of oil (Kroll 1983), but in many cases plant use must be implied from secondary evidence, such as the development of small ceramic containers that suggest the use of medicinal oils (Valamoti 2011).

The effects of the cooler and wetter climate experienced in much of Europe in the 2nd millennium can be detected in adaptations to the cereal assemblages in this region during the LBA. Barley and emmer cultivation declined, and broomcorn millet, rye, spelt, and bread wheat became more popular in different regions and in various combinations (e.g. Szeverényi et al. 2015; Valamoti 2016; Wasylikowa et al. 1991). A recently discovered type of wheat, called new glume wheat, rounds out the diversified array of cereals (Jones, Valamoti, and Charles 2000). LBA examples of this type of wheat, which most closely resembles *T. timopheevi*, were identified at Assiros in northern Greece, where glume wheats were stored discretely as whole spikelets, allowing for the identification of the new variety (Jones et al. 1986; Wardle, Halstead, and Jones 1980). An overall increase in the amount and types of pulses suggests that perhaps there was more of an effort to rotate crops in northern Greece; further north, however, the gross amounts of carbonized legumes decreased significantly, such as in the Pannonian Basin (Stika and Heiss 2013).

Studies of prehistoric animal husbandry in this region provided the foundation for the "Secondary Products Revolution" model proposed by Sherratt. Using evidence from the Carpathian basin, he argued that in the Neolithic animal exploitation was focused on primary products like meat, hides, and bone; but, by the Bronze Age, the focus of animal husbandry had shifted to renewable products like milk, wool, and traction by horse or bovines, a move that triggered many of the societal changes commonly associated with the BA including the emergence of early states (Sherratt 1983). Although aspects of this model are problematic, especially the chronology of certain innovations (e.g. Evershed et al. 2008; Isaakidou 2006), it seems to work in the Pannonian plain, where cattle were dominant and ovicaprines and pigs are found in smaller numbers (Choyke and Bartosiewicz 1999/2000). Greenfield, on the other hand, found that in other parts of the Balkans, the number of sheep and goat increased, but cattle, which were important for both milk and traction, decreased in quantity overall. At the same time, pigs continued to be present in variable amounts. He suggests that, rather than a shift from primary to secondary products exploitation, both strategies were utilized depending on "macroenvironments." This kind of diversification in exploitation strategies might have, as a result, initiated greater mobility and the exchange of goods between people living in forested uplands and lowland pastures (Greenfield 2010; Greenfield 1988).

Continental Lowlands and Alpine Europe

Central Europe, including the Alps, and the lowlands and plateaus of northern Europe up to the coast of the North Sea and the Baltic littoral (Figure 12.2), was populated by Únêtice cultural groups in the EBA who gave way to so-called Tumulus groups in the MBA and Urnfield cultures in the LBA. The climate of this area is generally characterized by cold winters and hot summers, although the mountainous regions of central Europe can experience significant variation. In the Alpine region, land at low elevations is cultivable but poorly

Figure 12.2 Map of Europe showing sites discussed in sections on Atlantic and Central Europe and Scandinavia. Source: Lynne A. Kvapil.

drained, growing seasons for grain are short, rainfall is variable, and rain shadows can starve otherwise arable valley floors; in the lowlands, moraines along the Baltic coast, Geest heathlands mixed with forests and lakes in the northern plain, and wind-blown loess of central Germany and southern Poland are the best suited lands for farming.

As in many other parts of Europe, numerous pollen diagrams from across Germany and Poland show that the human impact on the landscape increases at the beginning of the EBA, sometimes significantly, and again at the beginning of the LBA. Forested lands were continuously cleared for both cultivation and grazing in this region throughout the BA (Kühn and Heitz-Weniger 2015; Rösch and Lechterbeck 2016) with signs of reforestation in some places during the MBA that may correlate to social shifts marking the decline of Únětice culture (Heske and Wieckowska 2012; Kniesel 2012) or which may indicate a decreasing intensity in land-use strategies (Jahns 2015).

While land clearance represents the continuity of Neolithic practices, the array of cultivated crops illustrates a break with earlier traditions, especially with the abandonment of naked wheats in favor of other cereals that were better suited to regional climates and evolving subsistence practices (Kühn and Heitz-Weniger 2015; Küster 1991). In much of central Europe, barley, especially hulled barley, is the dominant cereal cultivated during the EBA and MBA. Emmer is also important but more so further to the east in the area of the Czech Republic, where it was the dominant cereal. Einkorn, broomcorn millet, rye, and spelt, which was increasingly important in the western Alps (Kühn and Heitz-Weniger 2015), were also cultivated but in smaller amounts (Dreslerová and Kočár 2012; Küster 1991). A deposit of emmer mixed with einkorn from Uhingen, Germany, suggests that perhaps some of the subdominant cereals were being sown as a maslin along with dominant types (Knörzer 1991).

The garden pea and field bean are the best-represented pulses from this period, and, in Alpine regions, the lentil completes a triad of pulses that continues to be cultivated through the LBA (Kühn and Heitz-Weniger 2015). Oil plants are rare (Knörzer 1991; Stika and Heiss 2013). Flax, which had been used for textiles already in the Neolithic period, was cultivated deliberately in some areas. A scrap of embroidered linen from Irgenhausen, a lake-dwelling in the Swiss Alps, has recently been dated to the EBA, suggesting that flax cultivation may have been more widespread than the archaeological record shows, although, as Rast-Eicher (2012) notes, linen was being replaced in many places by wool as the choice for textiles.

By the LBA, there is more diversity in the array of cultivated plants overall, and it has been suggested that farmers might have begun to focus on surplus production by this time. At the least, a diversity of cultivars would have shielded settlers from the agricultural risk assumed when portions of the population focused less on farming and more on metallurgy or craft production. Jacomet and Brombacher (2009) also suggest that, based on archaeobotanical data from the Basel region, the productive landscape may have first been divided into garden-type plots close to settlements that were devoted to intensive cultivation and less immediate fields for the extensive cultivation of grains using oxen as traction animals, an innovation that began as early as the MBA (Bartosiewicz 2013).

Three types of cereals dominated the region: barley, emmer, and millet, including foxtail millet, which was a newcomer in and around the Alps (Kühn and Heitz-Weniger 2015). Spelt and einkorn were still cultivated, but in lesser amounts. Oats were also grown in a few places, such Langweiler and at Hagnau-Burg near Lake Constance, and free-threshing wheat is attested in Poland. Increased diversity extended to legumes and oil plants as well, which are also found in greater amounts in LBA deposits. Lentil, garden pea, field bean, and bitter vetch are frequent. Gold-of-pleasure and poppy were commonly grown oil plants along with flax, which may have been cultivated both for oil and fiber (Knörzer 1991; Stika and Heiss 2013).

Although wool from sheep and goats was increasingly important, especially in the Alps, at the beginning of the BA cattle seem to have been the dominant form of livestock. In mountain hamlets, milk cows were kept close to home for dairying and even stabled and hay-fed or fenced in grassy meadows, while beef cattle were pastured further afield to avoid overgrazing (Kühn and Heitz-Weniger 2015). Not all sites preferred cattle, however. Stopp (2015) notes, for example, that sheep and goats were predominant at the site of Vinelz in the Swiss Alps, and she suggests that this preference may relate to connections between Vinelz and other sites with a preference for rearing ovicaprines. Sheep and goats provided milk and wool, although a larger proportion of female to male among skeletal remains suggests that milk was the more important product. Sheep and goat were the dominant form of livestock in the Alps at the beginning of the LBA as subsistence farming began to be supplemented by craft production that surely included wool working, but pig keeping was almost equally important (Barker 1985; Bartosiewicz 2013).

Atlantic Europe

Britain, Ireland, northwestern France, Belgium, and the Netherlands (Figure 12.2) experienced a climate during the EBA that was warm and dry but became cooler and more damp in the MBA and LBA (Mordant 2013). There was a slow transition into the BA in this region, accompanied by the veneer of cultural uniformity that seems to obscure a latent regionalism, which was previously apparent in the Neolithic period and reappeared in the MBA and LBA. This regionalism is illustrated by the way agricultural traditions developed here in response to environmental change.

The transition to the EBA in Britain and Ireland began slowly with the replacement of previously established communities and social ties with dispersed and sometimes mobile farmsteads or small settlements whose residents practiced a mixed-farming regime in the Neolithic tradition. There is no appearance of ranked society from settlement patterns, but mortuary data suggests the emergence of elites in places like western Ireland, where early forms of field systems may represent an interest in controlling land and the productive landscape (Jones, Carey, and Hennigar 2010). Otherwise, evidence for agriculture at this time is slim, in large part because farmers in some areas practiced a kind of seasonal mobility (Brück 2000).

Evidence for agricultural practices in Atlantic Europe in the EBA is also scarce, although the picture becomes much clearer in MBA. At this time, field systems of ditches reminiscent of those found in southern England were established in northwestern France at places such as Île de Tathiou (Marcigny and Ghesquière 2003, 2008). In the wetlands of Holland, farmsteads such as those in West Frisia were also equipped with systems of ditches that both drained and demarcated fields (Lohof and Roessingh 2014).

Mixed farming was practiced, and emmer was the dominant cereal along with barley, although variations again relate to underlying regional traditions. For example, millet was prominent at Fort Harrouard in northern France; but, at Vlaardingen in western Holland, a mix of cereals was preferred, including emmer, barley, bread wheat, and club wheat (Bakels 1991; Barker 1985). Stock included cattle, sheep, goats, and pigs in various combinations although cattle, used for traction as well as a source of food, seem more prominent. The appearance of three-aisled long houses at this time in the Netherlands and Belgium may emphasize the importance of keeping cattle and stabling them close to home rather than practicing long-range pastoralism associated with ovicaprines (Fokkens 1999; Fokkens and Fontijn 2013).

Throughout the LBA, a greater quantity and variety of sites appear, including small permanent farm communities, specialized production sites, and fortified sites. This diversification of sites along with prestige goods and the differential distribution of metals reflect an emergent social hierarchy, a desire to define spaces for specific activities, and growing exchange networks. The emergence of a social hierarchy is apparent in northwestern France and Ireland in mortuary practices as well as in the preparation and consumption patterns of plants and animals (Johnston 2015; Mordant 2013). In northern France, for example, evidence for the harvest of young pigs in the spring and the fall at Villiers-sur-Seine has been interpreted as a sign of elite feasting at a high-status site (Auxiette, Peake, and Toulemonde 2015).

The longhouse tradition persists on the continent, but LBA farmsteads of Britain and Ireland were characterized by roundhouses with ancillary buildings for storage or other farm activities, where mixed-farming traditions continued, but without mobility, as exemplified by the proliferation and sometimes restructuring of field systems in southern and eastern England (Evans and Knight 2001; Johnston 2005; Yates 2007). Field systems, which are increasingly discovered using LiDAR technology (e.g. Eve 2015), included coaxial field systems such as stone-walled field enclosures or reaves, livestock pens, and drove ways. Change in the organization of the landscape has been interpreted as the breakdown of EBA social networks and subsequent demarcation of self-sufficient farms in southern England beginning in the MBA (e.g. Brück 2000) or as an effort by emerging elites to control agricultural production in order to create a surplus (Yates 1999).

Preferences for certain grains among cultivated cereals also reflect an underlying regionalism. At Carrowmore in County Sligo, Ireland, barley was the most prominent cereal followed by oats and rye, which is introduced at this time; in Scotland, naked six-row barley was preferred since it was the best option for cold and wet weather and thin soils (Barker 1985; Grieg 1991). At Trethellan Farm in Cornwall, residents grew mostly hulled barley and emmer wheat as well as field bean and flax, which may have been used for fiber or oil (Nowakowski 1991).

Cereals were rotated with legumes in fields fertilized with domestic refuse. Recent work on islands north and west of England indicate that middens themselves were converted into intensely farmed field plots (Guttmann 2005), while on Orkney, a system of continuous use and fertilization of fields in immediate proximity to settlements and periodic cultivation of distant fields devoted mostly to grazing has been suggested (Farrell 2015). Horticulture may have played a key role in agricultural production as well. Johnston (2005), for instance, suggests that bounded or unbounded plots near houses were used for gardens rather than cereal or pulse cultivation.

Cattle and sheep were the primary livestock and were raised for meat and milk as well as wool as attested by finds of loom weights and spindle whorls. In the lowlands of Britain at sites like Fengate, field systems allowed animals, mostly sheep but also cattle, to roam in fens and wetlands during the summer but remain enclosed and foddered during the winter, a strategy called "structured mobility" by Pryor (1998). In the lowlands of the continent, cattle, which were the primary type of livestock, continued to be stalled at home while mobile pastoralists favored sheep and goat (Fokkens and Fontijn 2013).

At the turn of the first millennium, a shift from a warmer to a cooler and wetter climate affected agricultural production and marks the change from MBA to LBA (Brück 2007). Increased reliance on dairying for subsistence needs, possibly as a result of constraints on arable farming, has been proposed based on a variety of evidence including the increased production of salt (Harding 2013). The establishment of defensible farms fortified with ditches, palisades, and walled enclosures and even the crannogs of Scotland and Ireland may also have been a response to a growing scarcity of agricultural land. A direct relationship between these changes and changes in climate have not, however, been firmly established (Roberts 2013).

Scandinavia

Evidence for agricultural practices in Scandinavia (Figure 12.2), whose people belonged to the Bronze Age Nordic cultural group, is derived primarily from Denmark and southern Sweden. The scarcity of archaeological evidence for farming in Finland and Norway is due mostly to the small amount of cultivable land, which consists of strips of coastland and interior moraines. Marine and moraine soils in central and southern Sweden and eastern Denmark, on the other hand, are well suited to agriculture. The sandy soils of Jutland in western Denmark, while less naturally suitable, also preserve evidence both cultivation and stock rearing.

Permanent settlements were not common in much of Scandinavia until the LBA. Rather, dispersed settlements shifted perhaps every 30 to 50 years to allow cultivated land sufficient time to lie fallow and to take advantage of manure from livestock stabled close to home or in houses with built-in animal stalls (Gunilla and Olsson 1991b). The practice of stabling animals at home can be traced in the development of the three-aisled long houses, such as those at Egehøj or Thy in Jutland, which becomes a common type of house in this region (Bech 1997; Bech and Mikkelsen 1999).

Again, continuity over change characterized EBA farm practices, especially early in the period. Forest clearance begun in the Neolithic continues and in some cases intensifies, as is demonstrated by the appearance or increase in pollen from plants common to pasturelands, such as *Plantago lanceolata* (Andersen 1993; Björkman and Sjögren 2003; Karg 2008; Lagerås 1996). Land clearance was surely aided by the influx of metal implements, but the basic agricultural tools of the Neolithic period, like flint sickles, continued to be used. The ard plow pulled by traction animals is new, but in many cases the ard was made of wood rather than bronze, which was reserved for ceremonial implements (Boas 1997; Gunilla and Olsson 1991b). The presence of carbon in soil samples from a barrow in Skelhøj in western Denmark suggests that meadowlands were maintained through regular burning, yet another enduring Neolithic agricultural practice (Karg 2008).

The small, shifting EBA settlements practiced a mixed-farming regime aimed at meeting subsistence needs. Cultivation focused on cereals, primarily emmer and naked barley, although spelt, einkorn, and hulled barley have also been found (Gustafsson 1998; Jensen 1991; Tesch 1991). Naked wheats were cultivated, but seemingly in small amounts. A deposit of bread wheat from Egehøj caused Rowley-Conwy (1984) to suggest that perhaps this crop was grown more widely but less frequently, in small amounts, and for immediate consumption as a type of luxury food, which would decrease the chances that seeds would be preserved. The discovery of other discrete deposits of bread wheat seeds, such as that from Djursland in East Jutland, bolster this hypothesis (Boas 1997). Both rye and millet were cultivated in Sweden (Tesch 1991), but neither were grown in Denmark (Gustafsson 1998; Robinson 2003). There is little evidence for pulses, and gold-of-pleasure was likely the only oil plant to have been cultivated (Stika and Heiss 2013).

Cattle, which were grazed on cleared pastureland as well as in wetlands, were the dominant type of livestock and were kept for milk, meat, and traction (Bech 1997; Karg 2008). Ovicaprines were also kept for meat and milk, and weaving pits found in one of the long-houses at Egehøj attest to wool working (Boas 1997). Wool production seems to have been limited to households, however, as evidence suggests sheep and goat herds were kept relatively small.

During the LBA in Sweden, hulled barley became dominant among an increasingly diverse array of cereals that still included naked wheat, but also club wheat, spelt, rye brome, millet, and possibly oats (Berglund 1991; Engelmark 1992). Gustafsson (1998) has suggested that the shift away from emmer wheat and naked barley may be related to the establishment of permanent farmsteads and settlements whose fields would, in the absence of long fallow, require deliberate fertilizing accomplished by the plowing over of abandoned settlements. Robinson (2003), on the other hand, notes that this is likely an oversimplified explanation, especially since the shift to hulled barley is far less significant in Denmark, where there is already EBA evidence for manuring with peat and domestic refuse (Bech 1997).

Naked barley and emmer are still the dominant cereals in Denmark, although they decrease in importance; barley and emmer are also dominant at this time in Norway, where carbonized seeds represent the earliest signs of long-term agriculture (Sjögren and Arntzen 2012). The adoption of agriculture in Norway in the LBA is suggested by the analysis of pollen samples from Lake Kalandsvatnet. Pollen assemblages from lake sediments, which revealed a rich variety of pollens from the LBA, and reconstructions of vegetation cover indicate more intense human impact on the landscape at that time, especially in the form of increased land clearance (Mehl and Hjelle 2016).

The increased diversity of cultivars includes not only the adoption of new grains like spelt and millet but also field bean and oil plants. Gold-of-pleasure is much more significant at this time as attested by the discovery of more carbonized seeds (Gunilla and Olsson 1991a) as well as the impression of a seed pod on a sherd from Hallunda in southern Sweden (Hjelmqvist 1979). Flax is now also cultivated in both Sweden and Denmark, but there is no indication of whether it is grown for fiber or oil (Robinson 2003; Viklund 2011).

Animal exploitation changes slightly during the LBA as sheep and goat become more important, although cattle are still dominant. The discovery of a multitude of hoof prints alongside either wheel or ard marks at Glesborg, in addition to being a remarkable example of preservation, emphasizes the continued importance of pasturing cattle and their usefulness as traction animals (Boas 1997).

Sheep and goat bones are estimated to constitute nearly half of animal remains from Scandinavia by the end of the period (Bartosiewicz 2013). The southern Swedish region of Krageholm in Ystad has been interpreted as an area where the extensive summer pasturing of sheep, goat, or cows from now permanent farmsteads was practiced (Berglund 1991). This possibility is underscored by leaf-sickles from nearby Köpinge, also in Ystad, which have been interpreted as signs that stabled livestock was foddered in the winter (Olausson 1991). The growing scarcity of forest fodder, exacerbated by continuing efforts to clear wooded land, would have required farmers to adapt their foddering schemes. The changes in food sources for livestock may have had an effect on cattle, causing them to grow smaller over the course of the BA. The decrease in size may also be a sign that cattle were being kept for milk rather than meat (Tesch 1991).

Conclusions

The literature on Bronze Age agriculture has proliferated greatly due to the development of scientific techniques and new technology applied to the study of past food procurement strategies (e.g. LiDAR, residue analysis, stable isotope analysis). Even though there exists an astonishing abundance of data, what is needed now are more integrated studies that meld information on animal and plant husbandry into a coherent picture of agricultural practices and address the social context of food production. Much has been done from this perspective in the realm of food consumption, especially the use of food to initiate or strengthen social ties in an era of early state formation and the emergence of social hierarchies. But there is space for work on topics such as the agency of farmers in making food procurement choices, the management of human agricultural labor, or how the agricultural landscape functioned as a gendered space, all of which are subjects that have the potential to shed light on the small– and large-scale social changes that define BA Europe.

SUGGESTIONS FOR FURTHER READING

Graeme Barker's *Prehistoric Farming in Europe* (1985), may be outdated, but it offers an overview of BA agriculture in all of Europe that is difficult to find in more recent work. *Progress in Old World Palaeoethnobotany*, edited by Van Zeist, Wasylikowa, and Behre (1991), also covers Europe broadly despite being an older collection of papers written by the International Work Group for Palaeoethnobotany. This organization also sponsors the journal *Vegetation History and Archaeobotany*, which disseminates up-to-date articles relating to farming in the European BA. More recent comprehensive information relating to the Bronze Age in Europe in general and agriculture specifically can be found in the *Oxford Handbook of the European Bronze Age*, edited by Fokkens and Harding (2013), which references the subject throughout and includes individual chapters devoted to animal husbandry, plant cultivation, and field systems.

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PART IV

FROM THE EARLY IRON AGE TO LATE ANTIQUITY (300s CE)

CHAPTER THIRTEEN

Greece and Anatolia, 1200–500 BCE

Clémence Pagnoux and Julien Zurbach

Introduction

Geographical and Chronological Scope

This chapter deals with a chronological and geographical area characterized by many inequalities. Not only sources on agrarian systems, but also our knowledge of the general historical and archaeological framework are uneven. We will here give an overview of the current research on the area from Western Greece, including Greek settlements in the Western Mediterranean, to Cappadocia in Asia Minor (see Figure 13.1), recognizing, of course, the unevenness in data and research from period to period and between different areas. Beginning in 1200 BCE leads us to consider the very end of the Late Bronze Age as well, since the end of the palatial period (Mycenaean, Hittite, or Arzawan) marks a beginning in terms of economic and social history, rather than a dead end (overviews: Cline 2009; Bryce 2002; Sagona and Zimansky 2009).

There are some advantages in considering such a wide area during such a long period. Archaic city-states (see Figure 13.2) tend to be seen as forerunners of what comes next, but this is surely not the only possible perspective, and to consider them in the long term may be of interest. The coastal areas of Asia Minor, the Aegean, and the Western regions settled by Greeks show many common features, as do the inner mountains and high plateaus of the Balkans and Anatolia. Moreover, most of these areas share a common history in that the collapse of the palace systems around 1180 led to a period of apparent difficulties, with a complete disappearance of writing, before different forms of state, from the Phrygian kingdom to Greek, Lycian, or other city-states and *ethne*, redefined the sociopolitical structure of this large area. The textual sources follow a similar evolution, from administrative texts of the fourteenth and thirteenth centuries through a hiatus to the reappearance of scripts being used in completely different ways, such as the alphabets used in Anatolia, the Aegean, and the West.

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

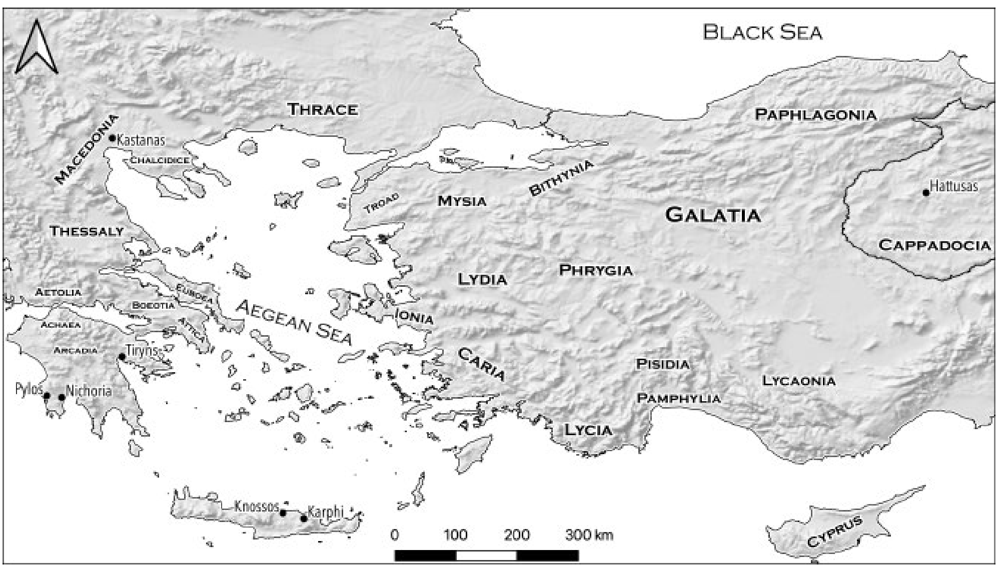

Figure 13.1 Map of Late Bronze Age sites. Source: Map by David Hollander with QGIS, Natural Earth raster data and map files from the Ancient World Mapping Center. "inlandwater.shx", "ba_rivers.shp", "coastline.shp", and "openwater.shp". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm].

The Sources

Pertinent sources show a high degree of diversity. We consider here only the specifics, not the general characteristics of sources on ancient agriculture.

The Late Bronze Age regimes have left some texts of administrative character. There are land lists pertaining to fiscal matters and functions in Pylos in Messenia and some other Mycenaean centers, like Tiryns in the Argolid and Knossos in Crete, where they are preserved on clay tablets in Linear B script – surely not the definitive version; land lists of similar character are known in cuneiform script and Hittite language from Hattusas, the Hittite capital. It is reasonable that such documents existed also in other Late Bronze Age palatial communities but were not preserved or are still awaiting excavation, notably in Western and Southern Asia Minor (on Linear B, see Del Freo 2005; Hittite: Paroussis 1985; Souček 1959).

A feature and consequence of the catastrophe c. 1180 is the end of Late Bronze Age palatial communities as well as the disappearance of scripts, showing that these scripts were above all administrative tools that would not survive the administrations themselves. This leaves us with no textual sources from 1180 to the end of the ninth or early eighth century, when Phrygian, then Greek documents appear. The reappearance of writing, in fact, does not change much for us since the alphabetic scripts were used in contexts far from the exploitation of land. Thus, we are dependent for the early part of the Archaic period, on sources which were surely (Homeric epics) or very probably (elegiac poetry) first transmitted orally. There has been a huge amount of work by historians and philologists on the historical use of the epics, the very notion of a Homeric society corresponding to a stage of ancient Greek history, and the social context of elegiac and other so-called "lyric" poetry from the seventh and sixth centuries. We cannot enter those debates; we consider here that the epics show a certain coherence from the institutional and economic standpoints, which can be considered to date somewhere before the Early Archaic phase, that is, during the eighth century, with most researchers favoring an earlier date for the *Iliad* and a later date for the *Odyssey*. There is no Anatolian equivalent to the Homeric epics – one surely did exist, but it is lost; Anatolia, however, is evidently not unknown to Homer.

One particular source deserving a special mention is the poem known as *Works and Days* and attributed to Hesiod (see Millett 1984; Edwards 2004). It is dated to the mid-seventh century, and is quite isolated in Greek literature, where it has often, in West's terms, been mistakenly classified as some "early Greek Georgics" (West 1978, v). It is, in fact, nothing like that; as West recognized and demonstrated, it is part of a corpus of texts found not only in Greek, but also in Near Eastern literature, and centered on a form of popular wisdom akin to fables and proverbs. Hesiod uses a narrative based on his conflict with his brother to give advice on the good management of a peasant household. He has a family, some slaves, land to be cultivated, and sometimes – reluctantly – takes his boat to sell his product.

Greek and Anatolian alphabetic epigraphy begins in the ninth (Phrygian) or eighth (Greek) centuries or later (for other Anatolian languages). In Greek epigraphy, an important change can be dated to the second half of the seventh century. Before that, we have only small inscriptions, mostly graffiti, of symposiac or religious context. After that date, Greek city-states develop a monumental epigraphy whose texts pertain to institutions and law. Early texts from Dreros or Tiryns do not give many indications on agriculture, but later and longer texts, the most important of which is the Gortyn *Code* dating to c. 450, are fundamental sources on family and inheritance law, agricultural labor, and many other topics. Once more, there are no such texts in Anatolia at that time.

External or later sources deserve a mention. External sources are to be found in the Near East: Egyptian hieroglyphic or demotic texts and Assyrian cuneiform texts have survived in

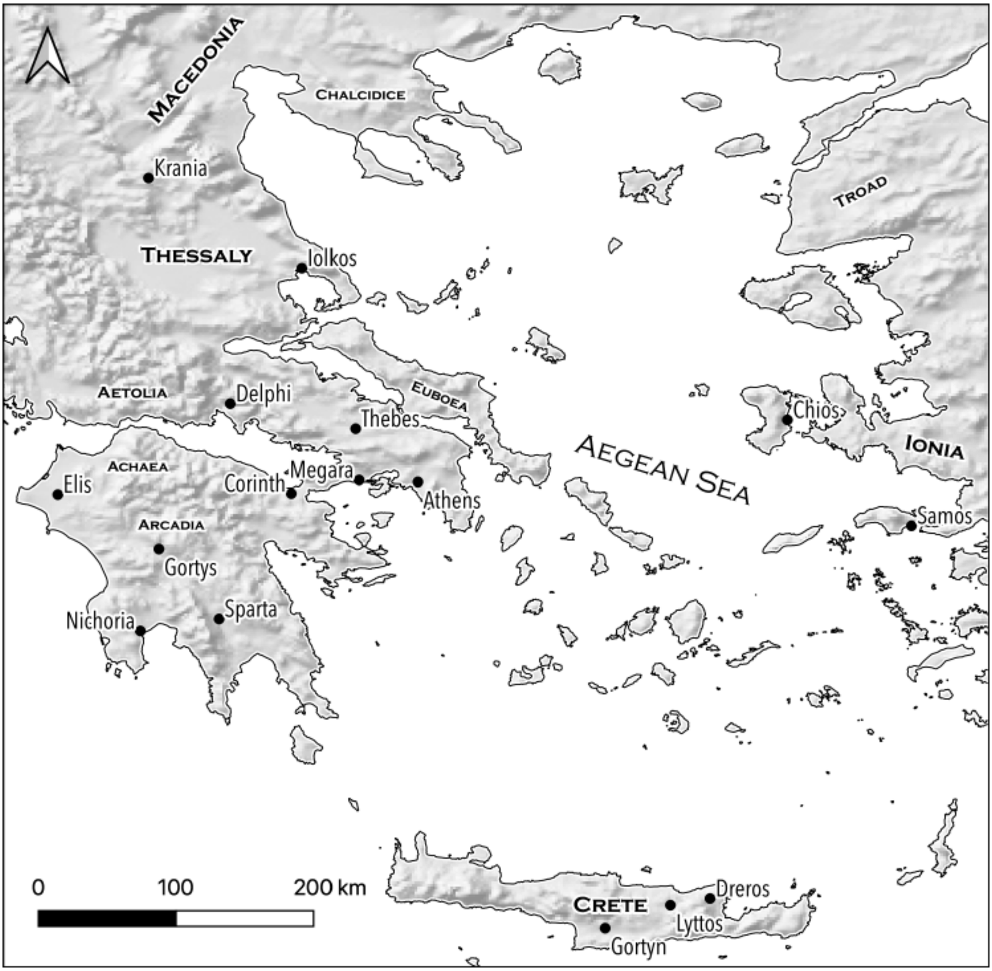

Figure 13.2 Map of Archaic sites. Source: Map by David Hollander with QGIS, Natural Earth raster data and map files from the Ancient World Mapping Center. "inlandwater.shx", "ba_rivers.shp", "coastline.shp", and "openwater.shp". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm].

quantity and often mention Greece and Anatolia, but not on topics related to agriculture, and the same is true of the Hebrew Old Testament. Later sources in Greek, however, are useful to reconstruct Archaic developments. The most important for us are two typical products of the school of Aristotle, probably the most universal mind of the Ancient Mediterranean. Some students of his wrote on "economics," that is, the best way(s) to manage a household; the so-called *Economics* of Ps.-Aristotle even considered higher levels of what we would call economic activity. This line of research had forerunners (Descat 1988), as Xenophon's work shows. The other category of research is natural history, dominated by Aristotle's most renowned student and successor, Theophrastus. Theophrastus' works are a very important source for every reconstruction of ancient agriculture; many of his analyses may be used for earlier periods as well, with due caution.

When it comes to agriculture, of course, textual sources are not the only evidence. Their lack of homogeneity, the lack of sources directly describing agricultural conditions as one would expect from cadastral registers, agronomy, and evidence of daily practice, makes it in fact a real pity that agricultural archaeology, and above all environmental archaeology, are only just beginning in the Eastern Mediterranean. As for archaeology in its traditional sense, including the study of structures and artifacts, the data assembled are quite meager. Iconography does not have a lot to offer, with the exception of Attic vases at the end of the period under study here; but in this case, apart from some isolated scenes of olive harvest or cereal sowing with the ard, which are reproduced in every handbook, artistic evidence is not very common (for Attic material, see Malagardis 1988). Tools are not very numerous: this could be a consequence of the lack of metal in their composition, but even on a fundamental topic such as the introduction of iron in agricultural production, we simply lack widespread data and must turn to a handful of particular site reports. The same is true for storage devices and capacities. Good examples are to be found at Himera, where one finds a silo (Allegro 1997) and a deposit of tools (Allegro 2000), but synthetic work is lacking. On storage devices one has to turn to considerations available in books on other topics, in particular on settlements and urbanism (Mazarakis 1997; Lang 1996). Certainly, problems of preservation of these objects and structures play an important role. It is undisputed, for instance, that structures of wine and oil production become archaeologically more visible and perhaps also more numerous around the fourth century, and that a study of agriculture has to explain this fact (Brun 2003, 2004; Foxhall 2007). But there is certainly also a problem with the attitudes of Classical archaeologists and their hierarchy of topics, with agriculture being only a part of the history of technology or the economy, which is itself in a marginal position. This has a cumulative effect, moreover, on the lack of settlement excavation, since such research approaches are the only way to study storage capacities or processing facilities for agricultural products.

One point where Classical archaeology has been efficient in the creation of new sources is the study of territories through intensive survey. The history of the method, centered on the systematic collection of surface artifacts, has often been described. It has been used in Italy, Greece, and Turkey since the late 1970s; a good number of these surveys have now been published (Alcock and Cherry 2004 give some sense of the range). Archaeological surveys constitute an important series of data on Ancient Greek territories, from which quite clear tendencies emerge, even if the data are often difficult to compare. Surveys are developing toward even more intensive methods of documentation and collection, as in the Eastern Corinthia (Caraher et al. 2006), and they now form part of integrated approaches to land use, alongside environmental studies and excavation of rural sites. Rural archaeology remains underdeveloped, however, as excavation of small sites is still rare and difficult. Administrative difficulties could explain the reluctance of archaeological institutions to use one precious excavation permit for a small farm. But excavation is often the only way to base the study of survey material on firm ground (notably the dating of common wares), and it promises much.

What we used to call environmental archaeology may appear underdeveloped in the areas of interest to Classical archaeologists, in comparison with proto-historic periods of Europe or the Near East. This comprises on-site and off-site data. Off-site, of regional value, are the data from sediment cores used particularly for palynology, enabling the reconstruction of environment and landscapes on a micro-regional basis. Geological and geomorphologic studies are essential as well, on the same regional level or on a larger one, to reconstruct the exact setting around ancient sites or arrive at more general conclusions on the impact of agriculture. Climatic reconstruction operates at a much more general level, using ice cores from the Arctic and many other data to define the phases of ancient climates. On-site data comprise the collection of plant remains, mostly through flotation, and studies on human and animal bone assemblages, which may now be approached through a range of scientific analyses on dietary and sanitary aspects (Schepartz et al. 2009; Papathanasiou et al. 2015, where the relative lack of data for Archaic and Classical Greece is quite clear). These are the new sources that will change the data on ancient agriculture in the next generation. Through these data, we can hope one day to be able to reconstruct in very precise ways the territory and the agricultural year of the communities of the Aegean and Anatolia.

The Technological System

Tools

Technological studies define production activities as productive chains (*chaînes opératoires*) of interdependent stages. Cereal agriculture is a combination of the following steps: field preparation (fallow to plowing and sowing); crop growing; harvest; pre-storage treatment; storage; transformation; and consumption (general: Mazoyer and Roudart 1997; Archaic Greece: Amouretti 1976, 1986, 1996; Amouretti and Comet 1993, 2002). In the first step, we may suppose a quasi-universal use of the ard plow. This tool is already old in our period; it is by definition a symmetric tool whose function is to open the ground (moderately), not to turn it in order to destroy the herbaceous stratum: this last function is assumed by the deep plow, an asymmetrical tool invented in Roman Central Europe. Moreover, the ancient ard is of a particular form: it is what Haudricourt and Jean Brunhes-Delamarre in their fundamental work called a *dental* ard (Haudricourt and Jean Brunhes-Delamarre 1955), or beam ard, where all elements are fixed on a massive piece of wood. This is in contrast with a lighter tool, the body ard, of very different construction, which is the main traditional tool of the Mediterranean today, from southern France to the Near East. The beam ard survives in precontemporaneous Mediterranean contexts only in parts of Corsica and some Aegean islands, including Crete. In the Ancient Mediterranean, and particularly in the first half of the first millennium BCE, the beam ard was almost in universal use, as shown by Archaic Greek models and iconography, Cilician coins, the Hesiodic description, or the contemporary Adriatic figurative situlae (Amouretti 1976). Other tools are known, like the sowing ards in the deep, irrigated soils of Egypt and Mesopotamia, or the simpler ard also known to Hesiod and akin to Northern Italian examples, but they were of secondary importance in the Mediterranean zones.

The question of the reasons for the predominance of precisely this type of ard remains open. Perhaps it is the most resistant to stony soils. Another problem is the relationship to other tools of field preparation, notably the two-pronged spade called the *dikella*. There is barely any indication of the relative importance of the ard and spade, animal and human energy. Even if spades were in current use during earlier periods, at the end of the Archaic period an inscription from Gortys seems to consider the ard an essential and normal part of any household. This text (*IC* IV 75, first half of the 5th cent.) forbids the seizing of, among other things, "iron tools, the ard, the oxen yoke, the cooking pot, and millstones." We have here almost all parts of the *chaîne opératoire* for cereals and pulses, which seems to confirm the dominance of cereal agriculture in the framework of the domestic unit. Nothing is mentioned here in connection with olive or grape cultivation. Wine is widely known in Linear B as well as in Homer; olives and olive oil as well are mentioned in the same sources. Obviously, however, they were not considered an essential part of the domestic unit of production. Hesiod in the 7th century does not mention olive oil and mentions wine only once, and it was probably imported (on *biblinos oinos*, see West 1978 *ad loc.*).

The place of metal in the inventory of tools is still an open question. It seems characteristic for the Late Bronze Age that bronze would be used for agricultural tools. In the metal deposits of the thirteenth and twelfth centuries there are indeed some sickles (Spyropoulou 1972), but they are not the most usual objects in those hoards, and the absence of metallic hoards in the following period means that we are not in a position to follow the development of those tools. Bronze sickles are known from Karphi in Crete in Subminoan times. The mention of tools in the epics and Hesiod, however, does not allow any conclusion as to their possible metallic elements. Hesiod describes an ard that has (apparently) no metal share but knows of iron tools that must be sharpened – perhaps sickles. However, the appearance of iron in agricultural production is no early phenomenon. The first iron in the Aegean (11th–10th cent.) was for weapons and personal ornamentation, as shown by Snodgrass (1980, 2006); this is probably true until late in the Archaic period when some deposits like the Himera one (*supra*) do allow us to consider that iron is really in general use for ard shares, spades, and sickles. A general assessment of this process is, however, still required.

It is clear therefore that for more precise analyses, one needs to turn to botanical and palynological data.

Crops

Botanical micro- and macroremains (pollen grains, charcoal, seeds, and fruit remains) give insight into the vegetation history and food habits of past societies, whereas palynological studies allow the reconstruction of past environment and vegetation patterns.

In Greece and Anatolia, these studies are scarce and wide areas are still understudied. Indeed, environments favorable to pollen accumulation (lake or peat bog) are not numerous. In Greece, the first palynological investigations were conducted in Northern Greece (Greig and Turner 1974; Turner and Greig 1975; Bottema 1974, 1979), in the lakes and delta of Western Greece (Bottema 1982; Jahns 2005), then in Crete (Bottema 1980; Moody 1987; Moody, Rackham, and Rapp 1996; Atherden and Hall 1994; Atherden 2000) and in the Peloponnese (Atherden, Hall, and Wright 1993; Jahns 1993; Atherden and Hall 1994). In Anatolia, information on vegetation history is provided by the Lake Van pollen record (Van Zeist and Woldring 1978), by lakes in Northern Turkey (Beug 1967), and by the lake Söğüt pollen record in Southern Turkey (Van Zeist, Woldring, and Stapert 1975). Recent studies based on integrated environmental data aim to examine vegetation and landscape history in relation with archaeological sites (Bottema and Sarpaki 2003; Kouli and Dermitzakis 2008; Kouli et al. 2009, Karkanas et al. 2011; Kouli 2012; Lazarova et al. 2012; Glais et al. 2016).

Pollen records reveal a decrease in arboreal taxa and an increase in herbaceous taxa from the Early Bronze Age onward. This pattern reflects the development of anthropogenic activities: the development of agriculture leads to deforestation, but herding also favors the development of maquis vegetation and grassland. Both result in a spread of herbaceous communities. During the Iron Age and Archaic period, the vegetation dynamics do not seem to change. Anthropogenic activities, according to the increase in herbaceous taxa, are still developing, while the forest declines (Lazarova et al. 2012; Lespez 2012, p. 138). Another important fact from palynological data is that in northern and central Greece, as well as in Attica, the late ninth century and eighth century probably saw the development of olive cultivation, indicated by an increase in olive pollen (Turner and Greig 1975; Kouli 2012).

The study of seeds and fruit remains is in development in Greece. However, some discrepancy exists from a geographical point of view: Thessaly and Northern Greece are well documented, while few sites in the Peloponnese and on the islands have been studied. Few sites have been investigated in western Turkey, while the eastern part is better known. Moreover, archaeobotanical studies are mainly focused on Neolithic and Bronze Age sites. The scarcity of data on the Iron Age and Archaic period must therefore be emphasized. However, archaeobotanical data are available from various areas from Macedonia to Crete and Anatolia. Seeds and fruit remains are mainly preserved through carbonization, except one assemblage from the Heraion of Samos (seventh century BCE). Remains there are waterlogged: this preservation process allows the recovery of various fruit, spices, and wild taxa, while carbonized remains consist mostly of cereal and pulses.

Barley (*Hordeum vulgare*) is the most frequent cereal, being well adapted to thin and rocky soils, and was widely cultivated in the Aegean until recently, particularly in the islands. From the Iron Age onward, six-row hulled barley (*H. vulgare* var. *vulgare*) is the single barley type attested in Greece (Megaloudi 2006). Hulled barley becomes the most frequent cereal at the end of the Bronze Age not only in Greece but also in Western Europe and in the Near East (for a review, see Renfrew 1973; Hopf 1991; Zohary, Hopf, and Weiss 2012).

Emmer (*Triticum dicoccum*) and einkorn (*Triticum monococcum*) are the commonest wheat species between 1200 and 500 BCE. Both species withstand dry summers as well as barley. Einkorn grows also on poorer soils and under colder conditions. Emmer can, however, be sowed in winter and in spring (Brinkemper 1993): this species may have been cultivated as a summer crop, in order to avoid crop failure in case of a particularly hard winter. Despite the scarcity of data, it seems that emmer and einkorn decline in importance relative to hulled barley at the end of the period. Barley is indeed more drought resistant and better adapted to Greece's thin soil.

Three cereal species are introduced in Greece at the end of the Bronze Age: spelt, common millet, and foxtail millet. Spelt (*Triticum spelta*), another hulled wheat species, is rarely attested. Numerous spelt remains have been recovered in the Bronze and Iron Age level of Kastanas, Central Macedonia (Kroll 1983). Then, there is no spelt evidence after 900 BCE. The decrease in spelt after the Iron Age is a general phenomenon in Europe (Körber-Grohne 1989). Common millet (*Panicum miliaceum*) and foxtail millet (*Setaria italica*) are both summer crops. Their short growing cycles allow some flexibility in sowing time, and allow a crop yield even in case of winter crop failure. Millet remains were recovered in Thessaly, Macedonia, and in the Troad (Jones 1982; Kroll 1983, 1993; Riehl and Nesbitt 2003; Luce and Marinval 2008; Valamoti 2016). Common millet has a wide range of adaptation to different climates and soils. Having low water and nutrient requirements, this species is, however, more productive in moist soils. This characteristic may explain its absence in Southern Greece and Anatolia, but it is more likely due to cultural reasons. Millet is widely found in Bronze Age assemblages from Central Europe, and thus it was probably introduced in Greece from the North. According to S. Valamoti, millet consumption may therefore be a "cultural signifier indicating an origin from the area of millet cultivation, or contacts with these regions" (Valamoti 2016, p. 58). In Anatolia, where spelt and millet are less prominent, naked wheat (*Triticum durum* or *T.aestivum s.l.*) seems to replace hulled wheat (einkorn and emmer) from the Bronze Age onward (Riehl and Nesbitt 2003). In contrast, evidence of naked wheat cultivation and consumption in Greece is really scarce. Three sites have yielded free-threshing wheat, and only at Kalapodi (layers of the eleventh and tenth century) are there numerous remains (Kroll 1993).

Pulses constituted an important part of the diet. They are rich in proteins, while cereal grains are rich in starch. They therefore complement each other and contribute to a balanced diet. Lentil (*Lens culinaris*) is the most frequent and most abundant pulse, during the Neolithic as well as the Bronze Age. In Greece, bitter vetch (*Vicia ervilia*) is also very common. Its seeds are bitter and toxic to humans, but soaking, leaching, and steaming can remove the poisonous substances. This crop may be used as food or fodder, and it is generally not possible to assess its use. The discovery at Iolkos (Thessaly) of a pure concentration of split bitter vetch seeds reflects their preparation for human consumption (Jones 1982). Pea (*Pisum sativum*), very common during the Neolithic and Early Bronze Age, is still frequently recovered but in smaller quantities. Grass pea (*Lathyrus sativus*) and fava bean (*Vicia faba*) are reported on several sites in Greece and Anatolia, but except a concentration of grass pea in Kalapodi, these pulses are never discovered in large quantities (Kroll 1993). Other pulses are occasionally found: chickpea (*Cicer arietinum*) and *Lathyrus clymenum* appear as secondary crops.

Grapevine, olive, and fig trees are the most frequent fruit trees. Large amounts (n > 200) of grape and fig seeds are frequently found. In contrast, few olive concentrations were recovered. The first assemblage containing more than 100 olive stones comes from the Archaic layers of Delphi (Luce and Marinval 2008). It could be linked with an extension of olive cultivation at the end of the Iron Age (ninth–eighth century BCE) suggested by palynological data (*cf. supra*). Grape pressings have been recovered from Karambournaki (Macedonia) (Valamoti 2005), and evidence of winemaking is available as early as the Neolithic in Greece (Valamoti et al. 2007; Valamoti et al. 2015); however, there is no evidence for extensive vineyards, nor of large olive groves, before Late Classical times.

New fruit were probably introduced in Greece during the Archaic period. First, the pomegranate (*Punica granatum*), domesticated during the 4th millennium BCE in an area ranging to the Caspian sea to Northern Turkey, reached Western Anatolia and Greece in the Late Bronze/Early Iron Age (Zohary, Hopf and Weiss 2012). A first attempt of introduction, or the importation of several fruits, occurred at Tiryns (Late Bronze Age, 1350–1050) (Kroll 1982, 1984b). Pomegranate is then clearly acclimatized after 500 according to Theophrastus, who mentions it among cultivated trees (Theophrastus, *History of Plants* 2, 1, 2; 2, 2, 4-5), and its introduction in Greece could be dated to the Archaic period. Remains were recovered in the settlements of Krania (eighth century) (Margaritis 2002) and Delphi (eighth century) (Luce and Marinval 2008), and in the sanctuary of Hera on Samos (seventh century BCE) (Kučan 1995). Apple (*Malus domestica*) and pear (*Pyrus communis*) are respectively domesticated in Central Asia and the Caucasus, and probably introduced in Greece at a similar date (Zohary, Hopf and Weiss 2012). However, one single site has yielded pear or apple seeds (Kastanas, Bronze-Iron transition) (Kroll 1983). Peach (*Prunus persica*) is cultivated and acclimatized during the Classical era and was probably introduced between the eighth and fifth centuries BCE (Zohary, Hopf and Weiss 2012). Peach remains come from the Heraion of Samos and are dated to the seventh century (Kučan 1995). They are associated with remains of various exotic plants, and the site is 'the coast of Asia minor'. Peaches, but also pomegranates, fruits, and spices may have been imported into the sanctuary by pilgrims from eastern regions.

These introduced species probably remain secondary fruits crops, whereas the olive tree, grapevine, and fig tree may be considered as productive and profitable trees. Other taxa seem to have a similar status. In Northern Greece, cornelian cherry (*Cornus mas*), almond (*Prunus dulcis*), sloe (*Prunus spinosa*), elder (*Sambucus* sp.) and blackberry (*Rubus* sp.) are frequent in assemblages dated to the Neolithic and Early Bronze Age. They become less common from the Late Bronze Age onward, but their cultivation as a marginal crop may be supposed.

Agricultural Practices

While Mycenaean economy and agriculture have been much studied, Early Iron Age agriculture has received little attention (e.g. Foxhall 1995). The scarcity of archaeobotanical data and complete lack of written evidence explain this gap in our knowledge; however, scholarship on Mycenaean agricultural practices is largely based on speculation. Linear B archives testify that the Mycenaean palaces were involved in very specific areas of agriculture, particularly in flax cultivation for linen production, olive cultivation for olive oil, and cereal production. Subsistence activities are out of their control. Evidence of diversified subsistence agriculture is provided by archaeobotanical data: several wheat species (einkorn, emmer, spelt, and naked wheat) and barley types (hulled and naked) have been recovered from Bronze Age assemblages, as well as several pulses species (lentil, peas, bitter vetch, and common vetch). Data from archaeological sites occupied during the Bronze Age and Early Iron Age display more similarities than differences in crops species. Evidence from Kastanas (Northern Greece) (Kroll 1983, 1984a) and Nichoria (Peloponnese), which was under the control of Pylos during the palace period and remained an important center after the end of the palatial system, shows that the same crops were grown during the Late Bronze Age and Early Iron Age, probably because small-scale farmers continued to farm and live the same way (Shay and Shay 1978; Foxhall 1995).

One characteristic of Mediterranean agricultural systems during prehistory and antiquity was probably the cultivation of various crops, in order to reduce the impact of crop failure. The association of winter and summer cereals allows the reduction of the impact of unfavorable climatic conditions or of plant diseases, but it is also a means of spreading out the harvests over time (Amouretti 1986, p. 40). Wheat and barley are mainly winter crops, but einkorn (*Triticum monococcum*) may be sown in spring, and millets are summer crops.

Cultivation of pulses offers several advantages. They can fix atmospheric nitrogen in the soil, which improve soil fertility. Pulses may therefore be grown as fertilizers. Then, several taxa cultivated for fodder may be consumed as food. In fact, bitter vetch or common vetch are nowadays considered as fodder more than food, but their high frequency in Bronze Age assemblages indicates that they were part of the human diet. A change in the use of these species may have occurred during the Archaic period in Greece: they were cultivated for fodder, but their seeds could be eaten in case of shortage (Luce and Marinval 2008).

Cultivation of mixed crops in a single field is therefore probable, but hardly demonstrated. Mixtures of crops with different climatic or nutrient requirements were grown to exploit their yields under various conditions. However, archaeobotanical samples reflect plant storage or consumption, and processing for storage and consumption may modify the sample composition. In contrast, pure monocrop samples may reflect stored grains after sieving or sorting (Jones and Halstead 1995; Dennell 1976).

Fruit tree cultivation also seems based on varietal diversity: in Greece, from the Late Bronze Age onward, different varieties of olive and grape were cultivated (Pagnoux 2016). This diversity may be explained by the requirement to ensure a regular annual level of production. Combining different types of trees aimed to reduce the effect of the alternate bearing phenomenon (the balance between fruit production and vegetative growth, especially for the olive tree), to limit the impact of parasite attacks and unfavorable climatic conditions, and to ensure optimal cross-pollination. Moreover, in order to benefit from various lands, annual crops and fruit trees were probably cultivated on the same land plots (polycropping).

Agricultural systems from the end of the Bronze Age to the end of the Archaic period may be defined as diversified agriculture mainly based on a human workforce, in association with herding. Indeed, agriculture and herding constitute a space which animals play an economic and cultural role. Of course, regional specificities must have existed, as well as chronological evolution. The main variable factor on that point is the place of animals. Sophocles' Oedipus lets his adoptive father's animals (sheep) graze in the mountains, in the common lands usually called *eschatia* in later times (Soph. *Oed. tyr.* 1133–1140). The Cretan Lyttos had regulations inscribed in stone c. 500 BCE for assembling the common herd for grazing (Koerner 1993, nr 88). But Hesiod does not report anything like that. It is clear that the animals, be they sheep or oxen, were for some part of the year, or even at night, on uncultivated land, allowing a transfer of biomass to the fields. In twentieth-century Greece, it was not unusual to have manure manually transferred from the pastures in the mountains to the fields or gardens.

The land under the trees may also have been used for grazing – which was another way to manure the fields. But herding is never the main activity; only in mountainous central Greece, and probably in Anatolia, did it constitute the larger part of the life of the community. The Athamanes, if one believes a fragment of Aristotle (Heracl. Lemb. *Exc. Pol.*, 53: Aristotle fr. 611, 53 Rose), had women cultivating the fields and men wandering with the herds, a situation contrary to the normal distribution of work in the domestic unit.

Territories and the Environment

The data from intensive surveys clearly show that an identical general rhythm existed at the supra-regional level. At the end of the LBA, mainland Greece and central Anatolia were densely occupied, at levels which were not to be seen again before the Classical period. Iron Age settlement was much less dense. This could be due in part to changes in the exploitation of the land and a greater place given to herding; but this remains a hypothesis (against Dark Age pastoralism: Zurbach 2017, p. 675–681). In the central zone of development of Greek city-states (Greece south of the Pindus, the southern Aegean, the coast of Western Asia Minor), a new occupation of territories appears during the Late Archaic period. The sixth century is the beginning of a period of dense occupation which is characteristic of the city-states and defined their relationship with their territories until the late third or second century. There were, of course, regional peculiarities: Crete was more densely occupied from Late Geometric times. Northern Greece and the Anatolian peripheries did not take the same path; and in Anatolia, it is not until the fourth century that we find densely occupied civic territories in Lycia and Lydia. Greek colonial sites of the Central Mediterranean and the Black Sea, however, seem to have followed the general pattern of developing small rural settlements in the Late Archaic period.

This general outline remains quite undefined. To go into detail would force us to cope with the incompatibility of survey results in many parameters, from pottery dating to geomorphology. Suffice it to say here that the "invisibility" of Iron Age and Early Archaic sites may in many cases be a matter of identification and dating of common wares and issues of geomorphology. Consequently, the general depopulation may have been less abrupt, and erosion may have obliterated many sites precisely where the earliest settlements would have been located – river valleys and coastal zones.

Erosion in its turn is not without connection to human activity, of course, particularly in fragile Mediterranean zones. This is not the place to summarize the whole debate on the rhythms of erosion since the publication of *The Mediterranean Valleys* (Vita-Finzi 1969; Fouache 1999, 2006); however, the extant data point to some interesting trends. The Late Bronze Age seems to have been a phase of intense wood cutting and reduction of the arborous landscapes in favor of cereal cultivation: this phase has been called the Beyşehir Occupation Phase because it is evidenced from lake cores from Lycia. Many hypotheses have been made in relation to a possible acceleration of the destruction through erosion of the original Mesolithic forest soils in connection with the Archaic expansion of rural settlement in the Aegean and South Italy, but this remains a complex question and certainly this phenomenon was not on the same scale as the levels of erosion of the Roman imperial period (Van Andel, Zangger, and Demitrack 1990).

A type of occupation of territories which has been considered typical of Ancient Greek city-states is the allocation of land in regular, orthogonal land plots. Philosophical writings of the fourth century were long considered reliable echoes of ancient practices of land distribution (Asheri 1966 relies heavily on them). The well-known case of Metaponto has shown that this view had many limits, since recent studies suggest that the lines visible on aerial photographs were not the limits of a rational and geometric territory aiming at ensuring a kind of equality among citizens, but the remains of a large-scale drainage system of the Late Archaic period, following many different and diverging orientations (Carter 1990). The main point, however, is that a cadastral scheme tells us about the exploitation of land, not property, and that orthogonal land allocations are to be found (in urban contexts, where they are easier to locate) throughout the whole Mediterranean, and not only in Greek settings.. They are a technical tool to intensify exploitation of the land, not evidence for rational politics, nor are they proof of any economic and social equality.

Economic and Social Perspectives

Property Rights from Late Bronze Age to Archaic Societies

There is a considerable discrepancy between the documents available from the palace archives of c. 1200 BCE and Archaic texts on real estate. The Linear B texts show a complex situation where palace land and public land are allocated to members of the community, specialized craftsmen, soldiers, or officeholders, suggesting a tendency to privatize land rights in some cases. This is described through a specialized vocabulary which remains obscure to us (e.g. the *ke-ke-me-na* and *ki-ti-me-na*, the first being community land, the second perhaps more "private"), because it did not have any subsequent role in Classical Greek: all the technical fiscal and cadastral vocabulary disappeared with the palaces, their administration, and script. One exception is the *temenos* of Homeric and Cyrenaean kings, which clearly continues the *temenos* of the Mycenaean kings. But the main sense of *temenos* in Classical Greek is that of a sacred precinct. On the whole, Archaic texts do not mention any differentiation in juridical categories of land. It may be that the land where *hectemoroi* were working in late-seventh-century Athens could be such a particular category subject to some kind of division of property rights between the peasant and a landowner. But Hesiod does not know of any such restrictions or limitation to his property rights on his land, nor does the Gortyn *Code* or other legal texts; and the cries for redistribution in Athens before Solon, or the problems of inequality in land at Sparta, do imply private appropriation. The Archaic city-states much later took diverse measures to protect the family household against alienation of land. "Inalienability" of land is therefore not a remnant of a very old custom but the product of a particular social situation where the city-state had no choice but to set limitations to private property either by limiting mortgaging (in Elis) or establishing an upper limit to wealth in land (Solon) or deciding that the number of *oikoi* would remain the same (Corinth, Thebes). This evolution has to be evaluated in relation to wider social changes.

Workforce

The status and condition of those working the land is an essential point of any agrarian economy. The first level on which this question has to be addressed is the inner division of labor in the domestic unit. We have very little indication on this point from the Late Bronze Age. But by the time of Hesiod and the Archaic literature, it is clear that the family is the basic residential as well as production unit. Labor on the fields after Hesiod seems a masculine occupation, for the father, his sons, and slaves; whereas textile production or the preparation of food seems feminine. Only the function of overseer may be entrusted to persons of both genders. The slaves occupied at producing flour in Odysseus' palace are also women (*Od.* 20, v. 105–108). These indications may be scanty, but on the whole the division of labor seems to be analogous to what we know of the Classical family unit.

The juridical status of workers, on the other hand, shows more variation. The Late Bronze Age situation is highly complex, but it must be emphasized that the palaces are not totalitarian states as was once believed, so that it is completely false to consider everyone a slave in the Late Bronze Age. Moreover, the difference between personal freedom and slavery was clear enough. It is often the case that works on Classical slavery take Finley's well-known phrase – that in Archaic times, "freedom and slavery developed hand in hand" – and conclude, again with Finley – that earlier periods knew a continuous, very diversified spectrum of personal statuses where almost everyone was a dependent of somebody. This is clearly a misunderstanding. Palatial societies in the Late Bronze Age clearly knew about enslavement, notably through war and razzia, but they also knew about personal freedom. The members of local communities were mostly free peasants. Sanctuaries and palaces had dependents and slaves, but this does not enable us to generalize this to the whole society.

Slaves were also in use in the Homeric and Hesiodic households. In the epics, slavery is well known, be it as a product of war in the *Iliad*, or as an element of trade in the *Odyssey*. But the aristocratic households use other kinds of workforce when it comes to agricultural work: the *temenos* of the *basileus* on Achilles' shield is worked by *erithoi*, "wage earners," at harvest time; the remote plot of land of Eurymachos could be worked by a beggar, for a wage (*misthos*) and some other advantages (*Il.* XVIII, v. 550–560, and *Od.* XVIII, 357–361). In Hesiod, the situation is different. Hesiod has slaves all the year round, and they do the harvest, which is surprising since one would expect wage earners to be used in this circumstance, like on Achilles' shield. The wage earners make their appearance when it comes to strategically important tasks, such as the control of stored products after the harvest. For this, Hesiod chooses free, landless people from the community. The labor market does not seem very flexible since Hesiod prefers to have all the year round the slaves he needs for harvest rather than hire landless free workers. This could be explained through a chronological difference between the epics and Hesiod, but it may also be that we are dealing with different attitudes whereby the aristocrats have the necessary power position to engage with wage earners on their land, but the modest household would prefer slaves to perform the bulk of the work.

A diversification occurs during the Archaic period, specifically the seventh century. The epics and Hesiod lack any reference to Helots or analogous conditions, and to debt slavery. Helots were relatively common in the Archaic period (Ducat 1990, 1994; van Wees 2003). For a certain time, it was believed that these categories were the result of the conquest of the land by Dorians or new settlers in the Dark Ages. But recent work has shown that they were, with perhaps some exceptions, a creation of the Archaic period. To use external conquest to enslave whole communities was certainly a response to internal tensions about land and workforce. At Sparta, it is clear that there were such problems during the time of the Second Messenian war. Such categories were also created during the colonization movements. An important point here lies in the definition of these groups. Hellenistic philologists have often listed them and described them as "between slavery and freedom." But, as Ducat underlines, Classical writers consider them clearly slaves, and in fact, they are slaves; their originality lies only in the fact that the rights of private property exercised on them by one citizen was limited and controlled by the city-state (Ducat 1990). The limitation which is most often found is that selling them abroad is forbidden. This is of, course, not to protect them, as later traditions would have it, in Herakleia Pontike, for instance, but to protect the agricultural workforce the city-state had created through conquest.

The fact that ancient authors and modern historians see these categories as belonging to a coherent group should not obscure the fact that Helots and other similar groups may have known very different conditions from their very creation onward. At Sparta they were probably, according to Tyrtaeus, obliged to give half of their product to their master, which means that they were slave sharecroppers. Surveys have shown that they lived probably in isolated farms in Eastern Lakonia, and in villages in Messenia. Some Thessalian Penestai, on the other hand, did receive rations, which indicates a direct control of the work, rather than sharecropping. Another important factor is the way Helots were attributed to masters – if they worked for a minority of aristocratic masters or for all citizens. In Thessaly, the link between having Helots and huge wealth in land seems clear.

Slavery for debt made its appearance in Athens when the older status of the *hectemoroi*, who were certainly sharecroppers and clients, as the Aristotelian *Constitution of Athens* describes them, ceased to be a satisfying way for the rich to exploit the poor's labor (Descat 1990). At this point, the wealthy turned to debt slavery, which is not the inevitable consequence of some eternal tendency of the peasants to fall into debt, as older work, and some more recent, believe, but a result of a conscious strategy of the rich to develop a slave workforce. This is probably linked to the transition from sharecropping, where the landlord has limited opportunity to decide on crops and products, to direct exploitation, where slaves are indeed more suited to landlord-controlled production. Traditions about debt problems have been transmitted for Corinth and Megara as well. These problems certainly go with the monetization of the Aegean in the seventh century, when weighed silver began to be used as money in all spheres of activity, from long-distance trade to private debt (Descat 2001, 2006a). The debt system in Hesiod is, in fact, exactly the reverse of the one supposed by debt slavery, without any possibility for the creditor to seize anything (Millett 1985). This transformation may be linked to the introduction of debt in silver, in contrast to debt payable in kind.

Debt slavery, however, exists in many forms, as ethnographic data show. Athenian debt slavery before Solon was surely of the executor kind, where a debtor is reduced into slavery through default. Only this form permits the creation of a slave who can then be sold abroad and has no hope of recovering his lost freedom. There are other forms, where from the beginning of the debt relation – not from its end – the debtor or his family works for the creditor, to pay back the capital or the interest. Then there is need for a specific status making official the monopoly one has on the work of this otherwise free man. This is widely known in the Near East, and is probably the condition of the *katakeimenos* and *nenikamenos* in the Gortyn *Code* (c. 450). The situation in Gortyn is probably the opposite to pre-Solonian Athens: there the debt relation leads to debt bondage, not debt slavery, and debt is not at the center of the question of agrarian work since it has been solved through the creation of *woikeis*, the Cretan Helots, which are also present in the *Code*.

Slavery was certainly known in Mycenaean times, but it would be erroneous to argue from this continuity of juridical form to continuity in economic system. In fact, an important evolution of the Late Archaic period is clearly the more general use of slaves of foreign origin, bought on the markets. Helots were a solution to the crisis for many cities; others left the constitution of the slave workforce to the markets they were organizing. This was certainly the case at Athens, where in Classical times many peasant-citizen households had slaves to work the land with the master or for him. The very transition from a "society with slaves," as the Homeric one, to "slave societies," where slave work has a critical role, as almost all city-states could be described, is to be dated in the period after the Archaic crisis, as a solution to it. This process becomes evident in its details and complexity only if one abandons very general notions like that of "dependence," which is much too broad to analyze any historical situation. It becomes clearer, on the whole, that the Archaic crisis is not so much about land as it is about the workforce. The Late Bronze Age was apparently a "full world" where access to land was essential, whereas in the Archaic Aegean the question is more about finding the people to work the available land.

Communities of Grain

From the point of view of social history, the period considered here begins with the end of the palatial systems which had very important effects on the agrarian systems. Local communities organized in villages were common in the Aegean and Anatolia, with the exception perhaps of mountainous zones, where less sedentary ways of life were not excluded but remain badly documented. The palaces as institutions were in need of fiscal revenues, workforce, military levies, and land. All these needs had to be met through authoritarian intervention in the life of local communities, and the systems of mobilization of goods and people in place around 1200 had a long history in all regions. The palatial systems are often described through the concept of redistribution, which is, however, not very useful since the palaces are *mobilizing* more than *distributing* goods. The interaction between local communities and the palaces developed with time into a very complex system of access to land and its products. The local communities were able to maintain, in most cases, their autonomy, their collective rights on land, be it common land or privately appropriated, and the freedom of its members. The palaces, however, developed networks of collective (fiscal) or personal obligations to meet their needs. An important part of the population, even at the local level, found its place in the palace system and developed links of more or less heavy dependence to it; for example, religious and secular officeholders and soldiers were granted either palace or community land.

The end of the palaces, then, inevitably saw a fundamental redefinition of the social and economic roles and rights of local elites, former officeholders and soldiers, craftsmen, and perhaps also new inhabitants. Only the highest strata of palatial elites disappeared; the more modest ones were seeking new positions in the new order. In the Aegean, it is probably around this time that a new type of community appeared. The remains of some parts of the palatial system merged with the local elite, who had remained inside the local community but profited from their position as middlemen for the palace. The result is the community known to Homer and Hesiod in the eighth and seventh centuries. The community retains the name *demos*, the same as in Mycenaean (da-mo, *damos*), but there is no palace anymore, and the main line of conflict and mobilization of goods has been transferred from its external position (between palace and community) to an internal one (between aristocrats and non-aristocrats). In the epics, every aristocrat may operate a levy on the *demos* if he has the need to be paid back for some gifts to a foreign visitor or simply if he is in need of something. The violence with which Thersites is driven away from the assembly (Hom. *Il.* II 212–277), the absence of any political function of the agora in Hesiod, where this place is reduced to bad justice and extortion of "gifts" (Hes. *Op.* 27–39), clearly shows the inequality at the heart of this kind of community. This community has lost every right to land or its products that the Mycenaean *damos* may have had. It is possible that some communities did not have resident aristocrats; this may have been the case of the villages given by Agamemnon to Achilles to pay him *themistes*, "traditional contributions" (Hom. *Il.* IX 149–156 = 292–298), or even of Ascra itself, which seems to be dependent on Thespies where the kings are sitting. But even then, these communities are what Marx described as bags of potatoes, groups of households linked by a very loose sense of solidarity, perhaps intermarriage (even if Hesiod is not very explicit on that point) without collective property or exploitation of land. In the epics, every aristocrat who has the means to do so may appropriate parts of unexploited land, and Hesiod has no concept of commons.

The history of communities in the Early Iron Age is then not only the development of a particular form of state but also the transformation of agrarian communities into city-states, through social and political conflict over fundamental issues like the access to land and its product or the status of those who work the land. It is not possible here to go into detail, but some points may be emphasized that may help define lines of evolution:

1. The political attitudes and situation of the non-aristocrats. Thersites, as we have seen, is beaten by Odysseus, and everyone is expected to find this entertaining. Hesiod simply does not want to go to the *agora* and does not mention any other function of kings than the extraction of "gifts." But in the late seventh century, at Megara the poor slaughter the animals of the rich, take power, take back the interest on their debts, and open aristocratic meals to everyone (Plut. *Quaest. gr.* 18). Around 600, a massive leveling movement at Athens wants to distribute all land again (Sol. fr. 34 West).
2. If one considers entitlement to land and its products, there is also a clear evolution (on entitlement: Sen 1981). A commoner in the epics – for instance, a rank-and-file soldier – has only his land to cultivate and his family to work with him. An Athenian citizen around 500 BCE has access to organized and regulated markets, where grain is being sold, and slaves also; he has a family in its broader sense, that is, with slaves; his rights on land are protected by the laws of the city-state; only the city-state may have fiscal claims on him. A Spartan citizen in the same period would also have Helots, provided mostly by external conquest.

It is clear that the evolution of entitlement may be seen as a solution to the other line of development, that of conflicts. Across the Mediterranean the seventh century is a period of aristocratic power, and in the Aegean it may be correlated with debt crisis, which is a means of creating a slave workforce, in Athens and perhaps in Megara and Corinth. It may explain some of the laws against the concentration of land. But the main response to this was the abolition of debt slavery and the creation of institutionalized markets, the *agora* and the *emporion*, at the end of the seventh and the beginning of the sixth century, together with the establishment of new protections and regulations of the private household economy. The history of the city-state is therefore above all the history of an agrarian community.

Levels of Change: Urbanization and Markets

It is not easy to unite all these elements in a bigger picture. It is clear, however, that the communities left alone by the collapse of the palatial system did have a much simplified agrarian system, and that they coped from the eighth century onward with many challenges. Demographic growth, on one side, is certain from the eighth century, and is parallel to an internal differentiation which leads to a clear aristocratic domination in the seventh century, a phenomenon visible across the whole Mediterranean. From those times we have traces of conflicts in the workforce, notably debt slavery and land concentration. The reaction of the city-state led to institutionalization of markets, limitation of the sources of the workforce (either external, as in Athens, or internal such as Helots at Sparta and elsewhere), and consolidation of the household as the basic unit of agricultural production.

It is in the sixth century, however, that population growth did begin to change something fundamental to the economy by creating larger urban settlements than ever before. Archaeological approaches to Archaic urbanization nowadays point to the sixth century as the period which saw the most fundamental changes. Together with the internal and external markets (*agora* and *emporion*) now controlled by the city-state (Descat 2006b), this had as a consequence the augmentation of trade in agricultural products. It is in this context that we may recall the agricultural innovations of Archaic times (see *supra* on new fruits) and also the beginning of specialized agriculture in wine at Chios and Corcyra, the two best-known examples, probably from the sixth century. Together with the new occupation of the rural territories of each city-state, it is clear that the sixth century opens a period which would close only with the Roman occupation of Greece.

FURTHER READING

Ancient textual sources, from Homer to Theophrastos, are easily available; on Hesiod, see the commentary by West 1978; on Linear B texts Del Freo 2005 gives an essential and complete overview. On techniques, Amouretti (1986) remains essential; on recent work in carpology and palynology, however, synthetic work is still lacking, and one has to turn to the references quoted above. The economic and social history of that period is currently changing rapidly; Descat (1990, 2001, 2006a, 2006b) explores new perspectives, as do van Wees (2003) and Ducat (1990). On monetization, see Kroll (2008). Finally, Zurbach (2017) provides a general overview of the main themes of the period.

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CHAPTER FOURTEEN

Agriculture in Greece and Coastal Anatolia, 500–100 BCE*

Christophe Chandezon

Introduction

The agrarian history of the Greek world is more often divided into separate topics—such as a history of territories, farming techniques, land use, and status—than studied in any integrated or comprehensive fashion. Any attempts to offer a wider, more integrated view are either out of date (Osborne 1987; Isager and Skydsgaard 1992; Burford 1993) or too brief (Foxhall 2006; Davies 2007; Kron 2015), with the result that the cohesiveness and interconnectedness of Greek agrarian history is overlooked and removed from wider historiographical debates—though publications dealing with the Greek Bronze Age are beginning to connect agrarian history with political, social and economic questions (e.g. Zurbach 2017). One large casualty of this is economics; the economic dimension of agricultural activity is generally lost as research questions narrow. Primitivism, for example, which saw economic motives at the heart of agriculture, should have aroused curiosity and comment, but this has not happened. Post-primitivism, which has become the mainstream approach today, has avoided thinking about agriculture, with only rare exceptions (Bresson 2016, pp. 118–174). In addition, historians of religion have not considered the agrarian dimension to rural religious life (an important exception is Ekroth 2014 on Greek sacrifices, who notes the connections between Greek religion and the agricultural sphere). We must acknowledge these shortcomings, even though it is not possible in the space of this chapter to overcome them.

Until the 1980s, the agrarian history of Classical and Hellenistic Greece was dominated by questions about legal status: i.e. the status of the land and the status of the workers of the land (see the historiographical section of Fantasia 2003). From the publication of Robert Sallares' book on ancient ecology (1991), archaeological data entered into the conversation, promoting an ecological approach to the study of the countryside (Rackham 1996; Horden and Purcell 2000). This perspective was fed by a proliferation of archaeological surveys, despite methodological debates concerning the practice and interpretation of field archaeology. At the same time, epigraphers seized on agrarian questions (e.g. Pernin 2014). This resulted, in

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the 1990s, in a combination of textual analysis and the archaeology of environments and territories that inaugurated a golden decade in the agrarian history of ancient Greece. At the same time, Greece, thanks to its integration into the European Union, finally realized its own modern agricultural revolution. Changes in the countryside strengthened researchers' impression of witnessing the end of a rural world in which they were likely to find echoes of antiquity. In the mid-2000s, the wave of agrarian studies gave way to new themes, though much yet remains to be done. While archaeology and epigraphy have greatly influenced the historian of Greek agriculture, the literary texts have remained all but neglected, despite that fact that Victor Ehrenberg had shown how important Aristophanes' comedies were to understanding the Athenian countryside (Ehrenberg 1974, pp. 73–94). Although a few rare cases have been explored, such as Theophrastus' botanical treatises, or as the *Geoponica*, a Byzantine collection of abstracts of ancient agricultural science (Dalby 2011), no one has yet studied systematically the information on the countryside that appears in the Attic forensic speeches or bucolic Hellenistic poetry. In addition, the study of iconographic sources has also failed to make an impression: the vases decorated with agricultural scenes disappear almost completely at the beginning of the fifth century CE, and not until first century CE does agriculture again find a place in Greco-Roman visual culture.

We begin our study of Classical and Hellenistic agriculture at the end of the Archaic Period, when the archaeological evidence suggests that a rise in population filled the countryside and prompted a search for new farmland. At this point, farming practices became more complex, and the emergence of markets was restructured to accommodate more diverse agricultural production and distribution. Later, during the early Hellenistic period, the first signs of a profound reorganization of the settlement patterns of the countryside appear, even if the territories of cities along the coast of Anatolia seem to remain well populated and prosperous. Finally, the first century BCE seems a time of deep depression and remains a convenient end for this study, though, in all probability, this depression persisted well into the beginning of the High Roman Empire, and it is only in the second century CE that the Greek countryside came out of these difficulties. In what follows, the reader must keep in mind that the history of Greek agriculture corresponds in part to the chronological patterns and periodization of political history. Yet, this chapter deals with agriculture, that is to say, that which relates to the cultivation of the land, the conditions in which it is organized, including the breeding and keeping of animals, which is closely linked to it. There will be no direct analysis of the circulation of agricultural products. Likewise, other ways of exploiting the land, such as mineral resources, are beyond our scope, as are rural handicrafts. For this reason, the history of agriculture is not fully "agrarian" history.

Agriculture and Landscapes

The word *landscape* has two different meanings. A landscape is a cultural perception of the environment, but it is also a geographical datum that the historian and the archaeologist can reconstruct. The first meaning does not interest us here, although cultural categorizations of landscapes appear quite early and testify to a long intellectual engagement with the land that has been refined over time (Robinson 2016). To approach agrarian landscapes as geographical data, texts and archaeology complement each other (e.g. Fachard 2012, for Eretria and its territory). I will begin with two examples, from different times and places, to set the tone.

The first concerns the countryside of Athens in the fourth century BCE, visible from both literary and archaeological sources. The Athenian forensic speech *Against Callicles* ([Dem.] 55) describes a valley surrounded by mountains (10), where several agricultural estates (*chôria*) rub shoulders, including those of the litigant and that of his opponent. Between their properties passes a road (*hodos*, 10), bordered by a watercourse (*charadra*, 16) for the evacuation of runoff. This watercourse was necessary, because during thunderstorms, water tended to invade agricultural land and cause damage (11). Moreover, when a landowner did not pay enough attention to his land, others tended to let their livestock overrun it and did not hesitate to cross it if necessary (11). One of the ways to prevent this was to fence off property with stone walls (*haimasia*, 11). The farmers mentioned in *Against Callicles* possessed slaves to whom they are sometimes emotionally attached (31–32). Thus, this little world is made up of people who know each other. They produce barley and olive oil, but their plots also have fig trees and vines (13 and 24). Undoubtedly, these crops conform to Theophrastus' recommendations: good land for cereals and slopes for trees (Thphr. *CP* 1.18.1–1.18.2, 3.6.7–3.6.8). In the *Against Callicles* speech, there is no mention of agricultural buildings, but old tombs (*mnemata palaia*, 14), those of the previous owners buried on their land, are mentioned. This recollection of the names of the former proprietors was a constant in these societies, and many agricultural domains continued to bear the name of those who exploited them in the past. In another speech, *Against Phaenippus* (42), written around 330 BCE, we see an outlying farm, an *eschatia* (5) located on the Cytherus deme in Mesogeia. This fairly large plot included wooded areas. Cereals were also produced (*sitos* 6 and 19, barley, 20, 24), and in large quantities as evidenced by the existence of two large threshing floors (*halos*, 6). This was a valuable resource at that time, as Athens was in a food shortage, and the price of grain had tripled (31). The farm also included buildings (*oikêmata*, 6). Their storage areas held a harvest of cereals, one of wine, and other crops also grown on the spot (19, 24). *Against Callicles* also evokes another element of the rural landscapes of Attica and the Aegean – these are the mortgage stones (*horoi*, 5, 28) that were erected on land pledged as security for a loan. We also learn that the owner, Phaenippus, was a horse racer and a breeder. Other Athenian texts of this period add further details, including the role of arboriculture in the landscape, describing olive trees planted along the roads and at the edge of the plot, or isolated in fenced areas, when it comes to sacred olive trees (Lys. 7, *The Matter of the Olive-Stump*, Xen. *Oec.* 19.13). Survey and excavation give a similar picture of the Athenian agrarian landscapes. The construction of the new airport in Athens, for example, made it possible to study the Spata area in the late 1990s. In the Classical period, this region was crisscrossed with rural roads, indicating a significant movement of goods across the countryside. Big hives of terracotta suggest that beekeeping allowed landowners to exploit all the resources, including the uncultivated areas. Thus, Attica of the sixth century BCE appears as a collection of *terroirs*, microecologies intensely exploited to meet the needs of the city more than those of more distant markets. These farms combined cereals, arboriculture, and livestock. The major crops were inherited from previous periods: the Mediterranean triad (barley or wheat, vines, olives) has, however, undergone some changes, particularly with the growing importance of the olive, the expansion of which was stimulated by the intensification of trade in the seventh and sixth centuries BCE. Alongside the triad were secondary crops, such as legumes, figs, or millets. Above all, agro–arboreal–pastoral integration often facilitated the cohabitation of livestock – where ovicaprines and pigs are largely dominant (see Howe 2008, 2014a, 2014b and Chapter 6 of this volume) – with cultivation and exploitation of *eschatiai*.

The other example that I will discuss concerns Hellenistic Asia Minor: several sanctuaries in the city of Mylasa (Caria) yielded inscriptions describing land transactions from the second half of the second century BCE (Pernin 2014, pp. 296–445). In these texts, individuals sold their estates to a local sanctuary and then took them back immediately as tenants, with a fairly modest annual rent. These lands were described, with their boundaries, and this allows us to get an idea of the settled landscape. The Mylasian plain was crisscrossed with numerous paths (*hodoi, atrapoi*) connecting the villages between them or serving the farms. The countryside was cut by streams, ditches (*taphroi*, Pernin 2014, No. 182, l.18) which would delineate the plots, as well as hedgerows (*harpezoi*, Pernin 2014, pp. 337–338, no. 169, l, 11, and pp. 341–343, no. 172, 1, 6). The main part of the farm consisted of land without trees (*gê psilê*) and therefore planted in cereals, and probably also in pulses. Some plots served as nurseries (*phyteia*), where young trees were raised for orchards (*paradeisoi*, Pernin No. 2014, pp. 303–305, no. 142, 1.4). Other parts were kept as grasslands for cattle (*nomoi*, Pernin 2014, pp. 303–305, no. 142, 1.5). Some large isolated trees served as landmarks (Pernin 2014, pp. 385–386, no. 218, l.13). These farms (*aulai*) were all well equipped; some have towers (*pyrgoi*, Pernin 2014, pp. 330–331, no. 162, l, 8) and rooms on the floor (*hyperoria*); many have the equipment to produce wine and oil and keep them. There were stables for cattle, apiaries (*zmênôn*, Pernin 2014, pp. 350–351, no. 179, 15), and wells. All this shows a rich countryside, intensely cultivated and exploited according to the capacities of each *terroir*. The juxtaposition of different crops translates the mixed-farming strategies onto the landscape. The survey by H. Lohmann in the lower Maeander, nearby, gives a similar picture. Farms were numerous in the peninsula of Didyma, while villages seem less common (Lohmann 2004, 346–348). As in Attica, the rural funerary compounds marked the attachment of the owners to their lands. In the territory of Thebes on Mycale, in a hilly and wooded terrain, the density of farms was lower (Lohmann and Hartung 2014, p. 181). Here, small livestock had a more important role, as did beekeeping (Lohmann and Hartung 2014, pp. 185–186).

The juxtaposition of these examples shows how Greek polyculture together with animal husbandry shaped the countryside, imposing a variegation of crops from one plot to another, far from the monotonous countrysides that current agricultural practices generate. The use of companion plantings reinforced the variegated landscapes. Barley and legumes were frequently sown between rows of vines (Theophr. *CP* 3.10.3 and 3.15.4; see Boulay and Vaudour 2015, pp. 225–230). The biennial fallow played a supporting role: it could be productive if used as pasture or if legumes were sown (intensive biennial, Amouretti 1986, pp. 54–56), which also improved the soil. Cultivation even penetrated into intramural areas and flocks were grazed in the necropolis, between the tombs (Plb. 9.17), sometimes even inside the sanctuaries.

In classical Attica, as in Hellenistic Asia Minor, we find similar strategies for exploiting the countryside. One type combined villages and isolated farms, another was more dynamic at its beginnings, tending to concentrate settlement and enclose the countryside. We will come back to it. Everywhere, market cultivation created webs of settlement much denser than we had imagined (for the *chora* of Eretria: Fachard 2012, pp. 91–109). Even mountainous areas were affected (Rousset 1994; Roy 1999a; Horden and Purcell 2000, pp. 130–132; Thonemann 2011, pp. 240–241). The particular activities they allowed (a animal breeding, logging, hunting) helped shape the natural environment, which was not only forest, but also maquis, *garriga*, and highland meadows for pastoral exploitation (Rackham 1996; Cavanagh et al. 2002, p. 81). When population pressure was high, farms appeared in these marginal regions (*eschatiai*). An inscription mentions an isolated farm in the Lower Olympus Massif, between Thessaly and Macedonia, and states that it has not withstood the instability created by the passage of the Galatians in 279 BCE (Ager 1996, p. 54). In the Dikte massif (East Crete), in the midst of the Hellenistic period, anyone who farmed or planted trees on land, thus marking out for sedentary agriculture areas which had been devoted to pastoralism, was recognized as an owner (Ager 1996, p. 158). Mountain spaces were therefore not abandoned spaces, nor were they insurmountable barriers. The links between communities on two sides of the same mountain range could be seen in the inscribed relationships among the various civic elites (Thonemann 2011, pp. 240–241; Horden and Purcell 2000, pp. 130–132).

The taming of the slopes was also a sign of the impact of agriculture on the landscape. For a long time, it was uncertain whether ancient Greeks had practiced terracing (on this aspect of the Mediterranean landscape, see Horden and Purcell 2000, pp. 234–237). It has now been shown that terraces existed since at least the Classical period (Price and Nixon 2005). In Delos, during the Hellenistic period, the territory was organized in large terraces (Brunet 1999, Figure 14.1). This phenomenon was found elsewhere in Aegean Greece (Attica: Lohmann 1992, pp. 51–57; Lohmann 1993, vol. 1, pp. 196–219, in Asia Minor, in the Mycale massif: Lohmann and Hartung 2014, p. 185). In addition, low walls (*haimaisiai, teichia*) were mentioned in leases or court cases of the fourth century (lease of Arkesine of Amorgos, Pernin 2014, pp. 270–275, no. 131; [D.] 55, *Against Callicles*, 11; see Brunet 1999, pp. 24–27; Price and Nixon 2005, pp. 666–670, 686–691) and prove that there was a Greek vocabulary for agricultural terracing (yet these interpretations have not always been accepted: Foxhall 2006, pp. 263–264; 2007, pp. 61–69).

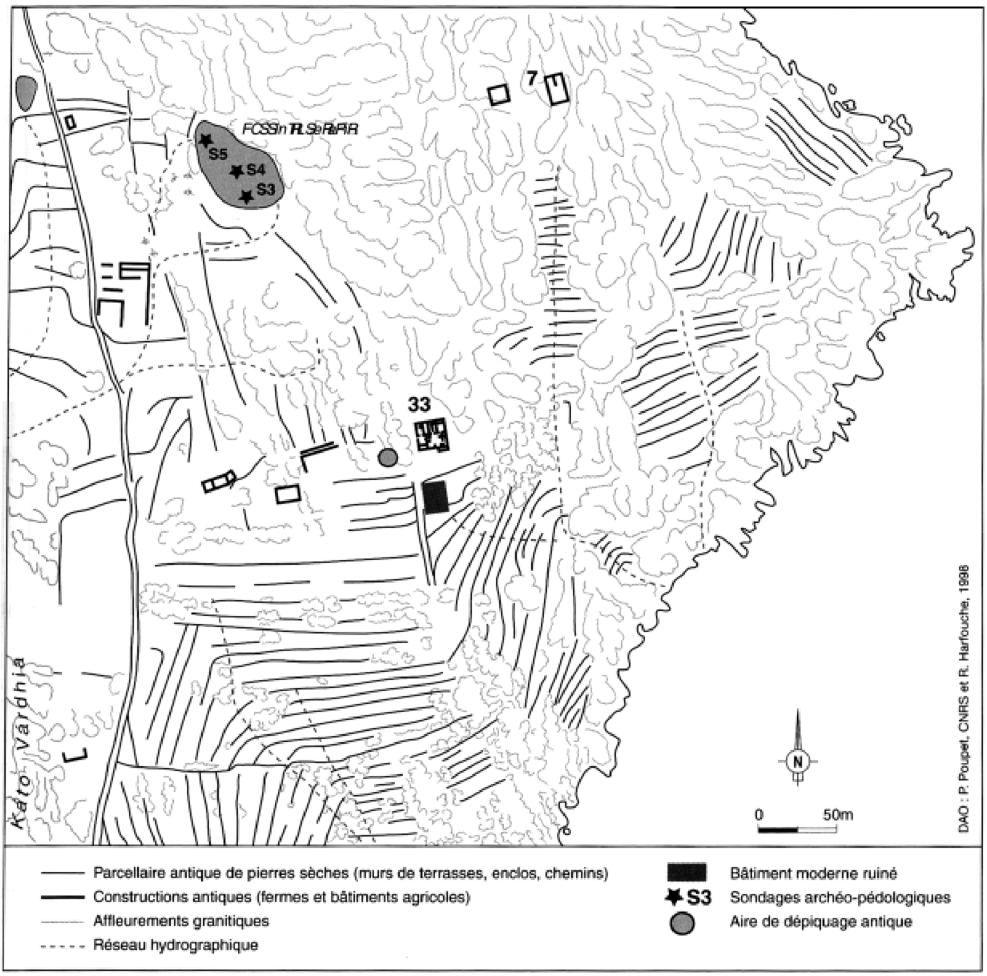


Figure 14.1 The ancient landscape of Delos is one of the best preserved in rural Greece: the island was left almost deserted after the 7th c. AD. The territorial structure has two main features: the most recent is a network of stone walls (18th, 19th th c.?). These walls overlap ancient terracing walls (Classical and Hellenistic), which are frequent in the southern part of the island. This ancient terracing system is bound with the farms of the same period and fills the valleys in a perpendicular pattern relative to the thalweg. This shows that the terrace walls were also used to retain humidity. Source: From Harfouche, R. (2005). Retenir et cultiver le sol sur la longue durée, les terrasses de culture et la place dubétail dans la montagne méditerranéenne. *Anthropozoologica* 40:45–80.

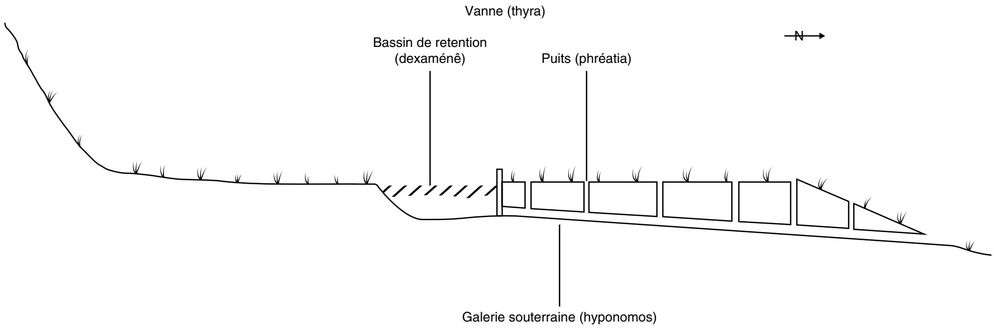


Figure 14.2 Reconstruction of the drainage system for the marshy lake of Ptechai (Euboea, territory of ancient Eretria, according to the inscription of Chairephanes). The natural drainage of the area was difficult due to the gentle slope. The solution chosen by Chairephanes was to dig up an artificial retaining basin (*dexamene*) just under the hills to collect water. An underground canal (*hyponomos*) diverts the water and a series of wells (*phreatia*) then controled the flow of waters. Chatelain 2001, p. 103. Source: Chatelain, Thierry. 2001. "Assèchement et bonification des terres dans l'Antiquité grecque. L'exemple du lac de Ptéchai à Érétrie, aspects terminologiques et techniques." In *Irrigation et drainage dans l'Antiquité, qanats et canalisations souterraines en Iran, en Égypte et en Grèce,* (ed.), 81–108. Paris: Thotm.

Terracing has the advantage of retaining soil on slopes and limiting the effects of erosion. It also keeps the soil moist and prevents cattle from straying. This type of development of the slopes would indeed have been one of the mechanisms that allowed the olive to conquer higher altitudes and to thrive on mountainsides (Mitchell 2009; Lohmann 1993, vol. 1, p. 198 connects the terraces of the deme Atene to olive growing). In the Parnon massif, in Laconia, the olive tree rises up to 850 m on well-exposed slopes (Cavanagh et al. 2002, p. 75). But terraces could be used for other crops. In Delos, the shelves were wide enough (from 8 to 15 m) for a team of oxen to maneuver (Brunet 1999, p. 46). Here, the Delians arranged plots of such a length to facilitate plowing by avoiding the need to turn too often. On the terraced shelves that were too narrow for oxen, preparation of the land for cereals could be done with a mattock (*dikella*).

The influence of agricultural activities on landscapes was also reflected in wetlands (Horden and Purcell 2000, pp. 186–190). In Boeotia, the Copaïs basin has been the subject of containment and water control works for millennia. It was necessary, in particular, to maintain the canals which directed the waters toward the catavothres, these natural crevasses where they rushed to reach the sea. Alexander the Great contributed to this enterprise: an engineer at his service and specialized in mining work, Krates from Chalcis, had undertaken to drain the land near Orchomenos (Str 9.2.18 = C407), probably by a series of polders. A smaller Beotian basin, that of Thisbe (Paus 9.32.2–9.32.3; Knauss 1992), was also dammed by a central dike to retain water in one half of its surface and to allow cultivation in the other. Similar cases existed elsewhere, as in Arcadia (Plut. *Moralia* 557C: Pheneos; Paus. 8.23.2: Kaphyai). An essential source for this type of enterprise is a contract from the city of Eretria with one Chairephanes to drain a marsh in its territory, that of Ptechai (*IG* XII.9, 191; Knoepfler 2001; Chatelain 2001; Pernin 2014, pp. 281–290, no. 134). The text, dating around 315 BCE, shows that the goal was to gain cultivable land that Chairephanes would keep operating for ten years against an annual rent of 3 talents, a sum which was indicative of the expected gains. The technique used was particularly elaborate, consisting of the construction of retention ponds, an underground drainage channel, and a well system (Figure 14.2). The lands gained from the water, when they remained wet, offered grazing for cattle, as seen on the shores of Copaïs where the city of Orchomenos was able to grant grazing rights (Migeotte 1984, p. 12; Howe 2013). The totally dry land favored cereals, fruits and vegetable crops.

The issues surrounding the control of water were also reflected by the presence of wells in the countryside, attested by archaeology (at Delos, Brunet 1999, pp. 27–44) as well as in leases. Often consisting of simple water holes, wells could also be equipped with complex devices, such as counterweights and pulleys (*kêlones*). The territory of Delos has also yielded water storage basins (Brunet 1999, pp. 27–42). One could retain 2000 m^3 and was located upstream from some terraces and was therefore at least as much destined to irrigate the fields as to water the animals. These improvements allowed for gardening as well as for keeping small livestock on the island. Laws would help regulate use (Pl. *Lg.* 844a). These devices remind us that Greek agriculture was not necessarily dry farming, nor was it agriculture that was always without fertilizer. Manure of human or animal origin was used for arboriculture or market-oriented gardening (Theophr. *HP* 2.7.3–2.7.4, 7.5.1). The use of water and fertilizers is a reminder that farmers often have two options to put a parcel under cultivation. Either they make a garden (*kêpos)*, which will provide a good return but at the cost of much work, or they opt for less intensive use. The technology existed for intensive cultivation, but choosing it was an economic decision that depended in particular on the proximity of a market.

From Landscape to Parcel, from Parcel to Settlement

There are many types of urban parcels, some irregular and spontaneous, others constructed. In the *chôrai*, we also see two types, one irregular and the other more geometric and thus resulting from a conscious placement of boundaries. The Delian countryside was in the first category. Here, divisions of land were mainly based on topographic considerations. The major circulation axis was central. In outline, it follows the line of the ridges (Brunet 1999, pp. 9–10). This same irregularity can be seen in certain Athenian demes (Lohmann 1993, vol. 1, pp. 219–224). For the other type, the property register of Larissa in Thessaly reveals geometric divisions reminiscent of Greek colonial foundations. The Larissa register also shows how much the movement and sale of goods very quickly changed the initial order, division, and grouping of the individual parcels (Salviat and Vatin 1974).

In both cases, parcels of land were created out of a common concern for demarcation of property. The land was first perceived as private property – sacred or public lands were very much in the minority (Papazarkadas 2011, p. 98), although they were found in all cities and were a normal way of securing income for the sanctuaries. This private demarcation involved the installation of boundary markers (see the Athenian lease from Aixône, Pernin 2014, pp. 84–89, no. 18), where natural boundaries were not obvious, and also fences (Lohmann 1993, vol. 1, pp. 219–224). In Delos, this fenced landscape begins in the sixth–fifth century BCE (Harfouche 2005, p. 61). Such fencing makes the practice of Cimon, the son of Miltiades, who in 470 BCE left his land unfenced, allowing all those who wished to use it in his harvest ([Arist.] *Ath. Pol.* 23.3), even more striking and noteworthy. One of the reasons for these property enclosures was to help manage livestock better (Harfouche 2005, pp. 56–67). The epigraphic evidence dwells on this problem, and sometimes a text explicitly links the construction of a fence with livestock management. Thus, movement of animals across properties was possible only at the cost of a strong agropastoral integration. It is perhaps not a coincidence that the regions that reveal traces of terraces and fences were at the same time the ones that give signs of a strong link between livestock and agriculture (Aegean Greece). Thus, parcels seem to have been specialized according to the operators' goal and according to the land's potential.

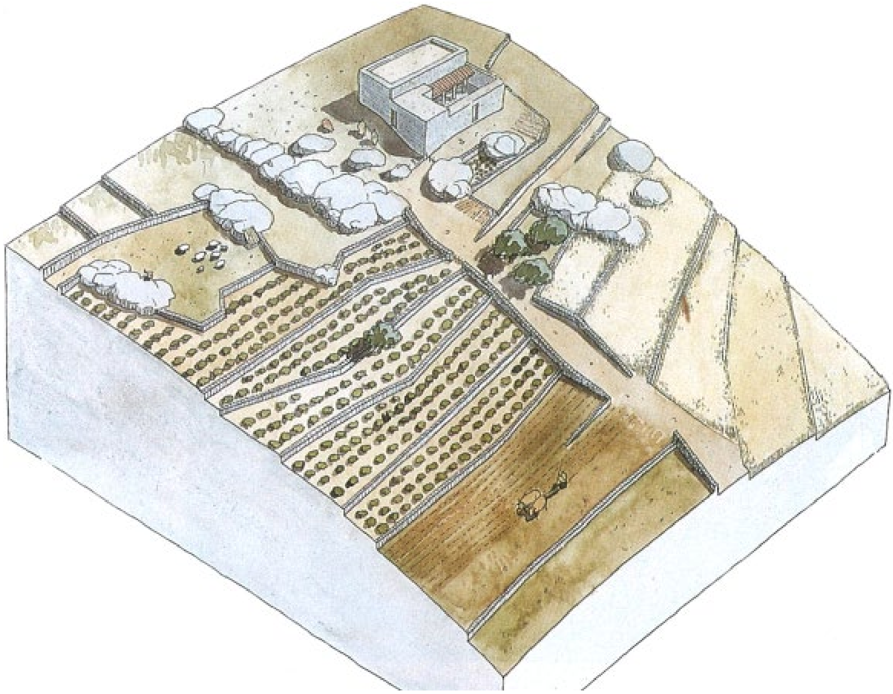
The cadastral sources used recurrent names: *oikopedon* for land that can be built on, *kêpos* for an irrigated and densely cultivated plot, *paradeisos*, for an orchard, *gê psilê*, for grain land, *eschatia* for an isolated or remote parcel, and so on. In uncultivated areas, where other resources were found (livestock, wood), private property was no longer the norm; here, there were mainly forms of collective exploitation of the land (*epinomia, epixylia*, see Lycia in the middle second century BCE: Rousset 2010, pp. 43–50).

A parcel is not the same thing as a land register. The latter took the form of property lists rather than a division of land, and the goal was thus fiscal rather than geographical. There have been records of this kind in Asia Minor, dictated by the Achaemenid monarchy, throughout the Classical and Hellenistic periods. They allowed the calculation of the tax, and Herodotus (6.42), evoking the action of the satrap in Sardis Artaphernes, said the land register was imposed in 493/2, which required the Greek cities of Asia Minor to measure their territories and pay tax to the King according to this measurement (see Briant 1996, p. 424; Marek 2016, pp. 160–161). A similar assessment does not seem to have existed in Greece in such a systematic way, even within the framework of the Athenian Empire (Faraguna 2000). Plato (*Lg.* 741c, 745b–e), however, wanted such measurements and recommended that land registers be deposited in the sanctuaries. The practices of regularization of parcels also appear: inscriptions attest that in many cities, it became customary to install newcomers on a *klêros*. Pharsalus in Thessaly had granted citizenship and 60 *plethra* of land per person to resident aliens (*IG* IX.2, 234). In Zeleia, Asia Minor, a new citizen was granted half a *klêros* of woodland, a *klêros* of land in the plain, a house, and a garden (Schuler 1998, p. 110). In Thessaly, in Larissa, inscriptions from the end of the third and the beginning of the second century BCE record properties and their owners (Salviat and Vatin 1974; Helly 1984, pp. 228–231). Although they appear very fragmentary, there originally seems to have been a system of regular *klêroi* of 50 *plethra*, dating back to the Classical period. Attempts to reform the Spartan territory, under Agis IV and then Cleomenes III, in the second half of the third century BCE, went in the same direction, with a division of the land into *klêroi* (Plut. *Agis* 8, *Cleom.* 11). The main purpose of these operations was to strengthen the civic body (and therefore the military), but also, as King Philip V of Macedonia told the Larissaeans, to make the territory better cultivated (*IG* IX.2,517).

The study of rural settlement has made great progress thanks to archaeology. Villages and farms are now relatively well attested. Villages (*komai*) were the characteristic of cities with large enough land to have secondary centers, as is the case of Attica (Jones 2004, pp. 91–123), where the demes are approximately 4 km from one another. The *chora* of Eretria gives an image very similar to that of Athens, with about 5.5 km between each deme center (Fachard 2012, p. 76). In Attica, some capitals of demes were real little towns, like Acharnai or Aphidna. As such, they possessed a strong identity perceived even by other Athenians. For example, the reputation of the Acharnians was related to the charcoal trade they brought to Athens (Ar. *Ach.* 214, 332, 336, on this activity, see Olson 1991). Each deme possessed its own political and religious life. It had its boundaries, its assembly of *demotes*, which voted decrees. It celebrated its feasts like the Rural Dionysia and had a busy sacrificial calendar – hero cults too gave structure to these communities. The demes also managed agricultural properties (Papazarkadas 2011, pp. 111–162). When excavations have been carried out, as in Ano Voula in Attica (perhaps the ancient *kome* of Halai Aixonides), we see sparse settlement, with alternating parcels with or without buildings. The area was dominated by a tower, a feature which one could find in other villages of Athenian territory (as in Thorikos). There were many small shrines in this village, as well as a banquet room, whose use is uncertain, and craftsmen's workshops, such as that of a blacksmith and a dyer (Lohmann 1993, vol. 1, pp. 129–134). The image that emerges from the excavation at Ano Voula suggests an intense village sociability that recalls Hesiod's Askra, with its community center (*lesche*) and forge (Hes. *Op.* 493–494).

The farmstead (*aule/epaulion*) is the other significant type of rural settlement. Its existence is now uncontested (on the debate on this subject during the 1980s, Brunet 1992). Excavations have shown that it was a prominent feature of the rural landscape. Farmsteads were very numerous in the Attic deme of Atene, especially since it did not seem to have included a village (Lohmann 1993, pp. 136–184). The survey conducted there was able to examine small areas of farmland that were connected or slightly fragmented. That of Charaka, 173 ha, consisted of 12 farms or rural settlements, and that of Thimari, with 136 ha included 10 (Lohmann 1993, p. 225). The term "farmstead," however, is an imprecise word and has posed problems for landscape archaeologists as they attempt to define the criteria with which to interpret a site as a farm (Osborne 1992; Pettegrew 2001; *versus* Foxhall 2001). The meaning of the Greek words *aule* and *epaulion* also deserves discussion. In addition, the words farm, *ferme* or *Gehöft* used by researchers unconsciously hide anachronistic cultural constructs. If we define as a farm any isolated built structure located in the countryside, or in near-urban areas that is dedicated to agropastoral production and at least a temporary residence of the farmers, we must accept that this generalizing definition covers up difference (on the farms, Jones, Graham, and Sackett 1973, p. 432; Hellmann 2010, pp. 139–155). Even in Attica, the footprint of a farm can vary widely. The farm of Dema, on the flanks of Aigaleos, whose central building forms a block of about 22 m by 16 (352 m^2 on the ground, Jones, Graham, and Sackett 1962, fifth century BCE) is much larger than that of Vari, on the flanks of Hymettos, at 17.5 m by 13.5 m (236 m^2 on the ground, Jones, Graham, and Sackett, 1973, fourth century BCE). In Delos, the Granite Door Jambs Farm, built in the fifth century BCE and used throughout the Hellenistic period, is about 300 m^2 (Figure 14.3). Larger farms have sometimes been identified. A traditional farm near Sounion, on the south coast of Attica, was situated in a very open plot of 790 m^2 (Lohmann 1994, pp. 85–93). The discovery in the early 2000s of very large farms of the Classical and Hellenistic periods in Macedonia has changed our knowledge of the rural habitation by revealing farms much larger and reminiscent of those of Greek colonial foundations. In Tria Platania, in the coastal plain at the foot of Mt. Olympus, a Hellenistic farm occupied for example 2400 m^2 (Figure 14.4). These buildings, which sometimes provided banqueting equipment, a sign of the owner's frequent residence, were very well equipped for exploitation (*Ancient Country Houses* 2003; figure 14.4). Some of these large farmsteads were oriented towards the production of wine for external markets (Margaritis 2016). The inscriptional evidence completes the picture offered by archaeology. If in the coastal areas of Asia Minor, like the territory of Miletus, farms resembled those of the whole Aegean world, the surveys in the territory of Kyaneai in Lycia reveal another type of Hellenistic farm, the rather massive and fortified compound (Hailer 2008, pp. 91–105). These examples show the great diversity in building types. Hopefully, scholars will one day arrive at a typology of the Greek farm taking into account all of these regional variants, but at present this is still out of reach.

In general, farm buildings were centered around a courtyard (*aule*) that gave its name to the type. The presence of a carefully constructed tower (*pyrgos*) was far from systematic. At Delos and Rheneia, only 2 of the 23 properties of Apollo have towers in the third century BCE, while of the 40 or so farms identified by Lohmann in his survey of southern Attica, at least 13 had towers. The tower farmhouse was a phenomenon that is found in much of the Greek world, as far as away as the interior of Asia Minor. It began as early as the fifth century BCE in Attica and culminated at the end of the Classical and early Hellenistic periods, to end only in the Imperial period (Morris and Papadopoulos 2005, pp. 155–167, on the rural towers), except in parts of Asia Minor, where it persisted into late antiquity. The rest of the farm buildings were built of mudbricks. Wood frames and tiled roofs were standard but could be removed and were therefore considered movable property – the Athenians took them away when they evacuated their farms at the beginning of the Peloponnesian War (Thuc. 2.14.1),



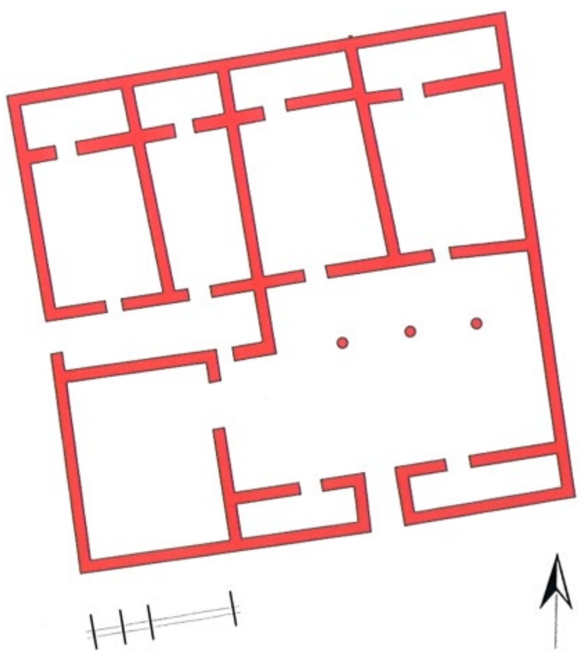


Figure 14.3 **(a,b)** Classical and Hellenistic farmhouse in Delos (the so-called Granite Door Jambs Farm). This farm was built during the 5th c. BCE. The building occupies approximately 300 m². The main rooms are located on the north side of the central yard where the inhabitants used to cook. Storage and crop processing (a grist mill for wheat and barley) took place within the farm. Archaeozoological remains (still unpublished) show the presence of sheep and goats, as well as poultry. Delos was one of the major spots for the development of the exploitation of chickens for meat and eggs in the Greek world. The occupation of the farm lasted for five centuries, until the end of the Hellenistic period. *Espace grec* 1996, pp. 63–64. Source: Courtesy of Nicolas Bresch (CNRS-IRAA).

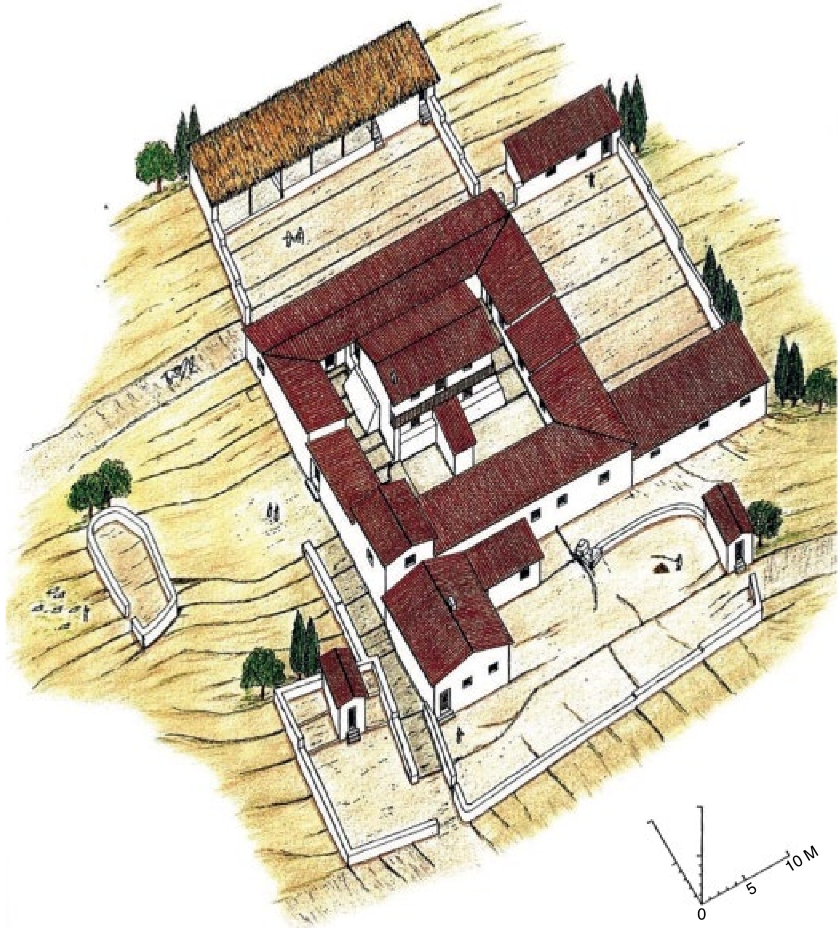


Figure 14.4 Macedonian farm of Asprovalta, located a few kilometers west of Amphipolis, near an important ancient road. This Hellenistic farmhouse (including adjacent buildings) was covered with tiles. With the courtyards, it occupies 914 m^2. In its center, a central tower house rises over the complex like a keep. Rooms were used as workshops for metal processing. Fine-quality ceramics and stamped amphoras from Thasos, Rhodos, and Cnidos show that the owner lived partly on his estate. *Ancient Country Houses* 2003, p. 106. Source: Ministry of Culture and Sports - Fund for Archaeological Resources and Expropriations (Hellenic Ministry of Culture and Sports / Archaeological Receipts Fund).

and the leases often specify whether the buildings were rented with or without a door. On the basis of this, it has been argued that simple farms in the Classical period could be considered movable, and this has been an argument in favor of the theory of seasonal occupation of buildings (Pettegrew 2001, pp. 196–197; contra: Foxhall 2001). Specialized rooms within farm buildings were known by epigraphy; at Delos, Rheneia, and Mykonos, inventories of the properties of Apollo in the third century BCE mention barns (*achurôn*), stalls for working oxen (*boustasis*), sheep pens (*probatôn*), granaries (*sitobolôn*), cellars (*pithôn*), mills (*mônôn*), bakehouses (*ipnôn*), and also living quarters (Pernin 2014, pp. 173–261). All this fulfilled three main functions: the housing of men and animals, the storage of crops, and the production of goods. Around the central core were secondary features such as threshing floors, pens for pigs and other livestock, and a vegetable garden. The differences between farm buildings and the urban houses are therefore not as clear as we would be tempted to think, especially as many townhouses, such as those at Olynthos, had equipment that suggest agricultural processing, such as the manufacture of oil, was carried out there (Cahill 2002, pp. 238–248; Hellmann 2010, pp. 139–143). This implies that cities could serve as a production and habitation center for the farm. In addition, farmhouses and townhouses were often organized around a courtyard, though unlike the townhouse, the farmhouse was not limited to the built surface nor framed by spaces dedicated to public traffic. The spatial management of social relations on these farmhouses is, however, poorly understood. The inventories of Delos mention rooms intended for the housing of slaves that were distinguished from other rooms of residence. There must have been some systems in place to distinguish these, but nothing to identify them has come up during excavation. It has been noted, however, that some farm towers had grilles that locked from the outside. Hence, the hypothesis that they were used to lock up slaves (Morris and Papadopoulos 2005). The central court also appears as the setting for much of everyday life. Work happened there (in the house from Dema, the equipment for grinding the grain was there), food was prepared, and eating as a family happened there ([D.] 47, *Against Evergus and Mnesibulus*, 55).

Agriculture in Context: Socioeconomic Aspects

Studies have often stressed that in Greece agricultural activity and land, in general, were intimately linked to the Classical city, and as a result have explored these connections (Hanson 1999; Morris 2000). So far, the debate has focused on the nature of a group of average landowners that we can call the *mesoi*, who worked their land themselves (the Greeks said they were *autourgoi*) from the eighth down through the fourth century. During this period, these same men assumed the role of defenders of the city as hoplites and, as citizens, they were the pillars of the polis (most recently: Duplouy 2018). All this was the basis of what Morris called the middling ideology of the city. The emergence of this group in the Archaic Period has been described as the "Greek agrarian revolution" (Hanson 1999, p. 87; contra: Howe 2008, pp. 33–38). In the Hellenistic period, though, these *mesoi* seem to fade in importance with the rise of a class of more powerful landowners. The archaeological surveys seem to support these two great movements in the social history of agriculture: everywhere rural sites were numerous in the Classical period and often still at the beginning of the Hellenistic period, but then many disappear and those which remain tend to increase in size. Here, we see the weakening of small and medium farms in favor of large estates; hence, the forcefulness of the claims for a division of land in the Hellenistic period. The inscriptions, nourishing a continuous stream of studies on the elites and their public behavior, only reinforce the impression of a Hellenistic city where the figure of the *autourgos* has disappeared. This debate, very fierce around 2000, quickly calmed down for lack of new data (assessment in Foxhall 2007, pp. 28–35). It is important to recognize, however, that this debate rests on an evolutionary scheme of the Greek city which wanted to see in the Classical period the "golden age" of the city and in the Hellenistic period that of its decline (see Hanson 1999, pp. 323–433; Howe 2008, pp. 33–38). However, in many areas, this type of decline and fall scheme seems outdated, especially for the Classical and Hellenistic city. That the decline of the Greek city was a myth which we have inherited from the Greeks themselves, a myth that does not accommodate the archaeological evidence from the post-classical polis (Howe 2008, pp. 1–24). All of this suggests we use caution when deploying a social approach to the history of Greek agriculture (Fantasia 2003, p. 143; Howe 2008, p. 25).

On this sociopolitical aspect of agrarian history, we will content ourselves with a few remarks. One is about the fundamental structure of the *oikos* (household). The household was based on the marriage of its male leader and thus on a couple who was the center; it includes both men and women (the *sômata*), landed resources from which they derive their sustenance (the *kleros*), and the house (*oikia*) in which they live; it also incorporates a network of relatives (*syngeneis*) and friends (*philoi*) that can be relied upon in times of need (McDowell 1989; Foxhall 1989; Davies 1992, pp. 288–292; Cox 1998, pp. 130–167; Roy 1999b; Oulhen 2004, pp. 292–293; Saller 2007; Damet 2012, pp. 33–37). The concept of the *oikos*, well present from the beginning of the Archaic Period, was still found in the texts of the second century CE. The household, then, was a sociopolitical constant and thus not unique to rural society. There are identical socioeconomic structures, like the *oustal* of southern France, which can be considered to have characterized Mediterranean Europe for a long time. At the same time, family and the physical house have a strong lineage dimension (Le Roy Ladurie 1975, pp. 51–87). An anthropological study of this type of structure would undoubtedly contribute a lot to our understanding of the Greek agrarian society but remains to be undertaken. And yet, the *oikos* has shaped the nature of the Greek farm. Indeed, the *oikos* was how Xenophon understood it: the *Oeconomincus* (1.5) begins with the question "What do we mean by the *oikos*?" Management of the work force and harvests were practical issues of *oikonomia* (*oikos* management). This has concrete implications for exploitation strategies because it is necessary to take into account the size of the family, its access to tools, the land that it can dispose of, the rights of use that it can benefit from, and its relations with the markets. The *oikos* was also a dynamic structure, not only because of the biological evolution of families and their networks of relationships, but also because of the rules of the transmission of goods, the existence of a land market, and the possibility of renting land. Thus, each *oikos* was constantly evolving. A farm must therefore be analyzed more as an *oikos* than as a *kleros* (a parcel/plot of land). *Kleroi* are the political means of organizing *oikoi*. The management of an *oikos* also has a symbolic dimension: the goods that compose it are also marks of status. This was visible for livestock (Howe 2008, 2011, 2014a). It has been found in the study of sacred leases that tenants could also be motivated by the desire to help the community to which they belonged (Papazarkadas 2011, pp. 150–155, pp. 204–206).

Second, agrarian society was a juxtaposition of *oikoi*, as Aristotle says (*Pol.* 1.2.1-10.1252a24–1253a5), and allowed for other socioeconomic behaviors that put strain on agricultural practices. The ancient texts stress the search for self-sufficiency (*autarkeia*), which underscored the overall capacity of producers to generate surpluses and put them on the market (Bresson 2016, pp. 199–203). To this, we can add other observations. The most striking is the weakness of collective practices. There is not a single mention of a common flock, which might have been a solution to the problem of wandering animals. There are also no signs of efforts to coordinate community-wide crop rotation. Biennial rotation has always worked only within the main production unit. Greek agriculture was an agriculture of "everyone at home." There is at best only a mention of public spaces that every citizen could access. The clearest case is that of the borderlands, which were difficult to use for agriculture. And they were restricted to citizen use. If a foreigner wanted to have access to a particular area of borderland, he had to receive a grant of pasturage (*epinomia*). If this were granted, the foreigner could, as a citizen did, graze his flocks there (Figure 14.5). The right to harvest wood, *epixylia*, was more rarely attested, and was never allowed on private property. There was no granting of rights like those we know later in Europe, which allowed everyone to harvest grains that had been overlooked by the owner or which opened the harvested lands to herds of cattle and other animals. This individualism in Greece does not mean the absence of a collective life, because it still existed in the context of village (*kôme*)

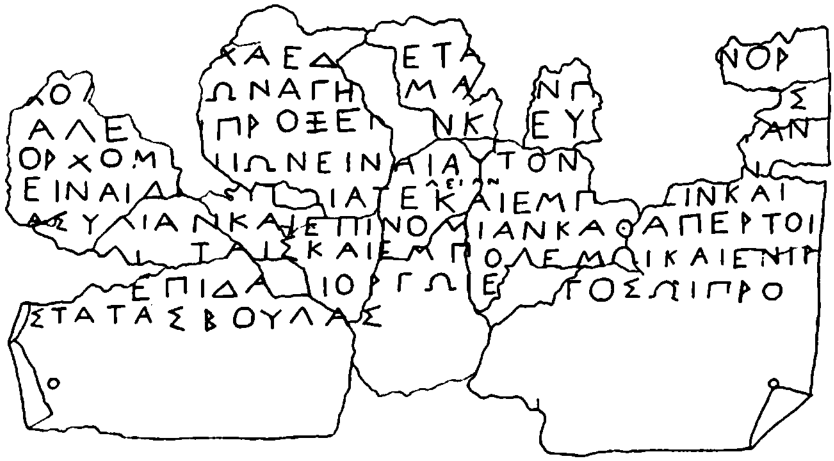


Figure 14.5 Proxeny decree of Orchomenos (Arcadia) for Agesimachos, citizen of the neighboring city of Alea with grant of pasture rights (*epinomia*). Such grants were frequent in certain parts of Greece (Arcadia, Laconia, Argolis, Thessaly …) and show that access to public pasture land was there considered as normal as was the right to own farmland (*ges enktesis*) everywhere in Greece. A few proxeny decrees, in Arcadia, also grant a right to cut timber (*epixylia*). Source: Plassart and Blum (1914). Reproduced from the National Museum, Athens.

and neighborhood relations. In the *Against Evergos and Mnesiboulos* ([Dem.] 60), when vindictive creditors attacked the inhabitants of a farm, we see the servants of neighboring homes ascend to their roofs to learn about what was happening and to help. This was all the easier as the scene takes place in a suburban area of Athens, where the countryside was already very dense, but nevertheless cultivated. This same reflex of mutual aid can be seen in the Cyclades, at the time when piracy was at its height – the first century BCE. While a squadron was preparing to attack isolated farms, the owners tried to warn each other, going from island to island (Bielman 1994, pp. 184–186). This reminds us of Hesiod's verse: "a bad neighbor is a woe, just as much as a good one is a great boon" (*Op.,* 346). There must have been frequent sharing of tools, as there must also have been quarrels between neighbors and the fear of encroachment ([D.] 55, *Against Callicles,* 12; 24).

As an economic unit, the farm was called a *chôrion* or an *agros* in Greek (Pritchett 1956, p. 262, pp. 268–269). Its structure remains largely unknown. It is impossible to say whether a farm was a single unit or collection of dispersed plots, which seems most likely (on this issue, Foxhall 2007, pp. 56–58). The *Attic Stelai,* a register of the auction of confiscated property from those convicted of the sacrileges of 415 BCE, reports that Euphiletos, son of Timotheos of Kydathenaion, possessed not only two houses in town (one in Semachidai, which sold for 105 dr. and another not located, which sold for the great sum of 1500 dr.), but also a plot of land with house and garden in Myrrhinous (sold for 205 dr.), another plot of land in Gargettos (sold for 105 dr.), and a third plot in Aphidna (sold for only 5 dr.). Adeimantos of Skambonidai had one parcel in Attica and another in Thasos, where the famous Thasian wine was produced (Pritchett 1956, pp. 270–271). In the leases of Thespiai or the accounts of the *hieros* of Delos, in the third century BCE, we see that some of the land leased was taken by people who were already owners and farmers (Pernin 2014, pp. 140–141, pp. 230–231). This is also apparent from the Athenian inscriptions (Papazarkadas 2011, pp. 299–325, Pernin 2014, pp. 515–518). In Mylasa, at the end of the second century BCE, a certain Thraseas exploited at least three distinct agricultural domains scattered across the plain. These were certainly different parcels because each one had its own buildings and tools. Thraseas' property was built up by inheritance, purchases, and even by leases; he has also become a tenant of sacred property (Pernin 2014, p. 442). The case of Thraseas is interesting and makes it possible to understand one point: the property of an individual did not automatically translate into the size of his farm because the same person could be the owner of several farms, according to a scheme which seems current among the elites and later more widely in the Hellenistic period. The Roman conquest will push this evolution to its end, allowing the accumulation of farms not only in several different cities, but sometimes even in several different provinces.

In terms of farm size, we have data only for some cities of the Classical period, most importantly Athens (Foxhall 1992). The figures concern nonstandard properties (Lohmann 1993, pp. 224–226; Foxhall 2007, pp. 57–58; Bresson 2016, pp. 142–149). A member of the Athenian elite of the early fourth century, Aristophanes son of Nicophemos, had more than 300 *plethra* of land (27 ha., Lys. 19, *On the Property of Aristophanes*, 29), and his holding was about the same size as Plato attributed to Alcibiades' property (Pl. *Alc.* 1.123c). Another large farm, that of Phainippos in 330 BCE, was more than 40 *stadia* when it was measured, according to the speaker ([D.], 42, *Against Phaenippus*, 5), which has sparked divergent interpretations. Most likely, the farm was about 40 hectares (Bresson 2016, pp. 146–149). The large Athenian properties therefore had areas that were measured in hundreds of *plethra*. This is far beyond what Alison Burford Cooper called the family farm, where the members of the hoplite class must be located. Here, we are dealing with only tens of *plethra*, probably between 40 and 60 (3.5 to 5.5 hectares, Burford Cooper 1977–1978, pp. 168–170). This was also the dimension of *kleroi* often attributed to new citizens. Below this size, there existed a category of micro-properties that allowed their owners to live off the land, but at the cost of significant risks, requiring strategies for the maximum exploitation of available resources. The hierarchy that emerges consists of three main tiers: (1) the fragile peasants, the *thetes*; (2) the well-off peasants, equivalents of the laborers of modern Europe; and (3) those at the top, an elite whose farms were managed very differently. The way everyone prepared their land for seed was a visible measure of their wealth and status. The poorest used a *dikella*, a digging stick, the emblem of the precarious peasantry (Amouretti 1986, p. 96); owning an ard and a *zeugos* – a yoke for the oxen – showed a certain wealth (hence the mention of social categories with a name derived from *zeugos*, like the Athenian *zeugitae*; hence also part of the symbolic valuation of the oxen plowing: Van Wees 2006, pp. 352–367). The great landowners must have owned several ards and teams of livestock and could afford the luxury of having both mules and oxen.

This hierarchy of properties was not universal and timeless, however. In classical Sparta, the Equals, the *homoioi*, have properties from 18.5 to 44.5 ha, (Hodkinson 2000, pp. 382–385), which was much larger than the property of an Athenian hoplite. In the Hellenistic period, we see very large properties well beyond those found in Classical cities (Bresson 2016, pp. 149–152). Relatives of kings were entrusted with large estates in return for their services. In Chalkidiki, Lysimachus granted to a certain Limnaios several areas planted with trees: 1200 *plethra* on the territory of Sermylia, 360 on that of Olynthos, and 900 on that of Strepsa (plus 20 *plethra* of vines). This suggests farmland under monocultures of 223, 32, and 108 ha (Hatzopoulos 1988). Another example, Aristodikides of Assos, received 6000 *plethra* (540 ha) from Antiochos I in 270 BCE (Welles, No. 10–13). Here, an important barrier had been crossed, that of the thousand *plethra*, but in particular conditions since it deals with *dôreai*, that is to say, with portions of royal land granted to members of the ruling elites close to sovereigns (Schuler 1998, pp. 179–180). Such grants upset the equilibrium of land in cities because in general these properties were then attached to the territory of a city.

Whatever one does, the sources, when one wishes them to be precise, always return to the great estates, those for which the agrarian *oikos* has become an *agribusiness*. The modes of management that were practiced on such estates were very different from those used by the less wealthy farmers. A major feature of these large estates was the delegation of decision-making power by the owner, the *despotes ges*. The oldest traces of this system date back to the fifth century BCE. Labor was then specialized and hierarchical under the supervision of a steward, usually of servile status (overseers/*epitropos* or *epistates* in Greek). This steward serves as an intermediary between land workers and landlord. The latter may be content to exercise his authority by examining the accounts presented to him by the manager. Pericles had obviously adopted a method of this kind, it has been considered something of a "household revolution" (Descat 1998, pp. 105–106, who speaks of an "oikonomic" revolution). Some owners, obviously in the minority, took a closer interest in their land and agricultural production. Xenophon, or at least his literary character Ischomachos, was the most emblematic figure of this group of *philogeorgoi*: one of the goals of the *Oeconomicus* was to urge the reader to become more involved in the exploitation of the land. The system of delegation could be made more complex to meet the needs of those who owned several parcels: it was enough to rely on businessmen, also often slaves, who were the interlocutors of domain managers. This usage, well attested for the Imperial Roman period, was already in place in the Classical period (for Pericles, it was a certain Evangelos: Plut. *Per.* 16.6; there is also the case of Arrhidaios, in the service of Queen Laodice II, in the middle of the third century BCE: Welles, no. 18-20). Managers used complex accounting techniques. All this was understandable only in the context of an exploitation intended to release surpluses, those which allowed in particular the maintenance of the Hellenistic elites. This was obviously not the method followed by all, and it obscured the existence of small farms oriented toward household food production. Although this elite production concerns only part of the agricultural sector, it does demonstrate that Greek agriculture could be based on complex structures (Morris and Papadopoulos 2005, p. 167, p. 180: "The scrutiny of the specifics of different farming strategies further recasts the classical Greek countryside as an arena of aggressive exploitation rather than sufficiency…"). Perhaps it is in this area that the most innovative and, in fact, one of the most essential drivers of economic growth can be found – though we must keep in mind that we are used to seeing agriculture as routine and perceiving it as an almost proto-economic activity. And yet, as many elements demonstrate, agriculture was an integral part of the economy. For example, the need to supply markets led to the intensification of agriculture in many peri-urban areas. In Delos, in the third century BCE, this resulted in a ring of market gardens (Bruneau 2006, pp. 470–489). Above all, some large farms were able to develop commercial crops and to create regions purposely devoted to the production of specialized goods (Thasian wine, Milesian wool, and the like) and thus precipitated the development of roads and redistribution of markets.

Large farms were primarily based on slave labor. It was a constant fact of the Classical and Hellenistic periods even if its magnitude was the subject of very lively discussions in the 1990s (Jameson 1977–1978; Jameson 1992; Cartledge 2002, pp. 163–164; Morris and Papadopoulos 2005, pp. 181–183). In Chios, for example, where as a center for the slave trade, this type of labor played a major role in the development of large farms in the late fifth century BCE; there, slaves were quick to desert (Thuc. 3.73, 8.40.2; Ath. 6.265b–6.266f; see Jameson 1992, pp. 139–140). It must be remembered that at this same time Chios was famous for its wine which it exported extensively. A similar connection between commercial viticulture and the role of the servile population can also found in Thasos in 374 BCE (Xen. *Hell.* 6.2.6). The *ampelourgoi*, the workers of the vines, are also one of the categories of specialized slaves which evidence regularly mentions. In this respect, the Hellenistic period has brought little systemic change. On the other hand, the question arises about the place of slaves in medium-sized farms. In the *Dyskolos* (328–331), Menander presents a fairly rich proprietor, a certain Knemôn, who wants to cultivate his land alone, without a slave, without a salaried worker (*misthôtos*), and even without the help of his neighbors. This was obviously a miscalculation, and Knemôn ends up realizing that one always needs help (713–714). Salaried work was a possible alternative to slaves and offered greater flexibility (Jameson 1992, pp. 143–144). It is partly for this reason that there were agricultural workers among the metics, as shown by the professions of some of those who fought alongside the Athenian democrats in 404–403 BCE (Rhodes and Osborne, No. 4; many metics are gardeners or hired land-workers, *georgoi*). Metics could also rent farms or acquire them if they had received the *enktêsis*, but the phenomenon does not seem to have been widespread (Papazarkadas 2011, pp. 323–325, about the sacred lands).

Entire regions in the Classical period operated according to another system, working the land with those considered to be subordinate and semi-servile. This is the case of the Helots of Sparta, the dependents of the Cretan cities, the Thessalian Penestes, the Gergiths of Miletus (Hodkinson 2000, pp. 113–149, for Sparta; Ducat 1996, for the Penestes). The payment of an agrarian rent (*apophora, syntaxis*) to the owner makes this system a form of sharecropping. In Hellenistic times, this formula disappears with the integration of these populations into the civic body (Cartledge and Spawforth 2002, p. 56, pp. 69–71). In contrast, the cities of Asia Minor included a rural population still largely non-Greek. The rural toponyms in the leases of Mylasa testify to the vigor of the old Carian ethnicity (e.g. Pernin, pp. 144–152). Should we juxtapose semi-Hellenized farms with owners living in the city and Hellenized ones? Probably not: in Mylasa, even the sanctuaries that buy and rent properties are largely identified as Carian. In the lower Maeander Valley, wet pastures were exploited by a population of *Pedieis*, apparently nomadic pastoralists who coexisted with a Hellenized population cultivating the hillsides and dry areas (Thonemann 2011, pp. 14–16). In other cities, the sources mention free agricultural populations, owners of the property that they exploit, but not holders of the citizenship of the city, in this case Colophon (Étienne and Migeotte 1998, with the *enektêmenoi*).

The Polis and Agriculture

Organization into *poleis* has strongly framed the development of agropastoral activities. In Classical Greece one had to belong to a *politeia*, that is, to be a polis citizen, in order to be a landowner. This right of *enktêsis* directed certain socio-legal groups toward, or diverted them from, these activities. The praise of husbandry was a frequent literary theme and highlighted how much this activity helped to build good citizens (Howe 2014b). A famous passage of Xenophon on this subject is often quoted (*Oec.*, 5.1–5.11). Agricultural products occupy a prominent place in the oath of the Athenian ephebes (Rhodes and Osborne, No. 88). The role assigned to the earth in the ideal cities of philosophers goes in the same direction. But we must not be deceived either: during the Archaic and Classical periods, the land was largely a good like the others; it was sold, bought, and rented. A passage from a speech of Lysias demonstrates this well (7, *The Matter of the Olive-Stump*, 4–10). In practice, the existence of many *poleis* in much of Greece has also largely determined the movement of livestock. Where the city was the norm, it was difficult to organize large-scale transhumance like that set up in Republican Italy. The animals moved, but only inside the territory of the city. The agreements organizing their circulation concerned only neighboring cities, which wanted to regulate the cohabitation of pastoralists in the border areas that separated them. The case of Hierapytna, in Crete, was very exceptional: this city seems to have pioneered the

Hellenistic era policy of favoring the access of its pastoralists to grazing located throughout the eastern part of the island (Chaniotis, 1995).

The Greek city also affected agriculture by the tax levies it imposed. On this point, the conversation has evolved a great deal since the time of A. Boeckh, when Athenian examples were used to reject the idea that the land and its products could have been the object of a taxation which was considered characteristic of tyrannical regimes (for example, under the Pisistratids: [Arist.] *Ath. Pol.* 16.4) or Hellenistic monarchies, unless they affected dependent peasant communities such as the Messenians (Paus., 4.14.4–4.14.5; Migeotte 2014, pp. 229–244, pp. 504–507). This dynamic has been challenged recently (Pernin 2007). If it remains valid for the Athenians of the Classical period, it is because Athens could afford the luxury of non-taxation, thanks to the income that it possessed, particularly that derived from its silver mines. It should be noted, however, that the Athenian *eisphora*, instituted in 427 BCE and imposed in exceptional but all too frequent intervals, was indeed a property tax, since the agricultural lands were entered in the declaration of the goods (*timema*) of the citizens. Moreover, Athens did not hesitate to create a tax on cereal production from its north-Aegean *klerouchia* (Stroud 1998). In places other than Athens, epigraphy reports multiple instances of regular taxes paid by the citizens on agricultural production in independent cities and thus not subject to the royal taxes. An inscription of Teos from the end of the fourth century BCE, on the occasion of the incorporation of a small neighboring settlement, gives a sense of the experience, taxing working oxen (which can also be requisitioned), sheep, and pigs, and even products of the forest. This list faithfully reflects the resources of the mountainous region in which the taxes were imposed (Robert 1976). A list of tax farmers from Cos, in the Hellenistic period, also mentions the levying of taxes collected from wine produced at Kalymnos, from gardens, and from wool (*Syll.*[3] 1000). The tax farmers (*telônai*), who generally had a rather bad reputation, did not hesitate to levy taxes on the rural population (Etienne and Migeotte 1998). The weight of these civic taxes would be added to those demanded by kings on the subject cities. Examples of agrarian taxation show that the preferred solution was to tax production rather than land. For livestock, on the other hand, it was easier to collect taxes on the animals themselves. Finally, it seems that the practice of agrarian taxation was more frequent in Asia Minor, which could be explained in part by the antiquity of the practice, as it goes back to the Achaemenid monarchy. The balance of all this, however, is a very different image from what we have for European peasantries of the Middle Ages and modern times, which were subject to heavy taxation. The same was not true of Greek agriculture, which was able to develop without too many fiscal burdens being imposed on it.

Another aspect of civic intervention in agriculture concerns crisis management. Disasters were a reality in ancient Greece, caused first and foremost by climatic hazards: abundant rains (and therefore devastating floods), late frosts, or excessive drought. These crises generated a recurring risk of poor harvest (*aphoria*). Athens even had bad olive years. Around 170 BCE, an Athenian decree shows that the city was forced to import oil for the needs of its population (*Syll.*[3] 640). Plutarch relates that during the winter of 307 BCE, at the time of the Dionysia, very strong and unexpected frosts destroyed the olive crop and the fig trees and compromised the entire grain harvest (Plut. *Demet.,* 12.5–12.7). Faced with these risks, religion offered some help. Here, it is necessary to comment on the agrarian dimension of Greek religion. A sacrificial tariff from Mycalian Thebes in Ionia demonstrates how mountain pastoralists honored deities from their herds' productions in the fourth century BCE (*IvPriene* No. 362). In the Hellenistic period, several new religious holidays incorporate a dimension of this kind. When Magnesia on the Maeander organized the festival of Zeus Sosipolis ("who saves the city"), it was decided that the bull to be sacrificed would be consecrated by the city at the time of sowing and that all would then say a prayer for the success of the crops and the prosperity of the flocks (*Syll.*[3] 589). A festival in the same tone was organized in 120 BCE by the city of Bargylia in honor of Artemis Kindyas (*SEG* 45, 1508).

War was the other great cause of crisis. From the beginning of Greek history, raiding was necessary to feed armies while on campaign. Beginningss with the Peloponnesian War, this was expanded to the destruction of crops in order to harm the enemy more directly, although the method was too complex to implement on a large scale (Hanson 1983). This practice continues in the fourth century and the Hellenistic period. The flight of part of the slaves working on the farms, as well as the loss of seeds and plow oxen, often aggravated the situation. In addition to these perennial threats, the cities of Asia Minor long had to face the raids of the Galatians after their invasion of 278 BCE. The risks associated with war have sometimes been taken into account in agricultural leases where the payment of rent is suspended or the period before the end of the lease is extended (Pernin 2014, pp. 519–521). Eretria's contract with Chairephanes (see above) includes the possibility that a war might prevent the beneficiary from exploiting his land. It is granted to him that he will be able to extend the ten years of use which has been granted to him. Strabo also says (9.2.18 = C407) that the disorders in Boeotia that marked the aftermath of Alexander's death explain why the Chalcidian Crates could not complete his infrastructure work. And yet, cities and kings tried to take measures to protect the crops. From the fourth century BCE onward, protecting the crops was integrated into the policies for protection of the territory (*phylakê tês chôras*). Not only are all the things that can be transported placed out of reach of the enemy (see Athens at the beginning of the Peloponnesian War, Thuc. 2.14), but the cities also developed their network of rural fortresses so that the farming population could find refuge. They also put some of their armed forces in the service of crop protection (Ober 1985; Boulay 2014, pp. 56–73). The city of Cyzicus during the decade of 270–260 thus invested part of the money given by the dynast Philetairos of Pergamon into securing the *chôra* against the Galatian invasion (*OGIS* 748). By this time, however, management of food crises (*spanositiai, sitodeiai*) by the cities no longer directly concerned agriculture, since the solution adopted at that time was to try to improve the external supplies of cereals and to distribute them to the urban population.

The Dynamics of Agriculture

The image of a routine and immutable system of farming is without doubt one of the most difficult ideas to get rid of. Yet the picture of Greek agriculture toward the end of the first century differs from that which might be common in the beginning of the fifth century. The two images offered at the beginning of this chapter, the Attic one from the fourth century and the other from Hellenistic southeastern Asia Minor, are misleading in that these were peak moments in settlement density, something that did not happen at the same time in both regions. In the latter Hellenistic period, when the lower valley of the Maeander was flourishing, Attica was in a process of decline. We know this through archaeological surveys, which made it possible to set up a periodization for the history of the countryside and also to tease out differences from one region to another. This work has compelled us to take account of the changes that affected Greek agriculture and also to question the idea of historical progress and linear development.

Survey methods originated in the 1960s and began to be applied in Greece in the 1970s and 1980s. After that, archaeological survey became commonplace everywhere in Greece, though used to a lesser extent in Asia Minor. Since the mid-2000s, the interest in survey has decreased, although it is still often deployed. Some initial conclusions were drawn 25 years ago by Susan Alcock in a landmark book (Alcock 1993, pp. 33–92). There, Alcock found that the published surveys reflected the same evolutionary arc: at the end of the Archaic Period, the number of rural sites had grown gradually and then accelerated in the sixth century, while in the Classical era sites appeared everywhere, suggesting an age of settled countryside, with a defined hierarchy of rural sites. The most numerous of these were of rather modest size and were interpreted as hoplite farms, the larger sites in turn corresponding to estates or villages. In addition, land near cities appears to have been heavily farmed. The scattering of a patch of sherds on farmland was seen as evidence for manure fertilizer from the inhabited centers. Regionally in the second half of the fourth century, and then more generally in the course of the third century, Alcock saw a decline in settlement: small sites disappeared, and only a few rural centers survived. This decline was to last until late antiquity across the Argolis, Boeotia, and Attica. At the same time, as observed by Bintliff (2008, p. 23, p. 28), the urban centers of these regions experienced a significant retraction, a sign that the population seemed to be disappearing from the countryside but also had not retreated to the cities. The explanations given for these phenomena were diverse: overexploitation of the environment and impoverishment of soils, and cities being more and more dominated by a narrow elite. It is difficult to translate these archaeological findings of a decline in the number of rural sites into economic history, but it is tempting to see the signs of the triumph of large estates.

Since Alcock's study, new surveys have qualified its synthesis (review in Bintliff 2008). First, in the same regions, cities do not always suffer the same fate. In Boeotia, for example, the Tanagran countryside seems to have been less affected than the other cities by the decline of sites in the Hellenistic period. In the Oropos region, decline was only slight, and occupancy was still based around small sites that appear to be farms (Cosmopoulos 2001, pp. 57–60, pp. 74–79). Oropos, which for a long time was a frontier region disputed between Athens and Boeotia, seems to have been much better off than the south of Attica. There, difficulties become clear only in the first century, when many sites were abandoned. Yet, this Hellenistic "depression" was not ubiquitous. Laconia, which has been documented by thorough survey (Cavanagh et al. 2002), presents a very different situation. Here, we see a peak in development in the years 550–450 BCE, with the decline occurring in the middle of the fifth century. In contrast, the end of the Classical period marks a renewed interest in the countryside, especially in the northern part of the region, toward Sellasia, though this activity too decreases over time. It is therefore tempting to relate this to the vagaries of Spartan history, as Graham Shipley cautiously did (Cavanagh et al. 2002, pp. 257–337). More notable are the signs of a new economic geography of the Greek countryside. If Attica, Central Greece, a good part of the Peloponnese, and the Cyclades seem to enter an age of deserted countryside, some regions are experiencing the opposite trend. Achaia and Aetolia – Greece on the western peripheries – seem to have very dynamic countrysides during the third and second centuries BCE, as do the eastern shores of the Aegean Sea. The research carried out by H. Lohmann in the region of Miletus shows that the Hellenistic period was an age of settled countryside (Lohmann 2004, 2014). We see the same thing on Samos and Chios. This dynamism corresponds to what is believed to be a shift in the economic heart of Greece from the western shores to the eastern shores of the Aegean.

Another sign of change: agricultural knowledge enters the field of literature. The fourth century BCE sees the writing of the first agricultural treaties, although Hesiod, with *The Works and Days* and its agricultural calendar, can be considered a model and predecessor (Amouretti 1986, pp. 223–238). These agricultural treaties must be taken for what they are, i.e. not studies of agronomy per se. It would indeed be anachronistic to put this production on the same level as that which develops after the eighteenth century and which is then based in particular on a scientific revolution. Moreover, the Greek word *agronomos*, when used as Plato does in the *Laws*, designates a person in charge of the rural police. The other difficulty is that we have almost nothing left of this abundant technical literature, except the *Oeconomicus* of Xenophon or the echoes we find in Aristotle, Theophrastus, and Athenaeus, in the Latin treatises of agriculture (see the list of Greek predecessors given by Columella, *Rust.,* 1.1.7–1.1.11), or in the Byzantine *Geoponica* (see discussion in Chapter 30 of this volume). Yet these are enough to show that from the fourth century BCE, sometimes very specialized works had been written such as those of Charetides of Paros or Apollodoros of Lemnos (Arist. *Pol.* 1.1258b40–1258a1) or Androtion, who had written on arboriculture (Thphr. *HP* 2.7.2–3; *CP* 3.10.4). The Athenian Euphronios and a certain Kommiades were interested in viticulture (Boulay, 2012, p. 96). This production had not slowed down in the Hellenistic period–on the contrary, even King Attalus III of Pergamum was recognized as an author to be read on these questions (Varro *Rust.* 1.1.10; Plin. *HN* 18.22; Columella *Rust.* 1.1.8). Agricultural science also participated in the wider intellectual dialogue. When Aristotle was able to describe the development of the chick in the egg (Arist. *HA* 6.3.561a6–562b) or Theophrastus the effects of rainfall on crops (*CP* 2.2), both reflect the integration of agricultural knowledge into botany, zoology, medicine, even philosophy. On the other hand, it seems that the agricultural treatises tried to describe agricultural practices and to encourage the ones that seem the best – for example, the advice about planting. The intended readership was the big landowners, from whom we sometimes see a real curiosity for experimentation (we see it, but outside our geographical space, in the archives of the nome of Apollonios in Egypt in the third century BCE: Clarysse and Vandorpe 1995). Of course, all of this was already noticeable in Xenophon (Kanelopoulos 1998). The practical dimension of these texts is undeniable even if they could also be the subject of scholarly or recreational readings.

Evolution of practice was also reflected by the exploitation of new plant and animal species that complement those that the Greeks had inherited from the Archaic Period. In this area, change was slow but steady in the long term, experiencing some acceleration from the conquests of Alexander. At that time, new trees such as hazel, cherry, peach, and apricot appear. The first citrus fruit (*Citrus medica L.),* also comes from the East (Amigues 2005). In gardens, melon and cucumber were seen as novelties. For previously known crops, the change was reflected in the multiplication of cultivars. Between Theophrastus and Pliny, for example, varieties of olive trees and grapes have greatly increased. These and other changes profoundly altered the diet of the Greeks. The breeding of hens spread from the middle of the Classical period, while the goose was until then the poultry par excellence. Another animal made its appearance in the Hellenistic period, without it being possible to understand the reasons for its expansion in Asia Minor (but not in Greece): the zebu (*Bos taurus indicus*), the ox with hump that comes from the East (Figure 14.6). But in animal husbandry, the most apparent sign of change was the continued growth in the size of some domestic animals such as cattle, as archaeozoology shows (Kron 2014). This was achieved through hybridization and improved breeding techniques and was part of a general trend toward the development of agricultural techniques that was first highlighted for processing equipment (grinders and mills; see Amouretti 1986, pp. 140–147, pp. 162–175) but which appeared also in efforts to improve the biennial crop rotation, notably by exploiting fallow by growing legumes. In winegrowing, we see the diffusion of new practices that testify to the progress of the empirical knowledge of winemaking processes. The appearance in the course of the Hellenistic period of the fashion for *thetalattomenoi* wines, that is to say the "sea water" wines, is a well-known phenomenon (Ath., 1.32d–1.32e), affecting a particular area of the Greek world, the southeastern Aegean (e.g. Cnidus, Halicarnassus, Myndos). This practice consisted of adding salt

Figure 14.6 Detail of the so-called Archelaos of Priene relief showing a humped ox (zebu) being prepared for a sacrifice to Homer, second century BCE. This Hellenistic work has been discovered in Italy, but the artist who created it was from a city in the Maeander valley. Zebus were progressively replacing normal cattle in this part of Asia Minor during the Hellenistic times. Coins from Magnesia on the Maeander regularly depict a humped ox, clear evidence that the Archelaos relief was designed in the native land of the sculptor, and not in Italy, where the zebu remained always unknown during Antiquity. British Museum, photo of the author. Source: Courtesy of the British Museum.

during winemaking, which prevented the proliferation of bacteria. To stabilize the wine, heated gypsum was also added (Boulay 2012, pp. 103–105). These practices have proven effective, and while all this certainly does not make an "agricultural revolution," it definitely removes the image of a routine activity and unchanging attitudes.

Conclusion

To see agriculture as an area where only routine practices prevailed misses the economic dimension. If we extend the perspective to include the Archaic and Imperial Roman periods, the impression of constant evolution is even clearer. Over time, we see a process that has resulted in the diversification of crops and agricultural practices, the conquest of landscapes, the integration of the countryside into the world of trade, and the development of large farms managed in a complex and efficient way. In this way, Greek *poleis* have been able to feed men by combining production and commerce. Obviously, these gains have not always been sustainable; the slow depression into which the countryside of much of Greece sinks in the Hellenistic era, which Imperial Rome will try to stop, shows that nothing was ever static. To put it another way, the Greek countryside has a history. Here again, surveys have served us well and deserve the historian's attention. Archaeological survey should be integrated into the questions of historiography – their role in the history of war has been especially fruitful. In sum, it is time to give the countryside a place in the history of Greek economics and religion.

ABBREVIATIONS

Syll.[3]	= Dittenberger, Wilhelm, et al. 1915–1924. *Sylloge inscriptionum Graecarum,* 3rd ed., Leipzig.
OGIS	= Dittenberger, Wilhelm. 1903–1905. *Orientis graeci inscriptiones selectae*, Leipzig.
Rhodes and Osborne	= Rhodes, Peter J. and Osborne, Robin. 2003. *Greek Historical Inscriptions. 404–323 B.C.*, Oxford.
SEG	= *Supplementum Epigraphicum Graecum.* 1923. Leiden/Amsterdam: Gieben/Brill.
Welles	= Welles, C. Bradford. 1934. *Royal Correspondence in the Hellenistic Period*, New Haven.

FURTHER READING

Two books can initiate the reader into the main conversations about ancient Greek agriculture. L. Foxhall (2007), about olive cultivation, is in fact a broad study about agriculture and a brilliant overview of 20 years of academic progress on this topic. In a very different way, N. Papazarkadas (2011) offers a systematic inquiry about a special class of inscriptions, land leases in Classical Athens. His conclusions are nonetheless important. Two shorter (and older) papers, Lohmann 1992 and Pritchett 1956, give a glimpse into survey archaeology and to rural life in Athens. Students and scholars must be aware that important work has been done and still is in other academic languages; therefore I recommend two books, one in French (Amouretti 1986, about grain and oil, as this book is a good example of anthropological approach of ancient agriculture) and the other in German (Schuler 1998, about Hellenistic Asia Minor).

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CHAPTER FIFTEEN

Agriculture in Magna Graecia (Iron Age to Hellenistic Period)

D. Alex Walthall

> Nous disons donc que la Sicile est une perle du siècle en fait d'excellence des productions, de fertilité du sol, d'agrément des villes et des habitations. Depuis les époques les plus anciennes, tous les voyageurs qui y sont venus du dehors et qui ont comparé entre elles…les mérites des diverses villes et capitales, se sont plu à vanter cette ile, à exalter…en général les avantages dont elle jouit.
>
> French translation from *Kitāb nuzhat al-mushtāq fī ikhtirāq al-āfāq* by Muhammad al-Idrisi (12th century), in Pierre-Amédée Jaubert, *La Géographie d'Edrisi. Traduit de l'Arabe d'après deux manuscrits de la bibliothèque du roi* (Paris: Imprimerie Royale, 1836)

Introduction

Magna Graecia has long been defined by its agriculture. Commentators from antiquity to the present day have meted no less praise for Sicily's fields of ripened wheat and Apulia's flocks of fleecy sheep than for the Classical temples of Paestum or the Norman palaces of Palermo. This chapter covers a period of roughly eight hundred years (c. 1000–200 BCE), beginning with the Greek Iron Age and ending with the Hellenistic Period. Given limits of space, much of the subsequent discussion focuses on the centuries following the arrival of permanent Greek settlers from mainland Greece in the eighth century BCE, arguably the most significant social, political, and cultural event to impact the region until the advent of Roman political domination at the end of the third century BCE. For this reason, the Hellenistic Period is defined here not by its traditional endpoint – the Battle of Actium – but by the fall of Syracuse to M. Claudius Marcellus in 212 BCE, the event that effectively ended the political autonomy of the region and heralded its absorption into Rome's overseas empire.

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

Region, Geography, and Climate

Today, we use the term "Magna Graecia" ("Greater Greece") to describe a region encompassing the island of Sicily and parts of southern Italy, which collectively witnessed major settlement from overseas Greeks between the eighth and sixth centuries BCE (Figures 15.1 and 15.2). While the Greek appellation *Megale Hellas* is attested as early as the sixth century BCE, no single definition emerged in antiquity (Lomas 1993, p. 7–12). In fact, it was not until the first-century *Geography* of Strabo (6.1.2) that the term was used explicitly to describe the region as we refer to it today. Although never politically unified in the eight centuries spanning the Iron Age and Hellenistic Period, the island of Sicily and the portion of southern Italy stretching south of the Cervaro River can be considered together as a regional unit, defined both by its geographic isolation from central Italy and by a shared cultural trajectory stemming from Greek colonization.

Mountains and hills dominate much of the region, leaving only about 15% of the territory to the low-lying coastal plain. The Apennine range forms a rugged barrier across the center of modern Campania, Basilicata, and Calabria (comprising ancient Campania, Lucania, and Bruttium), effectively cutting off southern Italy from the rest of the Italian peninsula. This is particularly true along the western coast, where the mountains run almost into the Tyrrhenian sea. Along the Ionian and Adriatic coasts, the rolling foothills of the Apennines gradually transition into high plateaus that eventually open onto coastal plains, the largest of which is found at the heel of Italy in Puglia between the Adriatic Sea and Tarentine Gulf. This plateau, the Tavoliere delle Puglie, extends over more than 3000 km^2 and is bounded to the north and south by the Fortore and Ofanto rivers. In Sicily, the Madonie, Nebrodi, and Peloritani

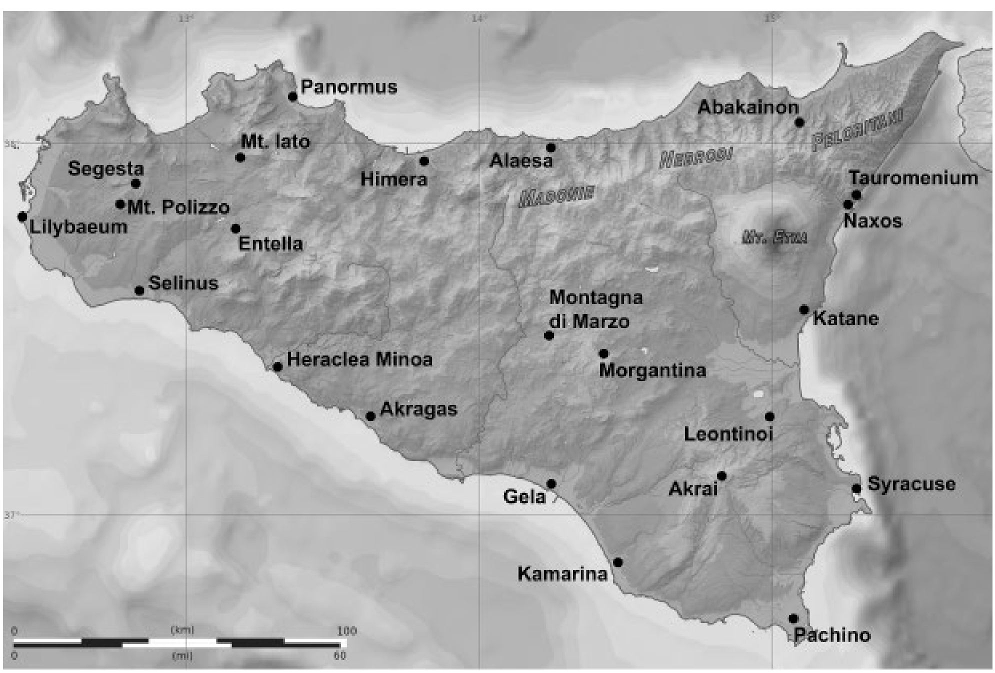

Figure 15.1 Map of Sicily, indicating the locations of important sites mentioned in the text. Source: From Semhur. Licensed under CC BY SA 3.0.

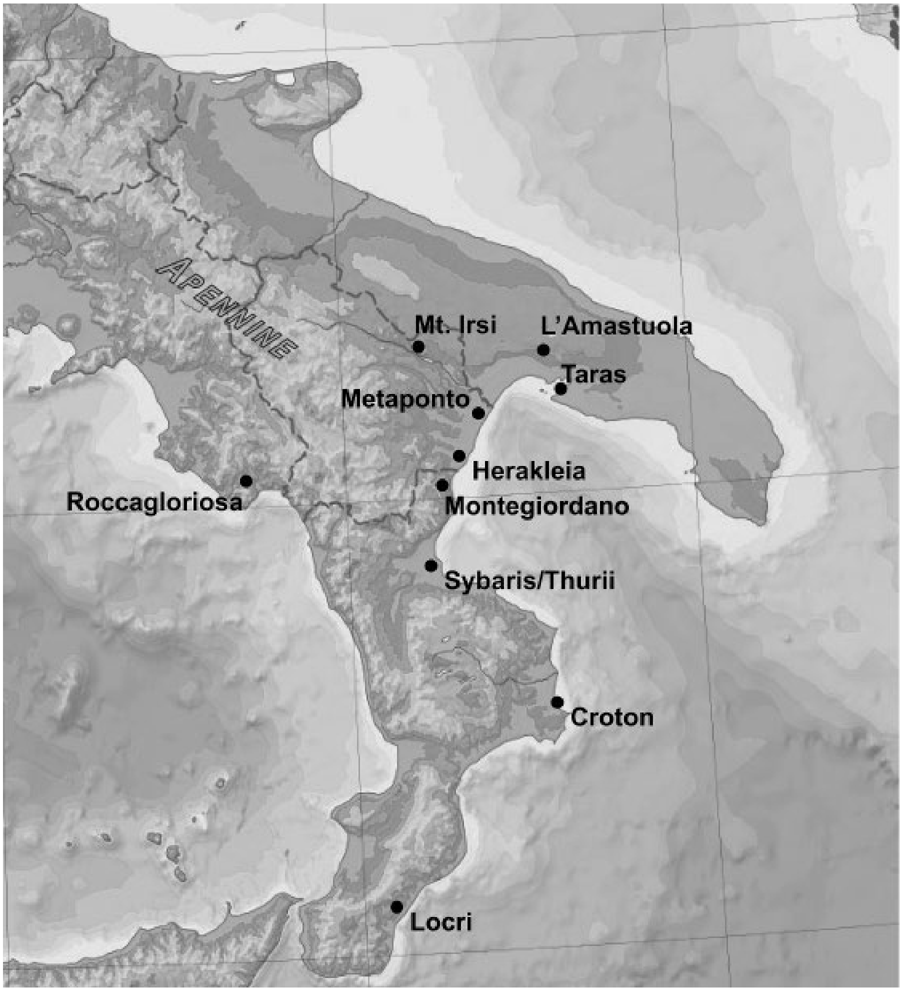

Figure 15.2 Map of southern Italy, indicating the locations of important sites mentioned in the text. Source: From Semhur. Licensed under CC BY SA 3.0.

mountains stretch across the island's northern coast. Much of the island's interior comprises a hilly upland zone extending from the Western Plateau in the modern province of Palermo down to the Hyblaean Hills in the province of Syracuse. As in southern Italy, open plains are largely limited to narrow bands along the coast. The principal exception to this is the expansive Catania Plain, which occupies some 430 km^2 between Mt. Etna and the Ragusan Plateau further south.

Geography played a significant role in determining settlement patterns and agricultural practices of the region. Indigenous Iron Age settlements are found both along the coastal plains and throughout inland zones, generally in defensible locations with ready access to fresh water and arable land. Given the rough inland topography of both southern Italy and Sicily, early Greek colonies were established along the coastline, taking advantage of sites with accessible harbors and fertile surrounding territories (Domínguez 2006). The limited availability of arable land along the coast resulted in the often violent displacement of established indigenous settlements, driving native communities to resettle in the rugged and mountainous interior (D'Agostino 1996, p. 536; de Juliis 1996, pp. 549–550; for an alternative interpretation, De Angelis 2016, pp. 44–45, pp. 53–55). Naturally, such limits to expansion also led to conflicts between Greek communities themselves, as in the 430s BCE when the residents of Taras went to war with neighboring Thurii over control of the fertile Siritis district lying between the two cities (Diod. Sic., 12.23.36).

Paleoclimate data suggest that the region's ancient climate was not dramatically different from that of the present day (Manning 2013, pp. 157–158), which is distinct from other portions of the Italian peninsula and more typical of the southern Mediterranean with its hot, dry summers and cool, wet winters (Spurr 1986, pp. 18–21). Temperatures vary across the region depending on location and elevation, with coastal areas experiencing warmer temperatures than inland zones throughout the year. On average, temperatures range from 9 °C to 11 °C in the winter and 22 °C to 26 °C in the summer months. Like most of the Mediterranean, the region can experience dramatic fluctuations in interannual rainfall; modern statistics register annual averages between 500 mm and 1000 mm. There is some evidence to suggest that between 800 and 300 BCE the western Mediterranean experienced a cooler and wetter period with more consistent annual rainfall than in the centuries before and after (Manning 2013, pp. 111–113; Sadori et al. 2013; De Angelis 2016, p. 227). Today, rainfall can be inconsistent across the region, and some areas receive more than double that of others. For instance, western Calabria is subject to more rainfall than areas east of the Apennines, which fall within the mountain range's rain shadow.

Rainfall today, as in antiquity, is largely restricted to the period between October and April, a fact that had a direct bearing on the agricultural calendar. Grains and legumes were sown in the autumn, shortly after the first rains of the season returned vital moisture to the soil. Abundant spring rains were to thank for Sicily's renowned fertility according to Theophrastus (*Hist. pl.* 8.6.6), who referred to the island as πολύσιτος, "rich in grain." Pliny the Elder (*HN* 18.12.20) noted that in Sicily one could find a variety of spring wheat which would ripen only two months after sowing; thus, crops sown in March could be harvested in early summer along with those planted the previous autumn. As in much of the southern Mediterranean region, harvest fell in May and June, when moderate temperatures and spring rains gave way to the long, hot summer.

With its diverse topography and temperate climate, the region was disposed to a mixture of animal husbandry and agricultural production. The coastal plains and river valleys were well suited for cereal production and were, at times, cultivated on an intensive scale. The more rugged uplands were better suited topographically to pastoralism and arboriculture, with grapevines dominating the lower hills and olive trees the higher elevations. The rich alluvial soils found across Magna Graecia provided a basis for the region's renowned fertility, even in low-lying areas which suffered from poor drainage (Bethemont and Pelletier 1983, pp. 185–186). Ancient authors, like Strabo (6.2.3–7), recognized the long-term value of volcanic activity for the soils around Etna, noting, for instance, the relationship between volcanic ash and the quality of vines cultivated in the territory of Catania. While the region today lacks extensive woodlands except in the more mountainous zones, ancient forests once covered significant portions of Sicily and southern Italy, judging from both literary sources (Diod. Sic., 4.84.1; Plin. *HN* 16.192; Sil. *Pun.*, 14.237) and the paleoenvironmental record (Leighton 1999, pp. 15–17; Bökönyi 2010, p. 32). Although vast tracts of land were undoubtedly cleared for agricultural use by both Greek and Roman settlers (Noti et al. 2009), the moment of irreparable damage to the island's forests seems to have occurred in the sixteenth or seventeenth century CE, as intensification of wheat production reached its apex (Wilson 1990, pp. 6–7).

Textual and Material Sources

We are fortunate to have a diverse body of literary and material sources relating to agricultural production and practice in Magna Graecia between the tenth and third centuries.

Literary Sources

The fertility of the region was a common theme among ancient commentators beginning with Homeric epic, if, as many Greeks themselves believed (Thuc. 6.2.1; Eur. *Cyc.*; Diod. Sic. 5.2.4), the account of the Island of the Cyclops (*Od.* 9) was conceived with Sicily in mind. From as early as the eighth century then, we have the first literary instance of what came to be a common characterization of the region as a place of nearly unimaginable fertility and abundance; where grains and vines grow wild, where broad meadows stretch up from the sea and the deep soil awaits plowing, where yields are heavy across every season. So influential was this image that by the time of the Roman Empire, the island had gained mythological priority in the etiology of agricultural practice (Diod. Sic. 5.2.3–5.5.1). It was claimed by some ancient authors that grain (σῖτος) originated in Sicily, and even that the agricultural goddesses Demeter and Persephone called the island home. The fifth-century poet Pindar wrote of this connection in his epinician ode for Chromius of Aetna:

> Sow, then, some splendor on the island, which Zeus the master of Olympus,
> gave to Persephone, and with a nod of his locks assured her that he would exalt
> fertile Sicily to be the best of the fruitful earth with her lofty and prosperous cities.
>
> Pindar, *Nem.* 1.13–1.16 (trans. W.H. Race)

The agricultural wealth of Magna Graecia is a topic that continued to spring up throughout Classical and Hellenistic literature, from the *Histories* of Herodotus to the bucolic idylls of the poet Theocritus, who offers a vivid glimpse of the region's pastoral landscapes and its denizens (e.g. *Id.* 5). The region's fertility remained a popular theme in later works of the Roman period, including the *Geographica* of Strabo and the *Universal History* of Diodorus Siculus. But it is with the *Natural History* of Pliny the Elder and surviving texts by Roman agronomists, like Cato the Elder (*De Agri Cultura)* and Columella (*De Re Rustica*), that one finds the most detailed testimony of agricultural practices in the region, including references to specific crops (Cato, *Agr.* 6.4), details of the agricultural calendar (Plin. *HN* 18.12.20), and figures for crop yields (Theophrastus, *Hist. pl.* 8.2.8), however unreliable we may consider these today. While these authors may have drawn on work by earlier Sicilian or South Italian authors – including the lost treatise on agriculture by Hieron II of Syracuse (Varro, *Rust.* 1.1.8; Bell III 2011, p. 193) – many of the relevant passages comment on the state of agriculture in the author's own day, a fact that should caution us against an uncritical application to earlier eras. Nevertheless, these later Roman works remain vital sources of information that our earlier literary sources lack and which may in some cases be corroborated by archaeology. When taken as a whole, the literary evidence presents a fairly consistent picture of the region as an agricultural powerhouse of the ancient Mediterranean, a status that greatly enriched its inhabitants and drew foreign powers into conflict over its control.

Two additional points of caution are worth noting when weighing the value of the available literary testimonia as a lens through which to view agricultural activity. First, ancient authors often reduce agriculture in the region to cereal production and, in particular, the cultivation of wheat. Without denying the importance of cereal production in Magna Graecia, one must also acknowledge the ample evidence for polyculture in the region. Here, the growing body of paleobotanical and zooarchaeological evidence can be used to demonstrate the region's biodiversity. Second, we should be aware of the implicit biases that may have played a role in the literary presentation of agriculture in the region. For instance, when Cicero (*Verr*. II.2.5) recalled Cato the Elder's description of Sicily as a *cellam penariam rei publicae* and *nutrix plebis Romanae* – a storehouse for the Republic and wet nurse of the Roman people – he did so while prosecuting charges against Gaius Verres, the island's former and infamously rapacious governor. In the context of the trial, it benefited Cicero to portray Sicily as Rome's bountiful larder deserving protection from one man's predations.

Coinage

Coin iconography offers another source through which to view the importance that agriculture held for communities of the region. Beginning in the second half of the sixth century BCE, Greek settlements in south Italy and Sicily began to mint coins. Coinage provided a mobile and highly visible medium for communicating aspects of civic identity, so it is no surprise that themes of agricultural production and fertility feature prominently on many of the issues struck by cities in the region.

In southern Italy, Metaponto and Sybaris were among the first cities to strike coins. A large barley ear appeared on the Archaic silver denominations of Metaponto and continued to be struck on the city's coinage well into the Hellenistic Period (Figure 15.3; Rutter 1997). The first coins of Sybaris bore the image of a bull, which may have been a reference to cattle rearing in the territory of the famously rich Greek colony. In both cases, coin types served to reinforce the connection between a community and the agrarian sources of their wealth. Among the Sicilian Greeks, barley ears and grains appear frequently on the early coins of Gela and Leontinoi, as well as on the coinage of numerous other cities including Syracuse, Messana,

Figure 15.3 Silver *nomos* of Metaponto, c. 510–470 BCE. Obverse type depicting a seven-grained ear of barley, META at right. Source: Courtesy of the American Numismatic Society.

Selinus, Himera, and Akragas. Naxos, on the east coast of Sicily, highlighted the connection between its territory and viticulture with the image of a grape cluster surrounded by the legend NAXION, "of the Naxians" (Vandermersch 1994, pp. 38–41). Indigenous communities, which began minting coins about a century after the Greeks, also came to highlight agricultural themes on their coinage. Morgantina, the first Sikel community to mint coins, struck small, silver *litrai* with the image of an ear of grain surrounded by the city's name (Erim 1989, pp. 5–7).

Epigraphic Sources

Inscriptions offer another valuable resource for reconstructing the agricultural realm, as they often record information not otherwise available in the literary or archaeological record. Surviving documents, though not numerous, can reveal much about agrarian practice in the region including, among other things, the size and location of agricultural land associated with urban centers, the types of crops cultivated, and the amounts paid in rent by tenant farmers.

The Herakleia Tablets (*IG* XIV 645; third century BCE) are a particularly rich source of information. This pair of inscribed bronze tablets records the leasing of land belonging to the sanctuaries of Dionysus and Athena in the territory of Herakleia Lucania (Uguzzoni and Ghinatti 1968). The considerable holdings of each estate (c. 300–360 ha) were divided into smaller parcels that were then rented out. Rents were paid in barley and totaled almost 4000 *medimnoi* (c. 210 000 liters) at the time the document was inscribed. Highlighting the crops that were currently cultivated on the plots (olives, grapes, and figs), the tablets specify that it was the obligation of the lessee to maintain the trees and vines and to replant in the case of loss by old age or wind. In one instance, the inscription gives a specific number of olive trees and vines that a lessee was obliged to plant on the property or risk paying a fine (I.122–124). From the amounts recorded, higher rents were paid for lots planted with grape vines and olive trees, suggesting that the cultivation of these crops might have been geared for sale on the market. The Locri Tablets (c. 350–250 BCE), a collection of 39 bronze tablets found together at Locri Epizefiri in southern Italy, record loans made by the Sanctuary of Zeus to the city (Costabile 1992). Loans and payments in kind are recorded on at least nine of the tablets, enough to give us an idea about the crops cultivated in the territory of Locri (wheat, barley, fava beans) and to illuminate the role that agricultural products, like olive oil and wine, played in the repayment of loans.

From Sicily, several documents help to fill in our picture of agrarian activity. Among this number are the *Tabulae Halaesinae* (*IG* XIV 352; third to second century BCE), three fragmentary stone inscriptions discovered near the modern town of Tusa on the north coast of Sicily that served as a cadaster of properties leased in the *chora* of ancient Alaesa (Burgio 2008). Although fragmentary, the inscriptions offer a glimpse into land management in the area during the Hellenistic Period. The largest fragment lists 12 or 13 lots and includes a brief description of each property, including standing architecture on the site (e.g. farm buildings, boundary walls). In addition, it describes the topography and physical environment (e.g. roads and waterways) of the area and enumerates agricultural features like vineyards, olive groves, and stands of fig, pear, and pomegranate trees. The Tauromenium Financial Inscriptions (*IG* XIV 422–430; third to first century BCE), a collection of accounts from ancient Tauromenium on the east coast of Sicily, underscore the role agricultural produce played in civic finances. The inscriptions record the amounts of agricultural produce and coinage entering and exiting the accounts managed by a group of local civic authorities called σιτοφύλακες, or grain inspectors (Fantasia 1999). Notable is the relative importance of legumes (fava beans) in these documents with respect to barley and other grains. Filling out our picture for Sicily are the Entella Tablets (Nenci 1980, 1982), which highlight the centrality of agriculture for the livelihood of a community and its relationships with its allies. The eight bronze decrees record honors granted to communities and individuals that had provided aid to the citizens of Entella when they were driven from their city and territory during the First Punic War (Loomis 1994; Ampolo 2001). One tablet (Entella A1 = V Nenci) records honors extended to four cities (Kytattaria, Makella, Petra, and Schera) and six private individuals who either gave gifts of wheat and barley or sold it at favorable rates when the Entellinoi were faced with a shortage of grain (ἔνδεια σίτου).

Archaeological Evidence

While our understanding of the Greek countryside still cannot rival that of urban centers, we are nevertheless fortunate that archaeological research over the past 50 years has paid considerable attention to rural activity in Magna Graecia. As archaeologists increasingly recover and analyze paleoenvironmental data from excavations and intensive survey projects, their efforts help to bring the region's agriculture into greater focus.

Intensive Survey

Since the 1960s, intensive survey projects conducted in the territories of Greek and indigenous urban centers throughout the region have revealed broad patterns of rural activity and occupation spanning several millennia. Turning our attention to the *chora* has led to a greater recognition of the vitality of the ancient landscape and the fundamental relationship that existed between urban centers and the productive territories that supported them. This intimate connection between city and *chora* ensured an evolving landscape that changed with the demands placed upon it by local and regional forces (Carter 2006, p. 121).

The single most comprehensive pedestrian survey in the region has been conducted in the territory of Metaponto, where archaeologists have identified hundreds of rural sites in the low-lying plain that stretches north of the ancient city between the Bradano and Basento rivers (Carter and Prieto 2011). Elsewhere in southern Italy, intensive survey projects have been conducted in recent decades in the territories of several other ancient Greek cities, including Croton (Prieto 2005, pp. 60–63) and Herakleia Lucania (Zuchtriegel 2012, 2016). Territories of several indigenous settlements have also been subject to survey, among them Roccagloriosa, a Lucanian site located along the Tyrrhenian coast in southern Campania (Gualtieri 1993a, p. 29), L'Amastuola in Apulia (Burgers and Crielaard 2007), and Monte Irsi, located in the Basentello valley of Basilicata (Small et al. 1998).

The territories of several large Sicilian cities have been the focus of intensive survey projects, including ancient Himera, located on the north coast of Sicily (Belvedere 2002), where archaeologists identified some 218 sites in the city's *chora*. Systematic survey of approximately 1000 km^2 in the territory of Gela revealed a rich mosaic of sites ranging in date from the Bronze Age to Medieval period (Bergemann 2010, 2011). Survey work has also been conducted in the territories of many smaller Greek and indigenous centers, including at the inland sites of Morgantina (Thompson 1999), Entella (Corretti and Vaggioli 2001), and Segesta (Bernardini et al. 2000), as well as at the coastal sites of Heraclea Minoa (Wilson and Leonard 1980; Wilson 1981), Alaesa (Burgio 2008), and Lilybaeum (Blake and Schon 2010). Each has added additional layers of detail that help to shape our understanding of agricultural activity in the region.

Farmhouses

Complementing the broad view of the regional landscape offered by intensive survey projects, the excavation of rural farmsteads has dramatically improved our understanding of the ancient countryside by generating new information about agricultural activities at the scale of the single productive unit. Increased attention among archaeologists to the question of rural settlement has led to the systematic excavation of farmsteads in the territories of Metaponto (Carter 2006; Lanza Catti 2014, pp. 409–410), Herakleia (Quilici 1967, pp. 148–150, pp. 212–213; Lanza Catti 2014, p. 411), Gela (Ademesteanu 1958), Akrai (Pelagatti and Curcio 1970), and Kamarina (Pelagatti 1980–1981, pp. 723–736; Di Stefano 2001, pp. 693–699; 2002), to name only a few locations. The growing register of excavated farmhouses in Magna Graecia calls attention to the variability of agricultural practices within the region and evidences surplus production for market exchange.

Paleoenvironmental Evidence

A salutary development within the field of Classical archaeology in recent decades has been the growing attention paid to the recovery and analysis of paleobotanical and zooarchaeological material from excavations. Initially a sporadic activity among a few forward-thinking archaeologists, environmental sampling is now standard practice for most archaeological projects in the region. The publication of the paleobotanical and zooarchaeological material has dramatically expanded our knowledge about the diversity of crops grown and animals raised in Magna Graecia. We are fortunate to have well-published datasets collected from various urban and rural sites, ranging from the indigenous Elymian settlement at Monte Polizzo in western Sicily (Stika 2005) to the Pantanello Sanctuary in the territory of Metaponto (Costantini and Costantini 2003; Bökönyi 2010). While paleoenvironmental data may be limited by its site-specific nature, the growing body of available data has already led to fruitful analysis at a regional level (Stika et al. 2008; Lentjes 2013) and will continue to improve our understanding of crop production and diet among the diverse populations of Magna Graecia.

Plants Cultivated

As noted above, ancient literary and numismatic sources tended to highlight the importance of cereal production in the region. This was particularly true of later Roman authors, whose characterization of Sicily and southern Italy as the proverbial breadbasket reflected the region's role as a principal supplier of grain to Rome (e.g. Varro, *Rust.* 1.2.6). Whether this portrayal is accurate even for the Roman period, retrojecting it into the Archaic and Classical periods risks underestimating the region's biodiversity. Franco De Angelis (2006) has critiqued a long-standing scholarly practice of using anachronistic literary sources to posit a monoculture regime based on wheat production in Greek Sicily. While acknowledging the importance of grain for Sicily's economy, De Angelis argues that the island's connection to wheat production, vaunted in Roman literary sources, was often as much a political and cultural construct as a literal representation of the ancient agrarian landscape (see also Cancila 1992, p. 3).

Even when discussing wheat production, it is important to note the varied types cultivated in the region. Ancient literary sources may not always distinguish among them, but the paleobotanical record shows that several varieties were cultivated at one time or another in Magna Graecia. Emmer wheat (*Triticum dicoccum*) was grown in the region prior to Greek colonization (Costantini and Costantini 2003, p. 6), as evidenced by paleobotanical remains at sites dating as far back as the Neolithic period. Like its wild ancestor (*Triticum dicoccoides*), emmer is a hulled wheat; thus, it retains its glume during threshing, requiring additional effort to free the edible grain inside. Even as the cultivation of naked, or free-threshing, wheat became more prevalent in the region, emmer remained a popular grain on account of its resistance to cold and its hardiness in poor soils. It is found, for instance, in Hellenistic contexts at Roccagloriosa (Bökönyi et al. 1993) and at the Pantanello Sanctuary. Another hulled variety, einkorn wheat (*Triticum monococcum*), was also cultivated from the Neolithic period, but appears infrequently in the paleobotanical record from the Iron Age onward. Remains were recovered at Monte Polizzo, but in such limited quantities that researchers concluded it was not cultivated as a crop (Stika et al. 2008). Certainly, the most common free-threshing variety was bread wheat (*Triticum aestivum*), which was cultivated throughout Magna Graecia for both local consumption and export. Its popularity grew over the course of the Hellenistic Period, gradually becoming the preferred wheat variety across much of the Roman world. Remains of *Triticum aestivum* have turned up at virtually every Classical and Hellenistic site in the region (Lentjes 2013; Costantini and Costantini 2003).

Wheat, of course, was not the only cereal cultivated in the region. Barley (*Hordeum vulgare*) had been raised since the Neolithic period and was perhaps the most widely grown and consumed grain in Magna Graecia during the period in question (Costantini 1979, p. 43). Comparable to wheat in its caloric value, barley has a relatively short growing season, which made it an excellent reserve crop. The apparent Roman distaste for the grain (Plin. *HN* 18.71–75; Columella, *Rust.* 2.9.14) has led to the incorrect assumption that the Greeks also preferred wheat to barley. However, neither the archaeological record nor extant literary testimonia bears this out (Gallo 1983). The frequent appearance of barley on the coinages struck by western Greek cities would also speak against such bias. Remains of the grain have turned up at almost every site – Greek and indigenous settlements alike – for which we have published paleobotanical remains (Costantini 1979; 1983, pp. 55–56; Di Vita 1983, pp. 32–35; Stika et al. 2008). Here too, surviving epigraphic sources are helpful, as barley is specifically mentioned in the Herakleia Tablets (I.102–104) as the medium by which lessees were to pay their rent; barley was also given to the Entellinoi by their allies during their time of crisis.

Unlike wheat and barley, millet (*Panicum miliaceum*) appears only rarely in the archaeobotanical record for the region. If ancient literary sources are to be trusted, it was a fairly unpopular grain among Greeks, although it seems to have formed a more substantial portion of the Roman diet (Murphy 2015). Plin (*HN* 18.24), for instance, notes that in his day millet was cultivated prolifically in Campania, and that both bread and porridge were made from it (see also Columella, *Rust.* 2.9.19). Aversion to millet may have played a role in cultural politics among Greek settlers and indigenous populations in Sicily. Among the three indigenous cultures recognized by Sicilian Greeks (Thuc. 6.2), those that occupied the western portion of the island were known as *Elymoi*, the Elymians, which was a pun on the Greek word for millet (ἔλυμος). Giuseppe Nenci (1989) has argued that by applying the label of "millet eaters" to this group, Greek settlers sought to distinguish themselves as culturally distinct by way of their dietary habits. Yet paleobotanical samples evince little preference for millet within Elymian settlements (Stika et al. 2008). Scanty remains of the grain have been recovered from Entella, an Elymian site in the uplands of the Valle del Belice, while not a single grain was recovered in excavations at the larger Elymian sites of Monte Polizzo and Segesta (Castiglioni and Rottoli 2008). In fact, the paleobotanical profile of Elymian sites in western Sicily resembles the profiles of other culturally Greek centers on the island, which show high concentrations of barley and emmer wheat. The near absence of millet from these

"Elymian" areas does support the idea that the term *Elymoi* was simply a pejorative label applied by Sicilian Greeks without basis in observable dietary practice.

Although grains likely dominated the average diet, a wide variety of other crops were also grown and consumed in the region. Legumes certainly formed a large part of the agricultural inventory. From the Pantanello Sanctuary (Costantini and Costantini 2003, pp. 7–8) and the settlement at Segesta (Castiglioni and Rottoli 2008), we get a glimpse of the considerable variety of cultivated legumes in the preserved remains of lentils (*Lens culinaris*), fava (*Vicia faba*), peas (*Pisum sativum*), chickpeas (*Cicer arietinum*), and vetch (*Vicia ervilia*). In addition to being an excellent source of protein, legumes grow well in the hot and dry summers of the southern Mediterranean and, once dried, their seeds can be stockpiled and stored for long periods as a hedge against famine (Garnsey 1988). When planted in rotation with cereals, legumes can serve as a "green manure" helping to restore nitrogen into soil, a fact that was recognized by Greek and Roman agricultural writers (Theophr., *Caus. pl.* 4.8.1–3; *Hist. pl.* 9.7.2, 8.9.1; Verg., *G.* 1.71–81; Columella, *Rust.* 2.13.1).

Fava (*Vicia faba*) was among the more prominent legumes cultivated in the region. Fava appears in fairly large quantities in Archaic levels at Monte Polizzo and L'Amastuola, but is absent from samples collected from contexts of similar date at Selinus and Roccagloriosa (Stika et al. 2008, p. 143; Lentjes 2013, pp. 115–124). The presence or absence of fava at these sites may reflect differences in local taste or may simply be due to the imperfect nature of environmental sampling. Fava beans are mentioned both in the Locri Tablets and the Tauromenium Financial Inscriptions, which record their stockpiling in quite significant quantities (Fantasia 1999, pp. 253–254).

Vetch (*Vicia ervilia*), also well suited to the region, grows even in thin and poorly watered soils. Paleobotanical evidence suggests it was widely consumed by both indigenous and Greek communities. Vetch seeds were found in great quantities in seventh-century levels at the site of L'Amastuola, often in contexts of storage and food preparation (Burgers and Crielaard 2007, p. 110). It has also been identified at Monte Irsi in Lucania (Hjelmqvist 1977) and at several sites in Sicily, including Monte San Mauro (Costantini 1979), Selinus (Stika et al. 2008), and Morgantina.

Among the many fruits cultivated, olives and grapes were dominant. Olives of wild variety (*Olea oleaster*) grew in Sicily from as early as the Mesolithic period. As for the introduction of the cultivar (*Olea europaea*), current evidence points to the period of Greek colonization (Noti et al. 2009). Intensive cultivation began in the Archaic period and was certainly driven by demand from the Greek population and, increasingly, from indigenous communities (Albanese Procelli 1997, pp. 8–9). Such demand was not universal, however, judging from the notable absence of *Olea europaea* in paleobotanical samples from Monte Polizzo, where chemical analysis of residues in cooking vessels revealed that animal fats, rather than olive oil, were used in food preparation (Stika et al. 2008, p. 146). Archaeological and epigraphic evidence helps complete our picture of regional olive cultivation and oil production. The remains of presses and vats used in the production of olive oil have been found in farmhouses dating to the fourth century at Priorato in the territory of Gela (Adamesteanu 1958, pp. 366–367) and Montegiordano in Calabria (Brun 2004, pp. 167–168). Olive trees surely dotted the landscape around most Greek settlements; we find explicit description of them in the surviving text of the Herakleia Tablets and *Tabulae Halaesinae*, which even mentions an olive nursery (*elaikomion*; Col. I, 69, 71).

As with olives, the widespread cultivation of grapes (*Vitis vinifera*) seems to have followed closely on the heels of Greek colonists, even though wild varieties (*Vitis sylvestris*) were present in the region since the Neolithic period. Doubtless local demand for wine among Greek settlers, indigenous, and culturally hybrid communities spurred viticulture (Rabinowitz 2004, pp. 341–375; Antonaccio and Neils 1995). Grape seeds from sixth-century levels at the

Pantanello Sanctuary are among the earliest examples of the cultivated species found in southern Italy (Costantini and Costantini 2003, pp. 9–11), while in Sicily, remains of cultivated grapes have been identified at both Greek and indigenous sites in contexts dating as far back as the late seventh century (Stika et al. 2008, pp. 141–144). The cultivation of grapes and production of wine in Sicily also received explicit references in surviving literary sources. Silius Italicus (*Pun.* 14.204), for instance, mentions vines growing abundantly in the territory of Entella, and Diodorus Siculus (13.81.4–5) attributes the great wealth enjoyed by the citizens of Classical Akragas in part to the popularity of the wine produced in the city's hinterland. Ancient authors even enumerate local varietals of grapes, including the *vitis murgentina*, which was once cultivated on the slopes around Morgantina (Cato, *Agr.* 6.4; Columella, *Rust.* 3.2.27) and considered by Pliny the Elder (*HN* 14.4) to have yielded the best wine in all of Sicily. While evidence for wine making at Morgantina is limited (Manganaro 1989, pp. 203–205), production is well documented at Sicilian Naxos, including on the city's silver coinage (Vandermersch 1996, pp. 159–168). Naxian wine seems to have been both popular and widely consumed, judging from the number of amphora handles stamped with the city's name (ΝΑΞΙΟΣ) that date between the fourth and second century BCE. Amphorae bearing this stamp – and presumably carrying Naxian wine – have been found at sites across Sicily (Syracuse, Lilybaeum, Akrai, Pachino, Montagna di Marzo), on the Italian peninsula, and even as far afield as Athens and Elis in Greece (Garozzo 2001, p. 41; 2011, pp. 429–436).

Rounding out the major tree fruits of the region, figs (*Ficus carica*) were widely cultivated and consumed in antiquity. Fig trees are mentioned in the Herakleia Tablets (I.172), and remains of cultivated fruit have been recovered at Selinus, Monte Polizzo, Segesta, Pantanello, and numerous other sites in the region (Lentjes 2013, pp. 115–124; Stika et al. 2008).

Animal Husbandry

The geography and climate of the region favored not only intensive crop cultivation but also livestock rearing. This was particularly true for areas like Apulia, where the seasonal migration of large flocks between the mountainous inland zones and the Tavoliere plain coincided with the cultivation of cereals, grapes, and olives (Small 1994; 2014, pp. 15–18). The Greek colonies of Magna Graecia were noted in antiquity for the livestock raised in the region (Kron 2014, p. 110). Pindar, for instance, begins his ode to Midas of Akragas by referencing the sheep-nurturing (μηλόβοτος) banks of the Akragas River (*Pyth.* 12.2; see also, *Ol.* 1.12). The paleoenvironmental record further supplements our picture of animal husbandry in the region. For instance, pollen samples collected from the farmhouse at Fattoria Fabrizio in the *chora* of Metaponto reveal a landscape dominated by pastureland (Florenzano 2014). So too, zooarchaeology offers a glimpse of the specialized rearing of livestock for economic and productive ends (Gualtieri 1993b, p. 334), particularly among the two most prominent domesticates in the region, cattle and caprovines (sheep and goats).

Sheep were the most numerous livestock raised in Magna Graecia during the Iron Age, prior to the arrival of Greeks in the eighth and seventh centuries, and remained a staple of animal husbandry throughout the Classical and Hellenistic periods. Sheep were raised for their meat, skins, wool, and milk, which could be made into cheese (on Sicilian cheese, see De Angelis 2016, p. 289; Dunbabin 1948, p. 217). Multiple references by Roman authors attest to the quality of South Italian sheep (Columella, *Rust.* 7.2.3) and their wool (Pliny, *HN* 8.73). Greek settlers were likely responsible for these superlative qualities. In the area around Metaponto and Incoronata, for instance, the analysis of faunal material has shown that the type of sheep raised by indigenous populations gradually disappeared from the archaeological record in the centuries following the arrival of Greek settlers, only to be replaced by a distinctly larger variety (Carter 1996). Researchers have hypothesized that this development might be due either to the translocation of livestock from the Greek mainland to colonial settlements or to the selective breeding of local livestock by colonial Greeks (Gaastra 2014, pp. 493–495). In either case, it is clear that Greek settlers in the region played a role in transforming the ovine population to their advantage.

Cattle were raised for their meat, skins, milk, and labor. In the centuries following Greek colonization, cattle came to replace sheep as the dominant species in the faunal record at many sites across southern Italy (Carter 1996, p. 367; Lentjes 2013). The importance of cattle rearing for the Greek settlements of Magna Graecia was highlighted in the depiction of bulls on the early coinage of Sybaris, Thurii, and Poseidonia. Several ancient authors mention the size and quality of Sicilian cattle (Theoc., *Id.* 9.10; Diod. Sic., 4.30) – and with good reason, judging from the growing body of zooarchaeological data that points to the impressive size of Late Classical and Hellenistic cattle in Magna Graecia (Kron 2004, p. 125). It seems that the Greeks did not find cattle of such remarkable size when they initially settled in the region, but played an active role in breeding larger animals, as they had done with sheep. Researchers have convincingly documented such selective breeding at Metaponto, where faunal remains show the steady growth in the size of cattle from the Iron Age to the Roman period. Sandor Bökönyi, who analyzed this material, concludes that "[t]his deliberate human intervention resulted in the emergence of specialized breeds, and increased the production of traditional domestic animals in both qualitative and quantitative respects" (Bökönyi 2010, p. 33). Bökönyi's research on selective breeding practices underscores the remarkable insights to be gleaned from the available zooarchaeological data.

Agricultural Practices

Looking beyond the region's agricultural produce, our literary and material sources provide valuable insight into how agriculture was manifest in daily life.

Farming and Production Sites

Literature reveals little about the farmsteads that once served as the sites of agricultural enterprise in the region. Much more informative are inscriptions, which often provide specific details about the organization of farms and the types of structures found there. In the Herakleia Tables (I.138–144), for instance, it is stipulated that the lessee of a particular lot was obliged to construct a cowshed (ὁ βοών) of specific dimensions on the property. Of the many farmhouses excavated throughout the region, most were modest one-story structures enclosing a central courtyard, such as the ten-room farmhouse at Fattoria Stefan in the territory of Metaponto (Carter 1980, p. 29; Lanza Catti 2014). Many of the excavated farmhouses appear to have been sites of permanent or regular occupation, particularly those located at some distance from an urban center.

The majority of farmsteads would presumably have invested in some form of mixed farming, combining cultivation of cereals and arboriculture with the rearing of livestock, rather than focusing on a single cash crop. Such diversification exploited differences in soils and terrain to favor particular crops. Planting multiple fields also hedged against failure in any single plot. Polyculture is well attested in both the surviving literary and epigraphic sources (e.g. the Herakleia Tablets, above), and is borne out in the paleoenvironmental record as well. Nevertheless, evidence for specialized production geared toward market exchange has been recovered at several farm sites of Classical and Hellenistic date. Carter (2006, p. 26), for instance, notes that pollen cores from the Pantanello Sanctuary suggest farming operations in the area switched from a diversified regime (cereals, olives, grapes) to a largely cereal-based cropping strategy around the end of the fourth century. The residents of the farmhouse at Ponte Fabrizio in the territory of Metaponto may have specialized in the rearing of livestock (Lanza Catti and Swift 2014, pp. 112–113). Occupants of the farmsteads at Priorato in the territory of Gela, at Iurato in the territory of Kamarina, and at Montegiordano in Calabria were involved in the production of olive oil and wine, judging from the specialized installations, such as stone presses and plaster-lined vats, discovered at all three sites (Adamesteanu 1958, pp. 366–367; Di Stefano 2001; Brun 2004, pp. 167–168). Evidence for the production and storage of honey was discovered at the so-called Fattoria delle Api (Fattoria Cancellieri) in the territory of Kamarina (Di Stefano 2002, p. 103; on Sicilian honey, see Varro, *Rust.* 3.10.14). In each case, the scale of production appears to have exceeded household consumption, suggesting that the residents of these farmsteads were producing surplus for the market (Carter 1990, pp. 423–425). In the case of Kamarina, the farmsteads evidently specializing in olive oil or wine production were generally found closer to the city, the nearest market for their merchandise (Di Stefano 2002, p. 109).

Labor

Relatively little survives by way of literary or material evidence to aid in identifying the sources of human labor employed in agricultural operations for the period in question. Nevertheless, it is safe to say that the land was worked by a mixture of landholders, tenant farmers, seasonal laborers, and slaves. For both the small and large landholder, additional manpower was almost certainly required at various points throughout the year. This was undoubtedly true around the harvest, when time constraints necessitated labor-intensive operations (Burford 1993, pp. 182–222).

Larger farms may have profitably utilized full-time laborers, both free and enslaved, to manage a vast range of agricultural activities. The shepherd and goatherd of Theocritus's fifth idyll, who compete in a singing contest near the river Crathis in the *chora* of Sybaris, are both slaves. Tellias of Akragas, whose vast wine production facilities are described by Diodorus Siculus (13.83), would have required a sizable workforce to manage his vineyards and winemaking operation, if Diodorus's numbers are to be trusted (De Angelis 2016, p. 285). Taking the Tellias story as a starting point, De Angelis (2016, p. 287) has hypothesized that upward of three thousand full-time laborers could have been employed in the production of olive oil in the territory of Akragas alone. This is to say nothing of those employed in viticulture, cereal production, and animal husbandry. Agricultural labor on such a grand scale was also to be found in the *chora* of Syracuse during the seventh and sixth centuries, where the land was cultivated by a subjugated population of prodigious number called the Kyllirioi (Frolov and Gaudey 1995). While the identity of the Kyllirioi has been the matter of some debate, the current *communis opinio* holds that they belonged to indigenous Sikel groups, who were subjugated by Greek colonists in the eighth century (Dunbabin 1948, pp. 110–111; Morakis 2015, pp. 43–44; cf. De Angelis 2016, pp. 163–164).

Tools and Technology

Among the most significant technological developments in the realm of agriculture was the introduction of iron tools to the region by Greek settlers in the eighth and seventh centuries. Iron implements like hoe blades, plowshares, and ax-heads facilitated the clearing of woodlands and the tilling of soil, ultimately bringing more of the region's arable land under cultivation. The earliest extant iron plowshares in Magna Graecia appear to have been *ex voto* dedications at sanctuaries sacred to the goddesses of agriculture, Demeter and Persephone. The earliest known specimen, dating to the late seventh or early sixth century, was recovered in the excavations of the Demeter Malophoros sanctuary at Selinus (Gabrici 1927, p. 368, figure 59). Two plowshares found in the excavation of the *thesmophorion* at Bitalemi in the territory of Gela date to the first half of the sixth century BCE (Orlandini 1965, pp. 446–447). Iron hoe blades and axes appear in domestic contexts from the fifth century onward; the most well known of these come from hoards of agricultural implements found at Himera, Morgantina, and Capodarso, near Caltanissetta (Allegro 2000). The hoard of iron implements from Himera, which must predate the city's destruction in 409 BCE, contained four iron plowshares, two hoe blades, and two ax heads. These likely represent the tools of a small- to medium-sized agricultural unit. The plow as a symbol appears quite frequently on coinages struck in the third and second centuries by several Sicilian communities, including Centuripe, Leontinoi, Enna, and Panormus. Clearly an allusion to the fertile territories of these cities, the choice of the plow was undoubtedly inspired by the region's newfound role as a major supplier of grain to Rome.

In the drive to expand their agricultural base, several communities undertook significant projects aimed at providing irrigation to inland farmsteads or, alternatively, drainage of swampy areas in the immediate vicinity of the urban center. Such reclamation projects often transformed the surrounding landscape by rendering fallow land productive. This is best seen in the expansive network of irrigation and drainage channels discovered in the territory of Metaponto (Carter 2011a, p. 768). These channels, believed to date from the fifth century, formed the regular grid-like boundary lines dividing the territory and provided drainage to farmsteads throughout the *chora* (Uggeri 1969; Carter et al. 2004). At roughly the same time, major reclamation projects aimed at draining marshy areas were accomplished in the territories of Kamarina (Di Stefano 1996; 2001) and Selinus (Diog. Laert., 8.2.70; Rambaldi 2010).

Technological advances also benefited milling, with the introduction of the Olynthus-type or "Hopper-Rubber" grain mill in the late fifth or early fourth century (Frankel 2003; De Angelis 2016, p. 284, n. 339). The gradual replacement of older saddle-quern mills by the more efficient Olynthus-type is well documented at Morgantina (White 1963). Here and elsewhere in the region, the Olynthus-type mill was itself gradually replaced over the course of the third century by the rotary or "Morgantina-type" mill, which operated more efficiently by substituting continuous rotation for reciprocal motion (Santi et al. 2015, pp. 805–806; Curtis 2008, pp. 373–376).

Rural Settlement Patterns

Stepping back from daily practice, we can observe several broad trends taking place in the countryside, thanks in large part to recent survey projects. One such trend, observable across most of the region, is the intensification of rural activity following Greek colonization, characterized at many locations by a dramatic spike in rural settlement in the Late Classical and Early Hellenistic periods. Surface collection in the *chora* of Metaponto, for example, showed a rise in activity following the foundation of the city by Greek settlers, such that by the middle of the sixth century, the city's territory was dotted by small, single-family farmsteads. Settlement in the countryside increased throughout the Classical period, ultimately reaching its maximum density in the half century between 325 and 275 BCE, when there may have been upward of one thousand farmsteads in the immediate vicinity of the city (Carter and Prieto 2011, p. 809). A similar pattern has been observed in the territories of Gela (Bergemann 2010, 2011) and Herakleia Lucania (Zuchtriegel 2012, 2016). Both communities witnessed the intensification of rural settlement in the late fourth century, despite having very different historical trajectories. A corresponding rise in rural activity during the Late Classical and Early Hellenistic periods has been documented in the territories of numerous indigenous settlements as well, including L'Amastuola in Apulia (Burgers and Crielaard 2007, p. 111), Roccagloriosa in southern Campania (Gualtieri 1993a), Entella (Corretti and Vaggioli 2001), and Segesta in western Sicily (Bernardini et al. 2000).

While rural settlement appears to have generally increased across the region during the fourth and third centuries, the organization of landholding in the countryside followed no single pattern. On the one hand, some communities organized the *chora* into regular allotments of land, as in the case of Metaponto, where archaeologists have found evidence for an extensive program of rural land division (Carter 2011b, pp. 1044–1051). Similar allotment of land in the territory of Kamarina has been associated with the democratic reorganization of the civic body in the mid-fifth century BCE (Di Stefano 1996, 2001; cf. De Angelis 2016, pp. 205–206). In the *chora* of Gela, on the other hand, no systematic or regular division of the countryside is evident. Rather, farmsteads seem to have been sited according to the topographic features, such as on hillsides, leaving arable land along flat plains open to cultivation (De Angelis 2000, p. 138). In the territory of Himera, archaeologists found that smaller sites generally clustered around the urban center and were rarely located at distances greater than 5 km from the city, while larger rural sites were almost universally located more than 4 km from the city (Alliata et al. 1988, pp. 200–205). A similar distribution pattern among rural sites has been noted in the *chora* of Morgantina (Thompson 1999, pp. 417–418).

One consequence of increased scholarly attention to the *chora* has been greater recognition of the vital relationship between urban centers and the productive agricultural landscapes that supported them. Often the vicissitudes of a city's political fortunes can be seen in the rural settlement patterns uncovered by intensive survey. This intimate connection between a city and its territory ensured an evolving landscape that changed with the demands placed upon it by local and regional forces. As Joseph Carter notes with reference to survey work conducted in the territory of Metaponto, "[t]he most important result to emerge from this sort of model of the *chora* is that the land regime was not a static system but developed constantly over the whole life of the colony, with plots changing shape, growing, or shrinking" (Carter 2006, p. 121).

Cultural, Economic, and Political Expressions

Among the clearest material expressions of the central role agriculture played in the daily life and well-being of the region is the widespread veneration of Demeter and Persephone. According to Diodorus Siculus, the cult's popularity in Sicily was due to the fact that the Sicilians were the first to receive the gift of grain from the goddesses.

> And the inhabitants of Sicily, since by reason of the intimate relationship of Demeter and Persephone with them they were the first to share in the grain after its discovery, instituted to each one of the goddesses sacrifices and festive gatherings, which they named after them, and by the time chosen for these made acknowledgement of the gifts which had been conferred upon them.
>
> Diod. Sic., 5.4.5 (adapted from trans. by C.H. Oldfather).

Worship of these divine patrons of agriculture took many forms, including the celebration of the annual *Thesmophoria* festival, dedicated to Demeter *Thesmophoros* ("Lawgiver"), which fell in late spring at the start of harvest season (White 1964). The venues of worship were widespread; notable extramural sanctuaries were built at Selinus and Gela in the sixth century BCE (Gabrici 1927; Orlandini 1966). A building identified as a *thesmophorion* has recently been excavated at Entella (Spatafora 2016). No fewer than three sanctuaries associated with the worship of the mother–daughter duo have been excavated at Morgantina (Bell III 2008), where the cult's ancient roots are evidenced by a pair of Archaic acrolithic sculptures from an extramural sanctuary identified as the city's *thesmophorion* (Marconi 2008; Greco 2012).

With regard to the agricultural economy, the establishment of permanent Greek settlements in the eighth and seventh centuries certainly had the greatest lasting impact on agriculture in the region. Greek settlers brought not only the taste for new products (olive oil, wine), but were also the drivers of greater exploitation of the landscape (Lentjes 2013). Region-wide intensification beginning in the Archaic period, paired with higher annual yields and larger arable territories than those found on the Greek mainland, placed Magna Graecia among the foremost exporters of agricultural produce to large urban consumer markets around the Mediterranean (De Angelis 2000; Garnsey 1988, pp. 151–154). Archaeology points to such market-oriented production and trade from as early as the eighth century at the Greek colonial settlement of Megara Hyblaea (De Angelis 2002). These changes were clearly not limited to Greek settlements alone. There is ample evidence to suggest that non-Greek populations in southern Italy turned from subsistence farming to market-oriented agricultural specialization over the course of the Late Classical and Hellenistic periods, likely due to increased contact with Greek settlements in the area (Lentjes 2013). Bökönyi, Costantini, and Fitt (1993), for instance, describe a "boom" in arboriculture between the fifth and third centuries in the territory of Roccagloriosa, which they attribute to a growing engagement with market production among indigenous and culturally hybrid communities (see also Brun 2004, pp. 167–168).

Beyond its economic value, the region's renowned fertility was also a resource to be exploited for military and political ends. This is perhaps most famously spelled out in Herodotus' account of the Athenian and Spartan envoy to the Syracusan tyrant, Gelon, in the lead up to the Persian invasion of Greece (Hdt. 7.156–162). In return for military command of the Hellenic forces, Gelon offered to provide enough grain to feed the entire Greek army for the duration of the war – an enormous amount by all estimates. While the historicity of this event is dubious (De Angelis 2006: 35–38), the episode remains a forceful assertion of the idea that control of agricultural resources could be translated into political authority and military power. Gelon's wealth was predicated on the extraction of agricultural resources from the communities under his rule, a system that may have borne some relationship to the Syracusan *dekatē*, or tithe (*FGrH* 327 F14; Thuc. 6.20; Ampolo 1984, pp. 31–33). The extraction of agricultural produce reached its most advanced stage under the Syracusan monarch Hieron II (r. 269–215 BCE), whose system of agricultural taxation may have closely resembled the complex administrations of the larger Hellenistic kingdoms of the eastern Mediterranean (Bell 2007). Details of the Hieronian system are preserved in the text of Cicero's prosecution of the avaricious provincial governor Verres (*Verr.* II.3; Carcopino 1914). Archaeological remains attest to both the reach and scale of Hieron's agrarian administration; these range from uniform handheld grain measures (Walthall 2011) to monumental granaries in the cities of his kingdom (Deussen 1994). In the tradition of Gelon, Hieron II mobilized the agricultural tithe for his political advantage by sending massive shipments of grain as gifts to his allies, including Rome, Carthage, and the Ptolemies – a practice some have referred to as "corn diplomacy" (Garnsey 1988; Serrati 2000). Hieron's long reign brought peace to the cities of southeastern Sicily, which had previously suffered from more than a decade of warfare and violence (Bell III 2011, p. 194). With peace came agricultural prosperity, the likes of which the poet Theocritus invokes in his Idyll 16, a poem which he addressed to Hieron:

> May the cities which enemy hands have cruelly razed
> Be once again peopled by their former inhabitants.
> May rich harvests repay their toil, and may sheep in their
> Countless thousands fatten in pastures, bleating across
> The plain; and may herds of cattle as they wander back
> To their folds quicken the evening traveller's steps.
> May fallow land be ploughed again, ready for seed-time,
> At the season when the cicada, keeping watch over shepherds
> In the noonday sun, sings loudly high up in the tree branches.
> May their armor be covered with spiders' fine-spun webs, and
> Even the name of the battle-cry be forgotten.
>
> Theoc., Idyll 16, 88-97 (trans. A. Verity).

Conclusion

With the fall of Syracuse in 212 BCE, the Hellenistic Period in Magna Graecia came to a close (stressing continuity, see Wilson 2013, pp. 79–80). Roman rule did not fundamentally disrupt past agricultural practices, but ushered in a new period when production and export were largely focused on supplying the voracious demands of Rome. The preexisting Hieronian system of agricultural taxation was retained and expanded to cover the whole of Sicily as the *lex Hieronica* (Pinzone 1999, pp. 29–35). Still, the Romans left their own mark in the agricultural landscape as the Greeks had before them. One significant change, noted by ancient and modern authors alike, concerned the scale of agricultural production: the rise of expansive villa estates geared toward the intensive cultivation of cash crops and large-scale herding of animals. It was long thought that these so-called *latifundia* drove out the many small farmsteads that once dotted the countryside by effectively consolidating land into the hands of a few wealthy families. While large estates certainly developed throughout the second and first centuries BCE in southern Italy and Sicily, a growing body of archaeological evidence attests to the survival of small- and medium-sized farms, where agricultural practices undoubtedly continued much as they had before (Pelagatti and Curcio 1970). The *latifundia* would eventually give way to the feudal estates and *masserie* of the medieval and early modern periods, but always with agriculture as the basis of the region's economy and the small farmer, whether peasant or tenant, its backbone. Even following the Risorgimento and Second World War, these agricultural traditions persisted, retaining much of their old character, a condition which locked the south out of the industrialization process that transformed much of central and northern Italy in the modern era. In a twist of fate, the agricultural enterprise that had once brought the cities of Magna Graecia great renown and wealth has in recent centuries left southern Italy and Sicily among the poorest regions of Italy.

Avenues for Further Investigation

Despite having received much scholarly attention over the past 50 years, the agricultural landscapes of Magna Graecia continue to inspire innovative research and investigation.

The wide assortment of agricultural products cultivated and consumed in the region has come into better focus in recent decades, thanks in large part to the increasing attention paid by archaeologists to the recovery of paleobotanical and zooarchaeological remains. While we no longer entertain the notion that Magna Graecia was devoted to a monoculture regime based on wheat, much work remains to be done in order to more fully appreciate the region's biodiversity. In this respect, many significant contributions undoubtedly await in the field of environmental archaeology, as archaeologists more regularly incorporate the collection and analysis of microbotanical remains (i.e. phytoliths, pollen, palynomorphs) alongside the study of macrobotanical and faunal material. As the work of Anna Maria Mercuri (Mercuri et al. 2015) and Michael MacKinnon (2004) clearly demonstrates, an impressive range of conclusions can be drawn when a wide variety of datasets are employed.

Excavation of sites in the countryside must continue to be an avenue of inquiry, if we hope to achieve a more nuanced understanding of agrarian enterprise in the region. Intensive survey projects in both southern Italy and Sicily have revealed landscapes teeming with activity, from small, isolated farmsteads to larger "agro-towns." But, we must wait for new excavations (or the publication of older work) at more of these rural sites before we can fully grasp the nature of these activities. Working at the site level gives us a higher-resolution image of the landscape and allows us to more clearly distinguish, for instance, sites of permanent residence from those of seasonal occupation or between farms that focused on subsistence agriculture and those that routinely engaged in market production.

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FURTHER READING

For those with a budding interest in the subject, Joseph Carter's *Discovering the Greek Countryside at Metaponto* (2006) remains an indispensable exploration of agrarian activity in Magna Graecia. Franco De Angelis (2016) provides a thorough overview of agricultural production and the agricultural economy of Sicily during the Archaic and Classical periods. His work now essentially supplants Dunbabin's (1948) discussion of agriculture in Sicily during this period.

Much recent work has been done to reconstruct the production and trade of wine and olive oil in and around the region, chiefly through the identification and distribution analysis of transport amphoras. On this subject, Vandermersch (1994) remains essential, and is now complemented by the excellent work of Brun (2010), Sourisseau (2011), and Pratt (2016). Further inquiries into the region's rich paleobotanical and zooarchaeological record should begin with the *Chora of Metaponto* series, which continues to supplement one of the largest and most well-published datasets for the region with each new volume. For more on the cult of Demeter in Magna Graecia, one should consult Valentina Hinz's *Der Kult von Demeter und Kore auf Sizilien und in der Magna Graecia* (1998) and *Demetra: la divinità, i santuari, il culto, la leggenda*, a collection of papers given at Enna in 2004 (Di Stefano 2008).

While this chapter focused principally on the Greek populations in the region, much has been done to systematically investigate rural activity and settlement patterns in the ancient countryside of indigenous and non-Greek populations, such as the Messapians in Apulia (Burgers 1998; Yntema 1993) and Punic settlements in Sicily (Spanò Giammellaro et al. 2008).

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CHAPTER SIXTEEN

Agriculture in the Hellenistic Kingdoms

J.G. Manning

All pre-modern economies were "organic"; labor was done by humans and animals, and "land (was) the source of food, it was also the source directly or indirectly of all the material products of use to man" (Wrigley 2010, p. 9). Every ancient culture, therefore, and much of the written evidence that survives, paid very careful attention to the conditions of the soil, water, and crops. The post-Alexander world and the new states that were formed at the end of the fourth century BCE in the eastern Mediterranean were no exception, but there were new dynamics in their economies that affected agriculture, agricultural production, and taxation. Ptolemaic Egypt provides the richest historical sources for pre-Roman agriculture in the Mediterranean world, although even here, the evidence is scattered and fragmentary. The Zenon Archive, the largest of the period, is the most important source but, documenting a large estate of the finance minister (*dioiketes*) of Ptolemy II, its emphasis on coinage, and experimentation in new crops and animals, and its connections to the king suggest that we must use great caution in drawing larger conclusions about the overall nature of agriculture in the period (Manning 2018, pp. 110–112). The Seleukid kingdom, far larger in both territory and population, is more difficult to access. Its geography was more complex, and encompassed both rain-fed and, in southern Mesopotamia, irrigated agrarian landscapes (see also Chapter 17 in this volume). Given the initial scale and geographic diversity of the Seleukid kingdom, an overall assessment of Seleukid agriculture beyond saying that it was regionally diverse, with strong continuity with earlier lifeways, but with substantial change in some parts of the kingdom where cities were founded, is precluded by the nature of our documentation.

Several new features dominated, or at least significantly altered, agricultural production in both kingdoms.[1] Among these were an emphasis on coinage, wheat, warfare, and new, large urban areas.[2] These features were coupled. Among the most important new foundations were Alexandria in Egypt (Fraser 1972) and Seleukia on the Tigris, both showcases of royal power.

1 For an excellent comparative overview of both kingdoms, see Fischer-Bovet (forthcoming).
2 On Seleukid city building, see Aperghis (2005).

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

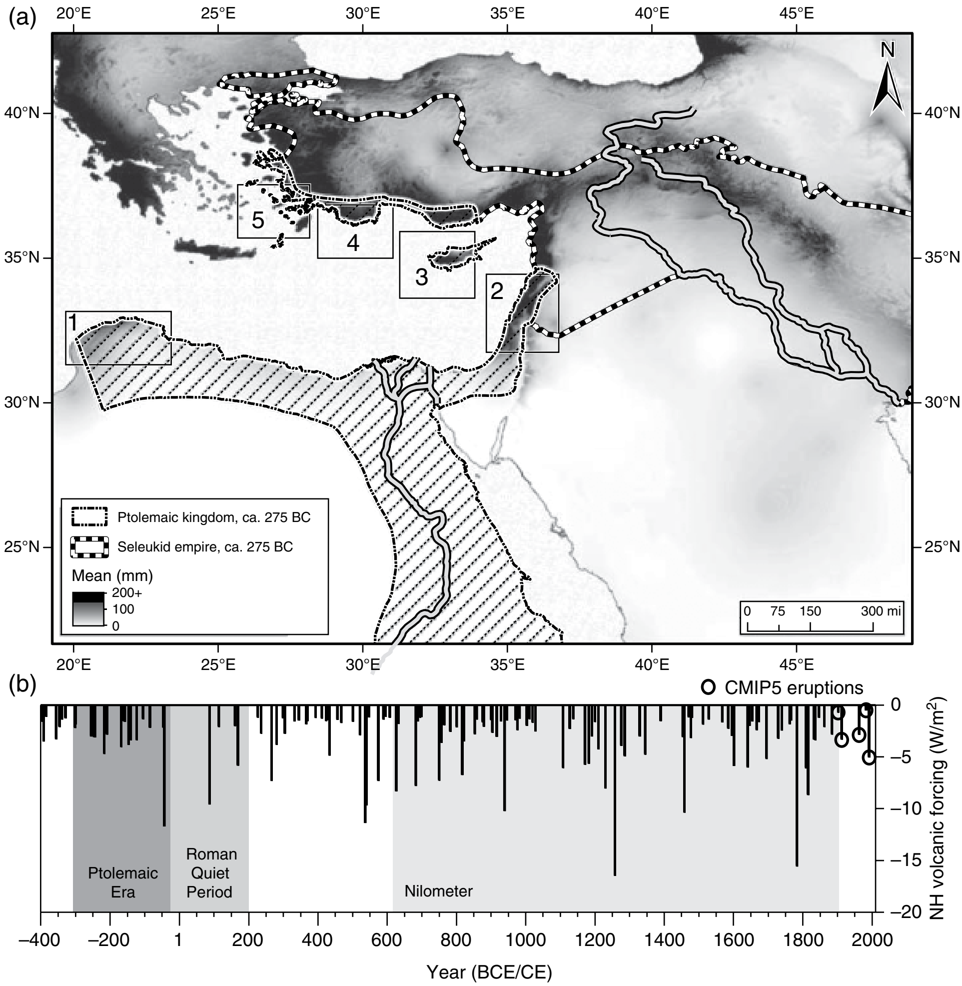

Figure 16.1 Political and environmental setting with volcanic forcing history. **a**. Eastern Mediterranean wet season rainfall (taking as an example the December mean, mm, 1950–2000, at 30 arc-seconds resolution, worldclim.org, v1.4) indicative of Ptolemaic and Seleukid territories potentially capable of rain-fed agriculture, with state boundaries c. 275 BCE overlain: Ptolemaic (black line with diagonal dashes) and Seleukid (thick gray dashes). Key territories contested by these states are numbered with red Arabic numerals alongside indicative rectangles (1, Cyrenaica; 2, "Koile" Syria; 3, Cyprus; 4, Lycia; 5, Caria) and are observed to focus on regions potentially capable of rain-fed agriculture. Selected urban power bases are located with Roman numerals ((i), Babylon; (ii), Antioch; (iii), Seleukia; (iv), Alexandria; (v), Memphis; (vi), Thebes). **b.** Ice-core-indicated dates of maximum aerosol forcing from volcanic eruptions with time-integrated (i.e. cumulative) forcing estimates for the Northern Hemisphere, 400 BCE to the present. CMIP5 eruptions are those five twentieth-century eruptions included in the Coupled Model Intercomparison Project Phase 5. Source: Reproduced from Manning et al. (2017). Licensed under CC-BY 4.0. https://www.nature.com/articles/s41467-017-00957-y

In the early third century BCE, both states, in the Fayyum in Egypt (Thompson 1999a) and in the region around Seleukia on the Tigris in Mesopotamia (Van der Spek 2008), undertook reclamation, canal building, and resettlement around these new imperial projects. Many new settlements, intensive warfare, experimentation in crops and in animal husbandry, and to a certain extent technological improvements were all serious constraints on the production function, since in most places production was limited to one annual agrarian cycle. While the relationship between new urban centers and their hinterlands, and the distribution of food in these centers, remains poorly understood, we can be sure that historical patterns were altered in the late fourth and early third centuries BCE. The usual contrast between the classical world's smallholding in nuclear families versus the large state-managed estates of western Asia and Egypt requires much modification. The distribution and tenure of land and state fiscal demands were regionally diverse and a mixture of deep historical traditions and innovations brought by new populations and new state fiscal demands. Variability in environmental conditions, variability in labor organization and supply, variability in the productivity of the soil, variability of water sources, and inter-annual variability of inputs and yields should be stressed. Although not explicitly mentioned in our sources, competition between the Ptolemaic and the Seleukid kingdoms over rain-fed territory may have been one of the drivers of inter-state conflict (Figure 16.1).[3] But the changing political conditions, a trend toward commercialization, and an increase in market transactions with coinage from the fourth century BCE onward appears to have had dramatic effects on agricultural production.

Ptolemaic Egypt

As with Roman Egypt treated by Haug in Chapter 25 of this volume, it is the papyrological sources, written in both Greek and demotic Egyptian in the Hellenistic period, that comprise our main sources for the agricultural history and agricultural practices of Ptolemaic Egypt (Figure 16.2). The Zenon Archive, the largest of Hellenistic Egypt, from the mid-third century BCE, documents both the private business and the administration of a large estate, approximately 6600 acres, near the new town of Philadelphia. The Menches Archive, a collection of administrative documents of the "village scribe" in charge of managing land around the village of Kerkeosiris in the Fayyum (Crawford 1971; Verhoogt 1998) provides a detailed record for about ten years of the agricultural production and state management.

The Fayyum received intensive attention by the early Ptolemies. The large reclamation project under Ptolemy II and III initially trebled the amount of arable land and established new settlements. Some of these new villages largely in the south Fayyum have provided us with the abundance of Greek papyri that makes the region the most intensively studied of the period, as it is under Roman rule.

Less is known about the external possessions of the Ptolemaic kingdom. Cyrenaica was a very productive region for grain.[4] It is not known if grain was ever transferred from Cyrenaica to Egypt, but in at least one well-known case, mentioned in the Canopus Decree, at a time of Nile flood failure, grain was imported into Egypt from some of its external possessions. The text mentions a serious Nile flood shock, plausibly in the 240s BCE, and Ptolemy III's response: the importation of grain. The Canopus Decree informs us that grain imported to

3 See Manning *et al.* (2017) with Figure 16.1.

4 Bresson (2011). Horden and Purcell (2000, p. 71) estimate that Cyrene had 2000 km^2 of arable potential.

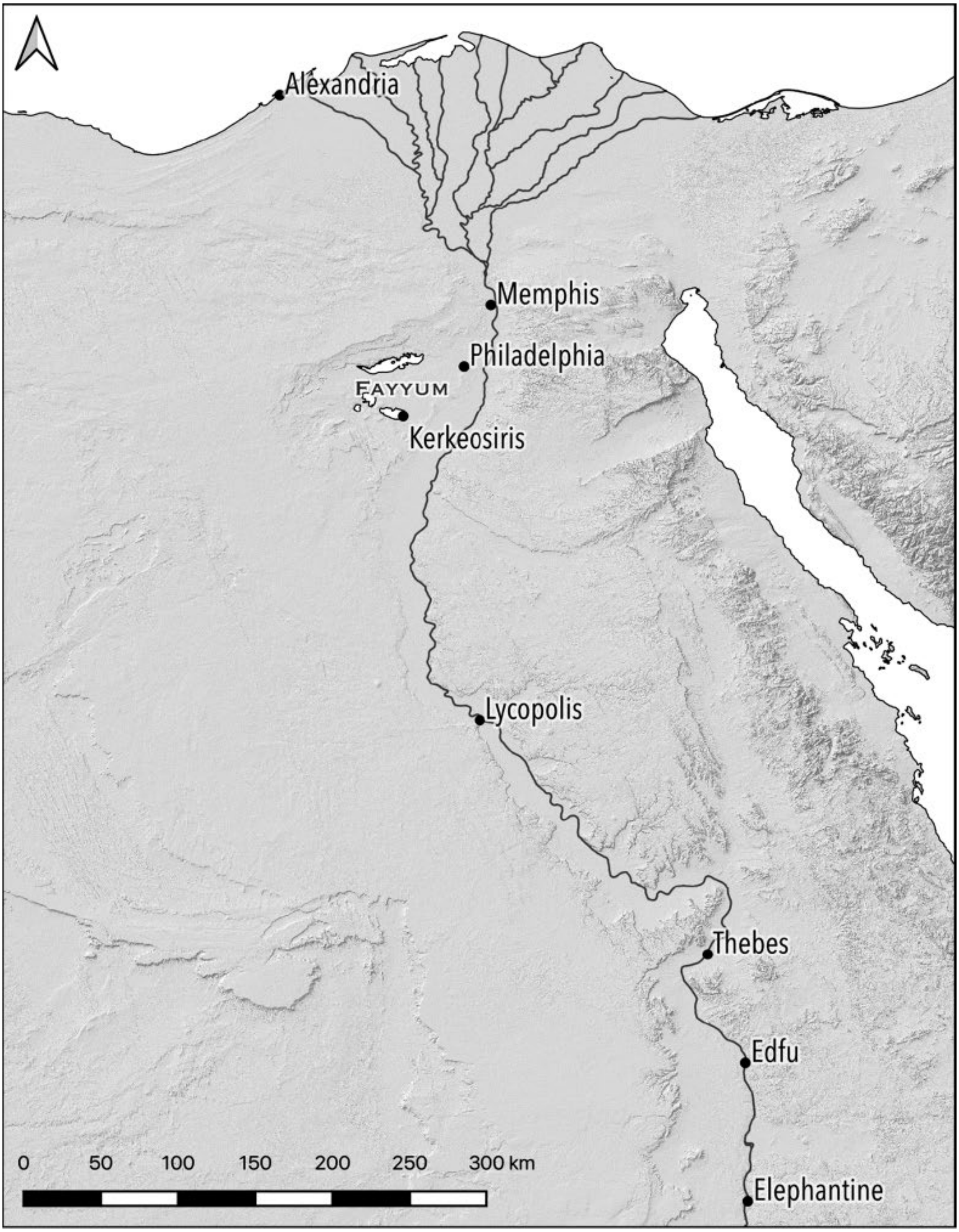

Figure 16.2 Map of Ptolemaic kingdom. Source: Map by David Hollander using QGIS and map files from the Ancient World Mapping Center. "inlandwater.shx", "ba_rivers.shp", "coastline.shp", "openwater.shp", and "carte_hillshade.tif". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm].

save Egypt from the Nile failure came "from Syria, Phoenicia and Cyprus and many other places at great expense, [by which] they saved the inhabitants of Egypt."[5] The Ptolemies controlled Palestine for the better part of the third century BCE. The Zenon Archive mentions

5 Ludlow and Manning (2016, p. 156).

another of Apollonios' "gift estates" located there. Here the texts, few though they are, exhibit similar features to agricultural practice seen in Apollonios' estate at Philadelphia outside of the Fayyum, with an emphasis on cash, wheat, and viticulture and the leasing of land controlled by Ptolemy II's finance minister Apollonios to tenant farmers.[6]

Agricultural production and demographic development reached a peak in the Ptolemaic and early Roman period, probably not reached again before the early nineteenth century.[7] The Zenon Archive documents new varieties of grape and the introduction of Milesian sheep. Tracing a wider spread of such experiments beyond Zenon and his circle is not possible.[8] The main substantive change in Egypt from earlier periods was without doubt the Ptolemaic state's emphasis on free-threshing wheat production. The demotic Egyptian documentary sources, coming primarily from Upper Egypt and from the context of temple estates, document the traditional land tenure system (Manning 2003). One recently published text dated from late second century BCE Edfu suggests that in temple contexts viticulture was far more extensive than it had been before.[9]

Overall, the Ptolemaic land tenure system was complex, and carried over traditional structures. Land called "royal land" was under the control of the crown, farmed by "crown tenants." At least that is the theory, developed largely on the basis of Greek papyri from the newly developed Fayyum region, but the ancient category of royal land existed as well, and it seems more likely that the Ptolemies carried over the term that was in effect a fiscal category of land without necessarily meaning that the king directly controlled it.[10] To be sure some "royal land" was situated within temple estates and controlled privately in Upper Egypt. "Temple land" was another ancient category adopted by the Ptolemies and referred to land controlled by the main temples throughout Egypt. A third category, "kleruchic" land, was given to soldiers according to rank and in exchange for the promise to serve when called upon. Over the course of Ptolemaic history, this category gradually developed the characteristics of private land. "Gift estates," *doreia*, are documented primarily from the third century BCE Fayyum, of which the estate of Apollonios at Philadelphia is the most famous.[11]

Without question, Egypt's agricultural yield could be exceptional, but the statement "at no time in the Ptolemaic or Roman periods, as far as we can see, did overall internal demand come close to matching or exceeding supply," must be qualified, as the author himself did after writing it (Bowman 2013, pp. 220–221). He qualifies by saying "averages smoothed over the period." And it is this, not smoothed averages but inter-annual variability, which was a critical factor in understanding productivity, internal supply and distribution, and social response to crisis, that we are now in a better position to understand, although much work still remains to be done. Consider, for example, these two examples. In 227/226 BCE, Ptolemy III sent a sizable gift of grain to Rhodes, after a devastating earthquake there, amounting to 30 million liters of grain, "one of the largest shipments known from the ancient world."[12] On the other hand, a few years earlier (the date of the text is not in fact specific, so other dates might apply), a large gift of grain to Egypt from Hieron II of Syracuse was

6 Pastor (1997); Kloppenborg (2008).
7 Hassan (1993); Monson (2012a, pp. 33–69).
8 Vines: *P. Cair. Zen* 59033; Milesian sheep: Thompson (2012, pp. 40–41).
9 Schentuleit (2006).
10 Monson (2012a, p. 76).
11 See Christensen et al. (2017) for the most recent treatment of Egyptian land categories.
12 Gabrielsen (2013, p. 68); Polyb.5.88/1–90.4.

received "during a shortage of grain in Egypt."[13] Kings, and perhaps to some extent markets, smoothed supply.

In both kingdoms, as elsewhere in the Hellenistic world, grain supply to cities was of special concern to the political authorities (Garnsey 1988). On the protection of the food supply to Alexandria, official correspondence urged:

> Take care that the grain in the nomes, with the exception of that expended on the spot for seed and of that which cannot be transported by water, be brought down—It will thus be [easy] to load the grain on the first [ships] presenting themselves; and devote yourself to such business in no cursory fashion—Take care also that the prescribed supplies of grain, of which I send you a list, are brought down to Alexandria punctually, not only correct in amount but also tested and fit for use.[14]

The basis of agricultural production in all periods of Egyptian history was, of course, the Nile River (see Chapter 26 in this volume). The annual flood, coming at a good time of year for a winter grain harvest, was fed by summer rainfall in the equatorial plateau (mainly via the White Nile) and the Ethiopian highlands (mainly via the Blue Nile and Atbara rivers). The annual flood surge and the Nile's headwaters were a marvel to ancient geographers, described most famously by Herodotus (2.19–2.28). It was caused primarily by monsoonal summer rain in east Africa and in the Great Lakes basin. Roughly 82% of the annual flood surge in the Egyptian Nile is attributed to water coming from the Ethiopian highlands around Lake Tana, creating the Blue Nile, 13.8% from the Atbara River, and 13.3% from the Sobat River. 16.5% of the water derives from the Great Lakes region, the White Nile, half of which is evaporated by the Sudd in modern Sudan.

Its flood volume is relatively small compared to the world's other great rivers. Before completion of the Aswan Low Dam in 1902 (and its successor, the High Dam completed in 1970), the annual flood was first observed at the first cataract (at Aswan/Elephantine) as early as June. Waters peaked in late summer (August to September) and generally receded by October, with sowing of the main crops beginning then. High productivity was achieved by harnessing the flood through hydraulic management of a network of dikes, canals, and enclosures to maximize groundwater recharge and alluvial deposition along Egypt's c. 745 mile (1200 km) Nile valley (Butzer 1999). However, a major feature of the flood, driven by seasonal rainfall associated with the East African Monsoon in the Ethiopian highlands around Lake Tana and drained primarily by the Blue Nile, is its pronounced inter-annual variability. The Blue Nile accounted for approximately 80% of annual summer flood volume to the Egyptian Nile. This was noted from ancient times, with insufficient or excessive floodwater (Nile "failure") often coincident with famine and mortality throughout Egyptian history. The variability occurred at several periodicities and was the result of complex geophysical forces. The primary driver is the El-Niño Southern Oscillation (ENSO), responsible for 25% of the variability. Other important drivers of long-term variability of Nile flow are the North Atlantic Oscillation (NAO), orbital and solar forcing, and human activity (Said 1993; Fraedrich et al. 1997; Kondrashov et al. 2005).

13 *FGrH* III B, p. 606; Athen. V.206d-209e. All that is certain is that the gift occurred during Hieron II's reign (269–214 BCE), but the 240s BCE fit the circumstances neatly. Huß (2001, p. 368) gives the broad time in which the gift occurred.

14 *P. Tebt.* 703, 70–85 (c. 210 BCE).

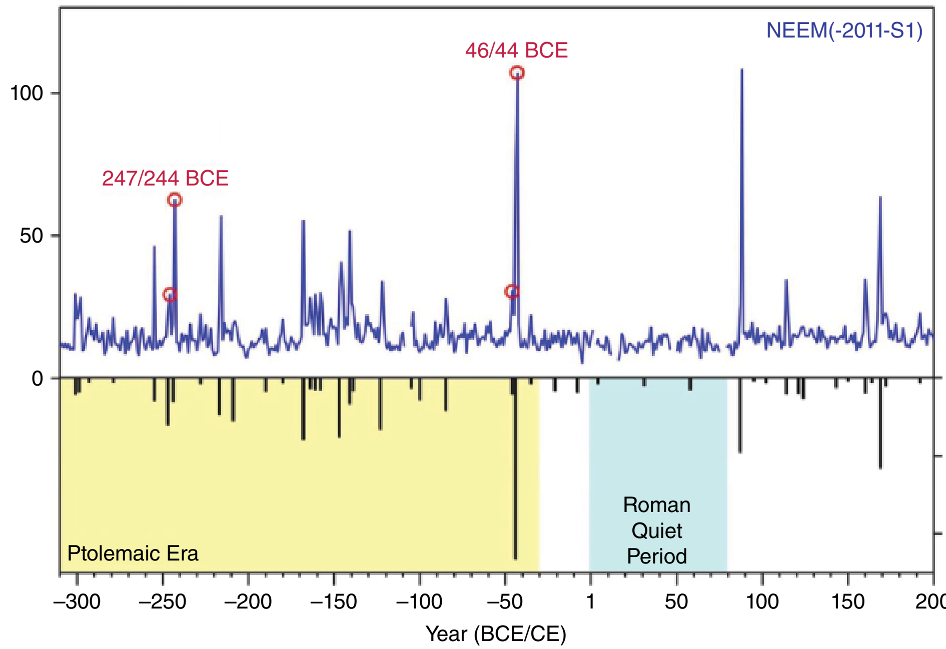

Figure 16.3 Chronology of explosive eruptions showing radiative forcing in Wm² (watts per square meter, bottom) and annual non-sea salt sulfate values (ppb) from ice core records from 305 BCE to 200 CE from the NEEM- 2001-S1 ice core record. Source: Courtesy of Michael Sigl, Paul Scherrer Institute, Switzerland.

Large explosive volcanic eruptions can impact the annual flood mainly by decreasing the solar radiation reaching Earth's surface, and thus the energy available to drive the evaporative flux of water from the ocean surface to the atmosphere (Trenberth and Dai 2007). This phenomenon is seen in reduced streamflow in many regions of the world (Iles and Hegerl 2015). Some climate models capture the hydroclimatic variability of East Africa and the Nile basin well (Oman et al. 2006), but streamflow impacts for the Euphrates and Tigris have received little attention. Large eruptions are known to significantly perturb the winter westerlies (Robock 2000), the positioning of which strongly influences the volume of winter snowfall over the Taurus Mountains (Turkey) that is available (via melting) to supply the Tigris-Euphrates Spring-Summer flood (Cullen and deMenocal 2000). Recent research has demonstrated the teleconnection between explosive eruptions and suboptimal Nile River flow that in turn could trigger social unrest. Presumably such reduction in river flow also had an impact on agriculture, food supply, and tax revenue, but these are not easily observed directly (Manning et al. 2017). Given the increasing precision of dating eruptions from sulfate deposition in ice cores, a useful time series can be developed to examine more precisely the relationship between annual reduction in streamflow and its socioeconomic impact on Ptolemaic and Seleukid society (Figure 16.3).

The ancient Egyptians measured the height of the annual flood at strategic places along the Nile such as Elephantine Island (Seidlmayer 2001). Few of these direct measured observations survive from the Ptolemaic period, but we do have qualitative observations preserved in the papyri. Our source for qualitative Nile flow in the period comes from the well-known table published by Bonneau (1971). The sources used (Bonneau 1971, pp. 217–220) are primarily taken from Greek documentary papyri dated from 261 BCE to 299 CE. We cannot establish a detailed annual record because of the gaps in the survival of texts, although there is now much new evidence in the Greek and demotic Egyptian papyri that would fill in some of these gaps. There are also gaps in dates and important differences in the nature of the sources themselves. Occasionally, a specifically dated text will provide an exact measurement of the Nile height. In most years, however, Bonneau established the quality of the flood by taking several texts from a given year as a composite indication of flood quality.

The Seleukid Kingdom

For Seleukid agriculture, cuneiform sources from Babylon (Figure 16.4) are the most important, but they are scarce for the period. The best material comes either from Asia Minor, Babylon, or from the preceding Achaemenid Period. Achaemenid land tenure institutions were probably slow to change everywhere in the Seleukid kingdom (Thoneman 2009). The balance between continuity and change is in any case not easy to measure. Achaemenid rule in western Asia built on ancient practice and shaped what the Seleukids did in terms of management. The Babylonian Astronomical Diaries, dating from the mid-seventh century to 61 BCE, form a valuable source for economic conditions at Babylon. "Astronomical Diary" is, in fact, a bit of a misnomer as Pirngruber (2017, p. 4) highlights, because the texts concern a plethora of other kinds of observations. These include conditions of the Euphrates flood and the prices of six commodities, together with weather, and astronomical observations. The texts are arguably the single most important price (and paleoclimatological) dataset from

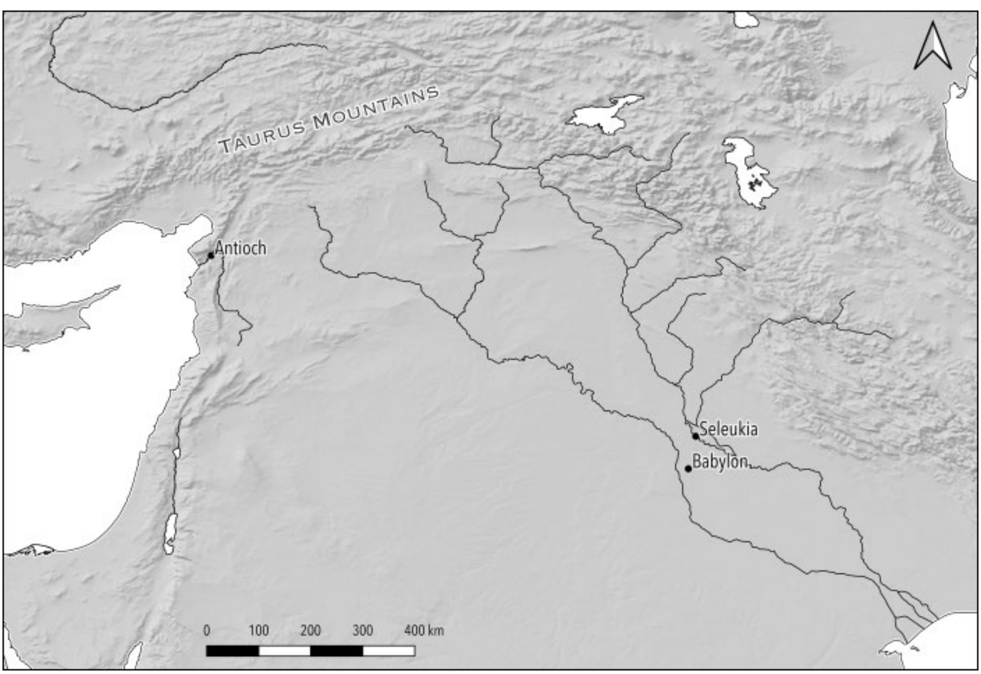

Figure 16.4 Map of Seleukid kingdom. Source: Map by David Hollander using QGIS, Natural Earth raster data, and map files from the Ancient World Mapping Center. "inlandwater.shx", "ba_rivers.shp", "coastline.shp", and "openwater.shp". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm].

antiquity. Information on the Euphrates river recorded in them is also of extraordinary significance, and while Slotsky's work (1997) was extraordinary, there remains much debate about the interpretation of the data (Pirngruber 2017, pp. 4–5 and the ongoing work by several scholars). No doubt future work will better integrate paleoclimate proxy records with this historical material. Outside of the Babylonian archives, our most important sources for Seleukid administration come from archaeological work, or from a distinctive region such as Palestine (Pastor 1997). It has been posited that Ps.-Aristotle's *Oikonomika* may well derive from an early Seleukid administrative context (Aperghis 2004). As such it is thought to provide a guide to the fiscal structure of the kingdom.

Broadly speaking, Seleukid agriculture had two distinct agricultural regimes, rain-fed or "dry farming" and irrigation agriculture practices in the great river valleys. This was a feature of all Near Eastern empires. Crop yields in the irrigated fields of southern Mesopotamia were higher than in rain-fed regions (Van der Spek 2007, p. 411). Water for the Tigris and Euphrates rivers, draining 158 302 square miles, is supplied by annual precipitation in the Taurus mountain range. Unlike the Nile River that was mediated by desert and marsh and thus was a slow-moving flood and exploited primarily by flood recession agriculture, the Tigris and Euphrates were supplied by Mediterranean westerly winter cyclones that produced rain and snowfall in the mountain ranges and a more dynamic flood. There were two components of variability. First, the seasonal rain runoff (December to March), and subsequent streamflow variability was driven primarily by the NAO. Half of the streamflow was driven by the second phase, April to June snowmelt, and not by the NAO. The rivers required much more maintenance and control than did the Nile. The Seleukid state invested in extensive irrigation networks (dikes, levees, canals, floodable marshlands) to maximize water inputs (Adams 1981; Gasche and Tanret 1998). Seleukid canal building is clear in the new area developed in the early third century BCE around the new royal city at Seleukia (Adams 1965). The continuing importance of tracking and controlling water levels of the Euphrates at Babylon is recorded in the Babylonian Astronomical Diaries (Slotsky 1997; Huijs et al. 2015). These texts are an invaluable source for market prices for several commodities (Pirngruber 2017).

The Neo-Babylonian (Jursa 2010) and Achaemenid periods are essential for understanding continuity and change in Seleukid agriculture. Massive resettlement of populations, and the development of new land, was not a new feature of Seleukid west Asia. But Seleukid activity, recovered by survey archaeology, in founding new colonies, building new irrigation canals and expanding the arable in some areas, the assignment of plots of land for specific purposes (grain, vines among other things) to new people, would have had a significant impact on several rural areas of the kingdom.[15]

Land Management

We are well informed about Ptolemaic bureaucratic involvement in agricultural production and taxation.[16] Documents generated by the bureaucracy emphasized centralized control and authority as well as tax collection. Grain was taxed in kind; orchards and vineyards in cash. *P. Tebt.* 703, for example, dated to the mid-third century BCE outlines the duties of the *oikonomos*, which included the careful attention to irrigation canals, the condition of crops

15 Kosmin (2014, pp. 192–99).

16 In general, see Manning (2018).

Table 16.1 Data from a crop report from the Fayyum, Egypt. January, 235 BCE. Source: Adapted from Thompson (1999).

Crop	*Arable under production (in arouras)*	*Total of arable, in %*
Wheat	135 315.5	74.6
Lentils	880.34	0.7
Beans	--------	--------
Barley	26, 260	14.5
Olyra (emmer)	3,118.69	1.7
Grass	4, 6121.5 +	2.5
Vetch (arakos)	10, 109.5 +	5.6
Sesame	261	0.2
Castor	55	0.04
Poppy	100	0.06
(3 other crops)	201.5	0.10

1 *aroura* = 0.66 acres.

and animals, and the adjudication of complaints in these areas, and the transportation especially of grain to the city of Alexandria, always of central importance to the kings particularly in periods of crisis.[17] The auditing of the revenues generated in the nome was another prime concern of the *oikonomos.* Clearly the centralizing ideology was overwhelmingly concerned with revenues. Ancient administrative districts, called "nomes," were maintained and to some extent altered by the Ptolemies. At the nome level, three officials: the nomarch, the *oikonomos,* and the *basilikos grammateus* ("royal scribe"), were responsible, respectively, for agrarian production, taxation, and record keeping, primarily with conditions of land and land tenure. The structure of that system is at its most elaborate and articulated in the so-called Revenue Laws.[18]

The expansion of free-threshing wheat production and distribution (probably a variety of *Triticum durum*) was the primary concern of the royal economy. The so-called "Syrian wheat" (*Triticum aestivum)* was introduced in the early Ptolemaic period, but did not prove popular.[19] The production of free-threshing wheat during the third century BCE, well attested in the harvest tax receipts from Upper Egypt and in land registers from the Fayyum, may have led to greater vulnerability of the rural population to drought/famine given wheat's sensitivity to drought. The shift to wheat in the newly reclaimed Fayyum is dramatically illustrated by a crop report dated to the year 235 BCE that covered nearly half of the total arable land in the Fayyum, almost 500 km^2 (Table 16.1). A similar emphasis on wheat (72% of the rents) is found in a text that summarized rents collected from the Hermopolite nome in Middle Egypt dated to the second century BCE (Monson 2012b, p. 29). Oil crops, including the olive although probably not widely cultivated before the Roman period, were extensively grown (Thompson 1999b, pp. 131–132).

17 For analysis of the text, see Samuel (1971); Huß (1980). For English translations and comments, see Austin (2006, no. 319); Bagnall and Derow (2004, no. 103). On the control of agricultural production at the local level, see Crawford (1971); Cuvigny (1985).

18 Grenfell and Mahaffy (1896); Préaux (1939); Bingen (1978).

19 Berlin et al. (2003).

Therein 74.6% of the arable land was under wheat, while barley amounted to 14.5% of the total production.[20] The shift to this species of wheat to some extent tracked Greek demand everywhere, but according to one recent assessment, "(t)he changeover was most dramatic in Egypt, where the native emmer was almost entirely displaced during the Ptolemaic period by the durum wheat preferred by the Greeks."[21]

The Ptolemies placed great emphasis on free-threshing or naked wheat. The commodity was also used as the main unit of account in grain accounts, against which other commodities, including barley and emmer were valued. But Ptolemaic exports of wheat to external markets in the Mediterranean, primarily through Rhodes, were probably very important to royal revenues. The traditional use of maslin crops as a risk-reduction strategy, called in the Greek texts by the neologisms "barley-wheat" and "barley-emmer," are documented in the Ptolemaic period.[22] Wheat could hardly be grown every year, and secondary plantings of vetch, grass, or some other crop was probably routine.

An important phenomenon to consider when discussing Ptolemaic fiscal and agricultural practices are the periods of social unrest (Veisse 2004). One of the longest periods of unrest known in the ancient Mediterranean world, lasting from 207 to 186 BCE, broke out in the Thebaid (Upper Egypt). Much of Upper Egypt from Asyut (Lycopolis) up to Aswan (although the border town of Aswan, with its garrison, appears to have remained loyal to the Ptolemies) pulled away from Ptolemaic control. Two kings, in succession and of unknown origin, were proclaimed. As far as the evidence permits, no taxes were collected by the state for twenty years. Serious unrest is also documented in the Delta from 197 to 185 BCE (McGing 1997, p. 284). Riots involving a wide social spectrum are recorded in Alexandria in 203 BCE. The southern revolt was finally put down in 186 BCE, and a heavier presence of soldiers and administrative control in the Upper Nile valley was established. Documents suggest that the revolt was both violent and widespread. Dramatically, one of the first acts of the rebels was the seizure and the stoppage in the construction of the great temple at Edfu. Temple construction in Thebes was also stopped. General confusion reigned throughout the countryside. Land was abandoned. One text, from Asyut in Middle Egypt, reflects what was probably widespread damage to agricultural production:

> *– – of Lykon polis – – found to be in the margin of error – – –* [*in addition to the survey carried out*] *by Herakleides and his staff – – 22 1/32 arouras which were discovered, i.e. 1/3 1/8 part of – – of Ophiertaios, 228 1/2 1/4 1/8 1/32 arouras, 15 1/2 1/8 1/32 arouras, – – which have not been overlooked – – for confiscation by the officials of the land–tax so that the entire surface of the land in the nome is measured. From the time of the revolt of Chaonnophris it happened that most of the farmers were killed and the land has gone dry. When, therefore, as is customary, the land which did not have owners was registered among the "ownerless land," some of the survivors encroached upon the land bordering their own and got hold of more than was allowed. Their names are unknown since nobody pays taxes for this land to the treasury. But of the cultivated area nothing has been overlooked, because the land–measurement of what is sown has taken place each year, and the taxes are being executed – – –*

On Seleukid land management there is little detailed information.[23] There would have been, as in earlier times, differences between rain-fed regions in northern Mesopotamia and the

20 Thompson (1999).
21 Sallares (2007, p. 33).
22 Mayerson (2002).
23 See Capdetrey (2007, pp. 135–166).

irrigated land in southern Mesopotamia.[24] As in earlier practice, and so too in Egypt, the control of land was divided between direct royal exploitation, temple holding, and to some extent private tenure arrangements. Royal domains and royal gifts of land are documented even in Babylon, although the extent of royal holdings is not known (Pirngruber 2017, pp. 67–68). The distinction between crown and private land appears to have been carried over from Achaemenid times, but private property may have been more extensive under the Seleukids. Royal land, much like the Ptolemaic system, was worked by "royal peasants," *basilikoi laoi*. The continuation of the *hadru* system and the extent to which it carried over from an ancient system of military land grants similar to the kleruchic land system in Ptolemaic Egypt is debated (Pirngruber 2017, p. 69; cf. Van der Spek 2007, p. 412). Land was assigned in land grants (*kleroi*) to new settlers throughout the kingdom as a means of social control and as a method of intensifying agricultural production. Northern Syria and the middle Tigris regions appear to have undergone the most radical change (Kosmin 2014, pp. 195–198).

The annual flood of the Euphrates arrived in the Spring. Grain harvest in Mesopotamia typically occurred during the summer. As in earlier Mesopotamia, barley was the main crop in the irrigated landscape of the south (see Chapter 26 in this volume) with wheat produced in rain-fed areas in the north. Babylonian crop yields were high because of its irrigation network and the use of the seeder plow (Chapter 26 in this volume).

We do not know the total size of arable land in Hellenistic Babylonia. Barley and date production were the traditional cultivars, and this no doubt continued under the Seleukids. Intensification in agriculture and in settlement was a comparatively slow process in the Hellenistic period. More intense development occurred in the Tigris region around the new capital at Seleukia on the Tigris. The city of Babylon and its hinterland itself appears to have had an independent or quasi-independent status, "to some degree autonomous on a local level" (Boiy 2004, p. 216). That Babylonia, however, was an important part of the Seleukid kingdom is demonstrated by local Babylonian records of royal activity including visits to important temples in the area (Boiy 2004). It was probably, however, only loosely integrated into the Seleukid state economy:

> The extent to which the Babylonian market was integrated in the world market. Karl Gunnar Persson has argued that "given the high costs of transport, the slow flow of information and the risky nature of local harvest carry-over, harvest fluctuations necessarily had a large impact on supply and prices. (…) The basic idea applied here is that market integration is related to the homogeneity of information in different markets and the opportunities for arbitrage and trade – that is, for exploiting the gains from moving goods from where prices were low to where prices were high" (Persson 1999:91). Hence Persson expects "price volatility to *decline with the extent of market integration and over time*" (Persson 1999:93; italics Persson). If we take this into account, one must conclude that the integration of the market of Babylonia with the rest of the (Seleucid) world was poor. Price oscillations were caused by the alteration of good and bad harvests, but warfare at home also appeared to be an important factor.[25]

The Babylonian region was, thus, a "closed system" (Aperghis 2004, p. 252); i.e. agricultural production was unlikely to have moved outside of the region, given transportation costs and local needs. But there were on some occasions special circumstances such as supplying military campaigns in Syria or Asia Minor when Babylonian commodities were used by the

24 Renger (1995) provides an historical overview of land tenure conditions in Mesopotamia.
25 Van der Spek (2003, p. 532).

Seleukid state. In "normal" times, it is presumed that production in the Babylonian hinterland supplied the local population. Van der Spek (2008) noted that the population of Babylon in the Seleukid era (ca. 300–141 BCE) could be fed by local production about 60% of the time. The decline of prices has been explained in the past in several ways: a tax decrease, increased salinization, and a reduction in silver supply. Climate change was likely a factor in barley and date prices (Van der Spek and Mandemakers 2003; Van der Spek and van Leeuwen 2014).

Tools and Equipment

Traditional lifeways in rural areas of Ptolemaic Egypt were probably left undisturbed. Ancient water lifting machines such as the *shaduf*, although not well documented in surviving texts, likely remained a standard tool to lift small amounts of water onto land. Scholars in the Alexandrian library mention several new machines, including the Archimedean screw. The diffusion of such new technology is difficult to trace either in the papyri or in the archaeological record. One famous Greek text (*P. Edfu* 8) suggests that the invention of new technology was not limited to the Alexandrian library. The text, a petition to the king requesting a royal audience and signaling some kind of new irrigation machine, was written by a man (probably a soldier given his name and title) living in Edfu, a major temple town in Upper Egypt. The text is not dated specifically, but it is generally thought to be a mid-third-century BCE text, and dating the text to ca. 245 BCE fits the circumstances.[26] It mentions a Nile failure of three years' duration, and a new irrigation "machine" that could "save" Egypt from famine:

> *To King Ptolemy, Greetings, from Philotas, the fire-signaller, one of the Kleruchs*
> *in Apollinopolis-the-Great. Given that now and for a long time, the inundation*
> *has become insufficient, I want, O King, to inform you of a certain machine the use*
> *of which does no damage and by means of which the country may be saved.*
> *Since during the last 3 years the river has not flooded, the dryness will produce*
> *a famine that […] but if you wish, this will be a year of good flood.*
> *I ask you, O King, if it seems good to you, to order Ariston the strategos, to*
> *grant me 30 days sustenance, and to send for me as quickly as possible to*
> *you or […] a petition so that, if it pleases you, seed will grow immediately.*
> *Thanks to your decision, within 50 days there will immediately follow a plentiful*
> *harvest throughout the whole Thebaid. Farewell.*[27]

We do not know specifically what the "machine" mentioned in the petition was. The introduction of the water-lifting device known as the *saqiyah* is generally dated to around this time, c. 240 BCE, on the basis of its mention in Philo of Byzantium's *Pneumatics*.[28] Michael Lewis has suggested that between 260–230 BCE many new water-lifting machines were invented in Alexandria.[29] Whether Philotas' machine itself was first "invented" in Alexandria or elsewhere and then improved upon in response to a specific flood crisis or for other reasons, remains unclear.[30]

26 Lukaszewicz (1999, pp. 31–32).
27 Translation from the French of Lukaszewicz, "Le Papyrus Edfou 8 soixante and après," pp. 29–35.
28 For a good survey of water-lifting technology and innovation, see Schomberg (2008).
29 Lewis (1997, pp. 20–21).
30 Wilson (2008, pp. 351–352); Oleson (2000).

Animal Husbandry

Like so much else, our sources for animal husbandry in Ptolemaic Egypt primarily derive from villages in the newly settled Fayyum. Developments in the period followed the increasing monetization of the economy and the growth of urban areas that demanded many of the secondary products of animals such as meat and cheese (Thompson 2011, p. 399). Greeks who had come to Egypt, particularly the military settlers, drove wool production for markets using slave labor. This was an important new aspect of animal husbandry in the Ptolemaic period (Thompson 2011). Sheep and goats were an important component of the estate economy documented in the Zenon Archive and also among military settlers (kleruchs) in Upper Egypt (Thompson 2011, pp. 395–396). Those individuals called "herdsman, servant of Horus at Edfu" in private sales of small plots of land in third century BCE Edfu presumably reflect an ancient practice of temple estates also controlling sacred flocks of animals. The use of some pasture land, guarded by state officials, was sold and monitored by the state, but there is evidence also of private sales of pasturage rights (Monson 2012b, pp. 22–24), and we are ill informed about the Delta, a historic region for cattle especially. Animals, either royally or privately owned, were registered in the census along with people, and were taxed in cash (Clarysse and Thompson 2006, 2: pp. 206–225). The same practice appears to have been applied to external territory as well (Syria and Phoenicia: *C. Ord. Ptol.* 21; Austin 2006, Text 260). Cattle were the main draft animal, and the omnipresent donkey the main transport vehicle.[31] The horse is well documented among the cavalry soldiers of the Ptolemaic army. A variety of pig species are documented in the papyri; pig rearing seems to have been dominated by Greeks and the military class, as with sheep and goats, and both small and commercial-size flocks are known (Thompson 2002).

Sheep, goats, and cattle are also well attested in the Seleukid kingdom, and are well known in earlier contexts as well (Jursa 2010). As far as the scant evidence permits, and in contrast to Ptolemaic Egypt, western Asia, except for a few regions, did not allow for commercial production (Aperghis 2004, p. 63). One might speculate that things would have been different in the hinterlands around the Seleukid urban areas. Traditional small flock pastoralism was no doubt common.

GUIDE TO FURTHER READING

The study of Ptolemaic Egyptian agriculture has been one of the oldest branches of Ptolemaic history. The papyri provide rich details of land tenure in some areas, primarily the newly reclaimed Fayyum and in the Thebaid, the region dominated by ancient temple economies. Weber's (1909 [1998]) treatment of Hellenistic agriculture, while dated and narrowly conceived, still contains valuable comparative insights, emphasizing social relations and fiscal institutions within longer-term historical developments in Egypt and the Near East. Schnebel's (1925) and Préaux's (1939) surveys are still a good account of Ptolemaic agriculture using the Greek sources, but both are outdated given the amount of published material since, and do not cover Egyptian material. Rostovtzeff's (1922) classic account of the Zenon Archive is also valuable, but was only based on a limited number of published sources. His emphasis on centralized control of the agricultural system is generally rejected now. Pestman's *Guide* should be consulted. The second largest Ptolemaic archive, that of the village scribe Menches, in charge of supervising agriculture around the village of Kerkeosiris at the end of the second century BCE, has been the subject

31 On the estimated number of donkeys in Egypt, see Manning (2002/2003) with the literature cited therein.

of two important studies, Crawford (1971) and Verhoogt (1998). The Egyptian tradition of land tenure in the Ptolemaic period is treated by Manning (2003). An important group of demotic Egyptian texts concerning the fiscal system and land tenure conditions in the early Ptolemaic Fayyum is Monson (2012b). Christensen et al. (2017) publishes a very important land survey text from the Edfu nome covering the third and second centuries BCE, of extreme importance for the history of Ptolemaic administration of land and military settlements on temple land. Schomberg (2008) provides an excellent survey of Hellenistic water-lifting technology and its legacy in the Arabic writers. For the shifts in diet, see Crawford (1979). A general treatment of Seleukid agriculture is provided by Aperghis (2004, 2015) and by Van der Spek (2007). The Babylonian archival record provides us the most detailed view of the state of agriculture in western Asia in the Hellenistic period. See Boiy (2004), Slotsky and Wallenfalls (2009), Jursa (2010), Temin (2013) and Pirngruber (2017). The Mesopotamian and Achaemenid background is essential, for which see Briant (2002) and Kuhrt (2007, pp. 763–825), and Chapters 26 and 27 in this volume.

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CHAPTER SEVENTEEN

Adapting to a Diverse Landscape: Agriculture in Hellenistic and Roman Anatolia

Turan Takaoğlu

Agriculture has always been the mainstay of the land that we regard today as Anatolia, the territory of present-day Turkey, excluding Thrace. With its fertile arable land, ample water resources, and diverse species of plants and animals that have made agriculture the main economic pursuit, Anatolia has often been seen as one of nature's most generously endowed lands, one that has maintained a remarkable degree of self-sufficiency throughout its history.

Etymologically speaking, Anatolia derived its name from the ancient Greek word Ἀνατολή, meaning "east" or "sunrise." This name is a relatively late construction that first began to be used in the Middle Byzantine period, since the region up to that time was called "Asia" or "Asia Minor," mainly due the fact that it forms the westernmost extension of the continent of Asia. The only difference between the names Anatolia and Asia Minor is that the latter has not often been considered to include the eastern part of Turkey, as the former does. This is the main reason why the name of Anatolia is preferred in this modest essay instead of Asia Minor, because the Greek and Roman presence was felt far beyond the Euphrates River Basin in eastern parts of Turkey as early as the Hellenistic era.

In a land like Anatolia, which has an extraordinarily complex and varied landscape, one needs to take into account a wide range of information to form a coherent picture of agriculture in the Roman period. It may be beneficial in this sense to examine aspects of agriculture in Anatolia in relation to issues such as the geography of the land, patterns of agrarian land use, types of crops and fruits cultivated, implements used during the various stages production, changes observed in agricultural strategies, and land ownership for a proper understanding of Anatolian agriculture during the Hellenistic and Roman eras. The role of local deities serving as patrons of farming should also be considered in this context, because a broad range of knowledge exists regarding the behavioral patterns of farmers, who frequently sought divine protection for their crops and livelihood in Anatolia.

The study of agriculture is also a relatively nascent field of research within the discipline of classical archaeology in Turkey, due in part to the diversity of evidence that has made scholars

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

reluctant to draw a full picture of this topic (Mitchell and Katsari 2005). The initiation of an interdisciplinary project at the Pisidian site of Sagalassos in southwest Anatolia by Marc Waelkens in 1990 was certainly a turning point, because it included environmental, zooarchaeological, archaeobotanical, and ethnoarchaeological objectives into its research agenda (Poblome 2013). This new approach, allowing classical archaeologists to view the Greek and Roman cities as places mutually interacting with their surroundings, was evidently an important step toward answering questions about the natural environment around cities, what plants were grown, and what animals were raised. Besides Sagalassos, the Phrygian capital of Gordion has been another exceptional site known for its interdisciplinary environmental and ethnoarchaeological approaches (Gürsan-Salzmann 2005; Miller et al. 2009; Miller 2010; Marston and Miller 2015). Recent interdisciplinary studies have helped us picture agriculture and land-use strategies adopted by people there throughout the city's occupation, an endeavor that has rarely borne fruit before in classical archaeology of Anatolia, apart from the above-mentioned Sagalassos project. Furthermore, numerous surface investigations carried out in the rugged rural areas between Lycia and Cilicia in southern Anatolia, with special emphasis on agricultural production, including olive and grape growing, has radically transformed our knowledge of the countryside (Rauh et al. 2006; Bulut 2005, 2007; Diler 2010; Aydınoğlu 2010). This is not the case in all locations. It should be mentioned that the manner in which land in the Pontic range along the Black Sea coastline and in mountainous eastern Anatolia was used for agrarian needs still requires archaeological research, although ethnoarchaeological data point to a nomadic and/or semi-nomadic lifestyle there. In this context, I present here a synthesis of the extant sources for agriculture in Anatolia belonging mainly to the Hellenistic and Roman eras.

The Geography of Anatolia

Because agricultural patterns cannot clearly be understood if they are not seen as mutually interacting with their physical environment, Anatolian agriculture in the Roman period must be assessed in the context of its highly complex and varied landscape, dominated by mountains, plateaus, and river valleys. Broadly speaking, Anatolia can be regarded as a rectangle, with the distance from the eastern boundary to the Aegean coast being more than 1600 km, and that from the Black Sea coast to the Mediterranean shoreline measuring about 800 km at its widest extremity. Its geography is dominated by the contrast between the high central plateau at an elevation of 1000 m above sea level and two major mountain ranges that lie parallel with the coasts, namely, the Pontic range running along the Black Sea coast to the north and the Taurus Mountains alongside the Mediterranean to the south. These two mountain ranges, reaching their highest altitudes in the east, gradually decrease in height toward the Aegean coast. Such topography is characterized by highly contrasting relief features derived from geological movements, resulting in dramatic climatic differences and making communication difficult between the coastal zones and inner regions.

Consequently, this dichotomy between the central Anatolian plateau and the peripheral mountain ranges gave rise to the emergence of considerably diverse agricultural pursuits and lifestyles. The Anatolian peninsula overall is bordered by the Black Sea (Pontus Euxinus) to the north, the Aegean Sea on the west, and the Mediterranean Sea to the south. Being one of the world's great crossroads, the Sea of Marmara (Propontis) is the only sea passage from the Black Sea to the Aegean, through the narrow straits of the Bosphorus and Dardanelles, and thus separates Anatolia from Thrace on the European mainland. In its proximity to both

Asia and Europe, Anatolia has traditionally been seen as a land bridge or contact zone between these two continents (Dewdney 1971, p. 2).

The Pontic mountain ranges in the north runs parallel to the coast, and its peaks rise steeply to heights of 1000 m or more a few kilometers inland, while short streams flow swiftly northward perpendicular to the Black Sea. The mouths of these streams in narrow valleys form small deltas and coastal basins around which settlements were able to grow. Such formations, along with the lower slopes of hills flanking the streams, proved highly productive for arable farming. The eastern part of northern Anatolia or the Black Sea region receives the greatest amount of precipitation in Anatolia with an annual average of 2500 millimeters. This area as a consequence has a fairly mild and moist climate (the average temperature in summer 23 °C and in winter 7 °C) that differentiates it considerably from other parts of the country. The contrast between high temperature and heavy rainfall pattern results in dense vegetation cover, making archaeological sites, consisting mainly of ephemeral materials, extremely difficult to identify. Ethnographic investigations carried out in the eastern Black Sea region demonstrate that the settlers of the region preferred the wooden dwellings with thatched roofs, a part of long-inherited knowledge, until several decades ago (Tunçel et al. 2004). Well-watered high altitudes rich in pastures provide contemporary farmers with the opportunity to pursue a transhumance-based lifestyle that mainly involves cattle rearing. Almost all the farmers of villages situated at low altitudes migrate seasonally to summer encampments in the uplands during the late spring. The first-hand examination of ethnographic data related to agricultural pursuits in this area also demonstrate that the farmers of this region are busy with sowing crops such as barley, beans, and maize on their steep lands around their houses in the villages before moving to the summer encampments. Such agricultural production, which fulfills only the needs of a given house, has not been geared toward exchange due to the small size of the lands each family owns (Takaoğlu in press). The subsistence pattern prevailing in this area since the medieval period may well have its roots in the Roman period. One exception is probably the eastern coastal strip, where tea plantations and hazel-nut growing took over traditional agricultural pursuits nearly a century ago.

The middle part of the Black Sea region is at present among the most densely cultivated land of Anatolia. The River Halys (Kızılırmak), emerging from the mountains in eastern Anatolia, joins the Black Sea after passing through the lands of central Anatolia. The fertile plains and surrounding lands provided optimal conditions for both arable farming and animal husbandry. Precipitation amounts decrease in the middle part of the Black Sea region dominated by the gentle relief features that make wheat, barley, rice, and maize cultivation preferable, although this region has been noted for its high-quality tobacco products, which were introduced into the region in the nineteenth century.

In the western part of the Black Sea region, where the height of the Pontic mountains drops somewhat, the Sangarius (Sakarya), running in various directions, offered river basins and large deltas with arable land favorable for intensive cereal cultivation. The area between and around these major rivers was home to the Phrygians from the Early Iron Age until the Late Roman era. The River Sangarius, which rises near the city of Pessinus, runs northward through the regions of Galatia, Phrygia, and Bithynia, then flows into the Black Sea.

The south of Anatolia is dominated by the Taurus Mountains, which rise abruptly from the sea at an average of 2000 meters above sea level and extend westward parallel to the coastline, maintaining more or less the same altitude. The climate here is truly of a Mediterranean nature, often marked by summer drought and precipitation varying from year to year. The annual precipitation in this region ranges between 600 and 1000 millimeters, though this ratio declines toward the east. This southern Anatolian region as a consequence has a hot and dry climate (average temperature in summer 26–28 °C and in winter 8–10 °C). The most fertile plain is in Cilicia, reached from the interior only via a natural pass called the "Cilician Gates." This plain, watered by the Sarus (Seyhan) and Pyramus (Ceyhan) rivers, is now mainly devoted to cotton production and wheat cultivation. The Pamphylian Plain, on the other hand, was reached from the interior plateau either through the pass located at Termessus or the one at Ariassus. The rest of the Taurus Mountains exhibit a quite rugged topography, with several plateaus located at high altitudes. Cereal cultivation is at present practiced only in a series of isolated uplands, while coastal basins to the western part of southern Anatolia are devoted to the production of citrus fruits. The ancient regions of Lycia, Pamphylia, Isauria, Pisidia, and Cilicia are consequently well suited for olive and grape growing, as well as for a nomadic pastoral economy. The geography probably led the populations of the region to develop a pattern of transhumance based on the movement of flocks of sheep or goats between lowland villages and summer pastures located at high elevations. The preponderance of transhumance-based strategies might have been common particularly in arid areas characterized by a relatively small amount of annual rainfall.

Between the Pontic and Taurus ranges and the mountainous eastern Anatolian zone is the central Anatolian plateau, which has a diverse landscape with an altitude ranging between 600 and 1200 m above sea level from west to east. However, the plateau is by no means a homogeneous landscape characterized by flat ground, as the name would imply. The vast and bare landscape contains contrasting geographic features such as uplifted blocks and sunken basins. Temperatures vary considerably between the summer and winter seasons, with rather dry summers and autumn but very cold winters. Despite the mostly steppe-like terrain accompanied by harsh climatic conditions, agriculture has always been the dominant activity on the central Anatolian plateau, where the majority of the population depends on crop cultivation for their livelihood. Comprising more or less the eastern half of the central Anatolian plateau, the ancient region of Cappadocia is dominated by two high volcanic mountains, Mount Argaeus (Erciyes) to the east and Mount Hasan to the west. Volcanic soils have made agriculture a popular pursuit in Cappadocia, although the relief factor limits the amount of land that can be cultivated. The fertile arable lands of central Anatolia (250–500 millimeters rainfall zone) are at present devoted to the production of wheat, barley, oat, rye, legumes, lentils, chickpea, and common beet. In addition, animal husbandry based on sheep and goats has long been a common subsistence pursuit in central Anatolia.

In western Anatolia, four major east-west oriented river valleys separated by mountain chains dominate the landscape. The broad deltaic plains and the valley slopes formed by these four major rivers, namely, the Hermus (Gediz), Caicus (Bakırçay), Cayster (Küçük Menderes), and Meander (Büyük Menderes), are the most fertile cultivable lands in western Anatolia. Due to alternation of mountains and valleys stretching perpendicular to the Aegean coastline, the links between the littoral zones and the Anatolian hinterland were sought along land-based routes that followed these four major river valleys for ages, as the clustering of settlements around them indicate. Major Greek and Roman cities located in extremely productive lands around these major river systems all had extensive and fertile rural territories. The regions of Bithynia, Lydia, and Caria from the north to the south all constituted a transitional zone between the western Anatolian littoral dominated by the coastal alluvial plains of these four major river systems and the central Anatolian plateau. Western Anatolia has a mild Mediterranean climate with average temperatures of 9 °C in winter and 29 °C in summer. Olive and olive oil production is particularly important throughout the western Anatolian littoral, since olive trees do not often thrive above 900 m elevation. Over 70% of olive trees in all of Turkey are now located in western Anatolian littoral zones. At present, grape growing is widespread only in the gently sloping lands around the Hermus River basin, where grapes were grown for either wine or its raisins. But this was not so prior to the 1920s, when grape cultivation for wine production was an important component of the agricultural economy of the societies of the western Anatolian littoral. Vineyards dominated certain parts of the landscape of this region for millennia until a gradual decline started to occur in the intensity of grape cultivation following the population exchange that took place between Turkey and Greece in 1923 under the Treaty of Lausanne. Joined by incoming Turks from the Balkans, the local Turkish populations of this region gradually began to replace most vineyards with olive groves because of religious prohibitions against alcoholic beverages and the high taxes levied on wine producers (Kaplan 2007). Thus, one needs to be cautious when studying the past patterns of olive and grape growing in western Anatolia based on merely the current distribution of vineyards and olive groves.

The well-watered fertile arable lands around the Meander and Caicus river basins, on the other hand, are at present intensively cultivated for cotton, though cereal cultivation and olive and fig growing are also of great importance for the present-day inhabitants of the region. Tobacco production, which was the main commercial product for the inhabitants living in villages around the Hermus River basin until two decades ago has almost completely ended, due to quota limits, and olive trees have replaced tobacco fields.

Mountainous eastern Anatolia is, on the other hand, characterized by three major river systems around which settlements developed. The Euphrates and Tigris rivers, emerging from eastern Anatolian sources, flow southward through Syria and Iraq into the Persian Gulf; while the River Araxes rises in northeastern Anatolia and flows eastward to the Caspian Sea after passing through the Caucasus. The eastern fringe of Anatolia is clearly marked by the region's highest peak, Mount Ararat (Ağrı), best known as the final resting place of Noah's Ark after the Great Flood, as related in the Old Testament (Genesis 8:4). Being the second highest mountain, situated on the northeastern shore of Lake Van, Mount Nemrut is another geographical feature that delineates the eastern border of Anatolia. Beyond the Euphrates to the east, a Greek and Roman presence has been documented as far as the Araxes River in eastern Anatolia. At one time, thinly settled eastern Anatolia was largely nomadic or semi-nomadic in character, whereby herding sheep and goats in large numbers in grazing lands should have been the predominant activity mainly during the summers. This is because the winter is very long, and snow remains on the ground almost from November until the end of April (the average temperature in summer is 17 °C and in winter is –13 °C) in most parts of eastern Anatolia, making animal husbandry an unavoidable choice for survival in such a harsh environment. Due to the large-scale clearance of tree cover derived from anthropogenic factors, the high-altitude areas are at present largely devoid of forests. The open pastures resulting from the clearance of forests make traditional nomadism an unavoidable subsistence pursuit in the eastern highlands of Anatolia. As a consequence, the secondary products of animals play an important commercial role for the present inhabitants of eastern Anatolia, supplemented by cereal cultivation that is limited to the basins surrounding the major river systems of this region (Zimansky 1985; Yakar 2000, p. 381).

Agrarian Land Use

Because rural areas supplied the main agricultural needs of urban centers, the economy of any ancient city cannot properly be understood without seeing it in the context of its relationship with its surroundings (Whittaker 1990). Archaeological evidence for agrarian land use is notoriously thin regarding the Achaemenid dominion between c. 540 to 330 BCE. The famous Mnesimachus inscription carved on a wall of the Temple of Artemis at Sardis, dating to the earliest stages of the Hellenistic era, provides some information regarding Achaemenid land management strategies (Dusinberre 2013, p. 39). This inscription shows that the estates located in Lydia during this period were centered on large houses, surrounded by vineyards, orchards, gardens, and fields as well as outbuildings for field laborers and livestock.

Increasingly, archaeological evidence, particularly from western and southern Anatolia, indicates that the immediate vicinity or countryside of cities was exploited through evenly spaced inter-visible farmhouses or isolated field houses dispersed in the open countryside from as early as the late Classical period. There has recently been a growing emphasis on the study of field houses and mixed farming centered on the production of cash crops, as well as grapes and olives in the immediate vicinity and countryside of cities in western and southern Anatolia. Such agrarian structures of varying functions and sizes, used either permanently or seasonally, began to appear following the beginning of the Hellenistic period and were evidently related to grape and olive growing for wine and olive oil, respectively, in addition to cereal cultivation. They are ubiquitous in surface surveys, either with architectural remains or only by artifact scatters in most regions of Anatolia, as also observed in most parts of the Mediterranean. Intensive surveys carried out in the territory of Sagalassos, for instance, identified numerous rural settlements such as farms and villages that point to intensification in the exploitation of the land following the Romanization of the region in the late first century BCE. These surveys also demonstrate that a dramatic rise began to occur in the number of such rural settlements in the territory of a city in this period (Donners et al. 2000; Waelkens 2002; Vanhaverbeke and Waelkens 2003).

Recent salvage excavations conducted in the immediate vicinity of the major Aeolian city of Cyme in western Anatolia revealed archaeological evidence showing one way in which Hellenistic and Roman cities maintained their land through isolated field houses or country houses dispersed over the fields optimal for olive and grape growing outside the city centers (Korkmaz and Gürman 2015). Among three Cymean field houses excavated, Field House I deserves a special mention because it is associated with olive oil production. During excavations, the topmost layer covering the architectural remains was remarkable for its high density of terracotta roof tiles, which probably resulted from a sudden collapse. Below the roof tiles, excavations unearthed the remains of a quadrangular farmhouse measuring 20 × 21 m in size, in which a total of 11 large pottery containers for storing olive oil, according to residue analyses, were found along with a stone-paved floor with remains of a screw press attached to the southeastern corner from the outside. Besides large vessels to store the olive oil and implements used to extract oil from the olives, the rooms inside the field house yielded several farming implements such as iron hoes. Three of the excavated small field houses from Cyme lie only one kilometer from the city, indicating that they could have easily been worked by the inhabitants of the city. The Cymean farmers probably moved back and forth between their field houses and the cities during the cycles of agricultural production. There is certainly a pressing need for such field houses or field houses of modest size in close proximity to other major ancient Anatolian cities to be excavated in order to demonstrate how such structures functioned and how the cities interacted with their immediate environs.

The rural parts of the ancient regions of Lycia, Pamphylia, Pisidia, and Isauria in southern Anatolia have also lately witnessed intensive research with agricultural-related questions in mind. In particular, archaeological surveys conducted in the territories of Trabenna, Lyrboton Kome, Neapolis, and Kelbessos, all optimal for olive and grape growing, identified a large number of Late Roman farmhouses with olive oil and wine-making installations attached to them, as well as olive oil workshops located in groves or orchards around the field houses (e.g. Çevik et al. 2005; Bulut 2005, 2007). Isolated olive oil and wine workshops with features such as press beds/crushing basins, stone weights, collecting vats, and storage basins (sometimes enclosed by walls) with no clear association with field houses have also been frequently encountered in the olive groves and vineyards situated in the countryside in the course of these surface investigations.

Another important contribution of archaeological surveys conducted in southeastern Anatolia's rugged rural landscape is the discovery of farmhouses with towers, a tradition that goes back to as early as the Classical period (Çevik and Bulut 2007). It is believed that towers were added to these farmhouses for security against bandits and looters who threatened the livelihood of the inhabitants. These farmhouses located outside the settlements on available fertile ground or near artificially made terraces possessed features such as wine and olive oil workshops, dwelling units, barns and water wells. In addition to Lycia, Pamphylia, and Pisidia, this pattern of exploitation of land for olive oil and wine production by building various types of agricultural buildings outside cities also existed in Cilicia in southern Anatolia in the Roman era (Aydınoğlu 2010).

The manner in which land was used during Hellenistic and Roman periods can also be archaeologically demonstrated by examining land terracing in southern Anatolia (Höhfeld 1998; Şenol and Walts 2015). As a land-use strategy, terracing was an important and ubiquitous feature of the countryside around Ionian, Carian, and Lycian cities as early as the beginning of the Hellenistic period. The work carried out in the countryside at sites such as Termera and Pedasa shows that the use of terracing in the steep, sloping, and hilly landscapes of the Halicarnassus Peninsula for the purpose of expanding the productive areas of the land surface was a tradition long predating the Hellenistic period in Caria (Diler 2010, 2015). As an adaptive strategy of food production, terrace walls associated with agrarian buildings and related wine-making installations were constructed on sloping ground to create additional cultivable lands particularly suitable for viticulture and olive growing. Archaeologists are able to separate ancient and modern terracing features through fieldwork and analysis of the wall-making techniques, since they are still a conspicuous feature of the present-day terrain in most parts of southwest Anatolia. Ethnographic data from southwestern Anatolia show that dry stone walling was the most common technique employed by the modern farmers, in which natural stone boulders used as the building material were collected from the hillsides in their lands. Modern farmers fill the area behind the constructed terrace wall with earth they gather from elsewhere through ox-drawn carts before planting olive trees or grapevines on these newly created fertile pockets, if they will not be used in cereal cultivation or vegetable growing.

A detailed study of Greek agricultural terracing has already demonstrated that the ancient Greek word *haimasia* could refer to an area of land bounded by dry stones (Price and Nixon 2005). This study also reveals, on the basis of textual evidence, the presence of terraces at several western Anatolian sites, including Miletus, Ephesus, Didyma, Olymos, and Mylasa. Among these, one inscription from Olymos in Caria, reading "in those places, on the one side up to the long *haimasia*, which is entirely beside [...with all its] trees, olives and figs and the adjacent reeds, and on the other side up to the whole mountainous area above," clearly helps us picture what these agricultural terraces might have looked like, at least in the western Anatolian littoral during the second century BCE (Blümel 1987–1988, 814, ll. 8–9; Price and Nixon 2005, p. 689).

Regarding the central Anatolian plateau, which has a different landscape and climate from western and southern Anatolia, cereal production and pastoralism provided the livelihood for most of region's population in the Hellenistic and Roman periods. Herodotus's comment (5.49) on Phrygians to the east of Lydia being the richest in flocks and in the fruits of the earth clearly shows that central Anatolia had plentiful natural sources in his day and even in earlier periods. Agricultural patterns involving animal husbandry and farming had probably not changed much in Phrygia even during the Roman era. Very recent research conducted at the Phrygian city of Gordion in the heart of Anatolia demonstrates that significant changes may have occurred mainly in the way farmers exploited the land outside their settlements from the Hellenistic period to the Roman era. These changes included an increase in crop diversity and expansion into previously uncultivated marginal land. Basing their argument on two distinct activities, namely, intensive irrigation farming of free-threshing wheat and extensive pasturing of herd animals, researchers were able to reconstruct a Roman land-use practice that permitted large rural populations to develop in both lowland and upland areas around the settlement compared to earlier levels of occupation and to maximize agropastoral production (Marston and Miller 2014). Indeed, ethnoarchaeological studies conducted around Gordion demonstrated that animal husbandry was a common subsistence pursuit of those villages located in uplands where there are limited lands suitable for traditional wheat and barley cultivation (low-rainfall zone with annual 300–350 millimeters) (Gürsan-Salzmann 2002, 2005). In contrast, animal husbandry is of secondary importance among villages located in the plains around Gordion, where cereal cultivation supplemented by small-scale animal keeping is more advantageous.

The use of the plow and draft animals clearly helped crop cultivation expand into previously unexploited areas to increase the quantity of crops harvested. Artistic representations appearing on numerous gravestones dating mainly from the second and third centuries CE in Anatolia indicate that plowing the land with draft animals such as a pair of oxen was a common method of loosening the soil before sowing. The most common agricultural scene, depicting a man plowing with two oxen, has frequently been attested on Roman gravestones from the second and third centuries CE. Animal remains from archaeological sites that could be used to ascertain the presence of draft animals used in plowing in rural Roman Anatolia is unfortunately limited. This is important because certain pathologies observed in cattle bones are often thought to be resulted from the pulling or plowing action. Located in the western Taurus Mountains at Pisidia, Sagalassos is probably the only site where a zooarchaeological study was conducted to determine whether or not animals were used in plowing, as well as hauling agricultural commodities and non-agricultural products such as pots (De Cupere et al. 2000). Analyses of foot elements such as the phalanges and tibiae of cattle from Sagalassos hint that both oxen and cows may have been used in draft-related activities. Analyses of faunal remains from Sagalassos also demonstrated that the Roman settlers of the city raised sheep and goats, along with some cattle and pigs for their meat and milk products (Van Neer and De Cupere 2013).

Based on archaeological and zooarchaeological data, combined with data derived from geochemical analyses of trace elements in animal bones, a study of urban-rural integration conducted at Sagalassos demonstrated that the subsistence requirements of the city's populations were derived mainly from the immediate region of the city, and they little relied on the countryside in the Early and Middle Imperial period (c. 35 BCE–300 CE) (Vanhaverbeke et al. 2011). This conclusion was derived from an archaeometric study of cattle bones from the site. The identification of the Pb and Cu contents in cattle bones, believed to have resulted from a polluted habitat, shows that animals may have been grazed in the immediate vicinity of the city. Another important result of this valuable study is that sheep and goats may have also been grazed in this same polluted habitat around the city. According to this study, it was only after 300 CE that the population of Sagalassos began to go beyond the immediate region of the city and strengthen the ties with the countryside.

In a similar way, archaeobotanical studies conducted at the Roman levels of Gordion demonstrated what effect the agriculture practices had on the local environment in rural areas around this important site (Marston and Miller 2014). The results of this study show that a notable intensification occurred in the cultivation of bread wheat, although other plants were also grown for food such as two-row and six-row types of barley, as well as lentils and grapes

(Marston and Miller 2014, p. 766). Barley and bitter vetch may have been grown for animal fodder. Gordion therefore remains an important source of information from which we can draw general inferences regarding the crop varieties cultivated in central Anatolia in the Roman era.

In Anatolia, pastoralism based on transhumance was another factor that led to the exploitation of marginal lands outside cities that were not used for crop cultivation, growing olives and grapes, and planting of vegetables and other fruits from almost as early as the sixth century BCE to the end of the Roman era. It is most likely that farmers keeping small flocks could have fed them by grazing in fields other than those left for crop cultivation, including scrubland and woodland in the immediate environs of their cities. In cases where grazing fields might not fulfill the needs of farmers keeping large flocks, they had to develop a transhumance-based strategy involving movements of these large stocks to seasonal pastures to support their subsistence base. Here, the grazing fields were used as pasture for herds of cattle, sheep, and goats for their secondary products such as cheese, butter, and wool. A zooarchaeological study of animal bones at Sagalassos in this context has demonstrated that goat herding could have been a common practice during the Roman Imperial period. Because the goat bones that were analyzed displayed a pattern of slaughtering at an old age, the Sagalassians might have depended on goats for their milk and wool (De Cupere 2001, p. 87).

Land Management

Epigraphic evidence regarding land management for agricultural purposes is fragmentary during the Achaemenid period. There are hints in epigraphic sources that agricultural lands belonged to royal individuals who could have passed the right to use them to others in return for annual tribute (Dusinberre 2013, p. 39). Because a steady flow of revenues and acceptance of Achaemenid authority was essential, the needs of the local people were fulfilled by adopting such a mutually beneficial land tenure system.

Under Seleucid control of Anatolia following the conquest of Alexander the Great, however, the settlements of non-urban character such as villages of various sizes were the main centers of agricultural production. These villages belonged either to royal estates, temples, cities, or tribes during the hegemony of the Seleucid kingdom (Broughton 1938, p. 637). Royal estates were probably operated by serfs who either worked for the royal landowner or worked the fields for themselves by paying rents or tributes. This efficient administrative control of royal agricultural land had probably been inherited from the Achaemenids, who dominated Anatolia for over two centuries before the Hellenistic kingdoms. The best-known royal land from Seleucid epigraphic sources is surely that which belonged to Laodice I, an Anatolian noblewoman and the first wife of the Seleucid King Antiochus II Theos. Mysia was just one of the regions where Laodice I owned estates in western Anatolia. A record dating to this period from Sardis records her lands that were titled royal (Aperghis 2009, p. 102). The staple cereal crops of this Seleucid land management system included wheat and barley, while olives and grapes were limited to the Aegean and Mediterranean regions of Anatolia. Animal husbandry was also practiced alongside crop cultivation. This Seleucid pattern of land management apparently gradually disappeared from Anatolia with the beginning of the Romanization process (Mitchell 1993; Waelkens 2002; Dmitriev 2005).

Agricultural villages belonging to the temple lands might have also been a common feature of the Seleucid land management strategy in Anatolia. Each temple landholding, which comprised a central village and the considerable territory attached to it, was managed by a priest and had large numbers of both male and female servants responsible for working of land (Aperghis 2009).

It can also be deduced from the Hellenistic epigraphic sources that settlements consisting of Macedonian newcomers were introduced into the already existing agrarian population of Anatolia during the Seleucid period. These newcomers, including soldiers and veterans being rewarded for their services, received small allotments, usually by means of the division of the royal land (Broughton 1938, p. 632). Such was also the case for Jewish soldiers who played a role in Seleucid military affairs. The letter of the Seleucid King Antiochus III to his governor, Zeuxis, regarding the establishment of 2000 Babylonian Jewish settlers in Lydia and Phrygia around the end of the third century BCE shows that such colonies were founded in important locations in western Anatolia. Josephus (*Ant.* 12.148–12.153) helps us visualize what the newcomers encountered when they arrived: "When you have brought them to the aforementioned places, you will give to each of them a place for building a home as well as a plot of land for farming and viticulture and you will grant a tax exemption for ten years on the produce of the earth" (Cohen 1995, p. 212).

Significant changes occurred in Anatolia in the early Roman Imperial period with the disappearance of existing land management strategies resting upon an immensely long tradition. The Romanization process attracted and created an upper class that had the will to invest in the agricultural economy. There is rich primary data regarding the management of land for agricultural purposes in the territory of cities located in certain parts of Anatolia in this period (Broughton 1934; Mitchell 1993; Corsten 2005). These epigraphic sources provide useful insight on issues such as land ownership and the ways in which the right to use the land for agrarian purposes was transferred by its owners to the persons who worked it. These sources, however, do not provide much information regarding the actual agricultural products. The evidence overall points to lands owned by emperors, Roman citizens coming from abroad, native Anatolians, and temples after the Augustan period.

In terms of land management, one of the best-documented areas controlled by large estates lies in the territory of the city of Kibyra, interestingly situated in a liminal zone of the regions of Lycia, Caria, Phrygia, and Pisidia in southwestern Anatolia. A valuable study undertaken there identified two large private estates (Corsten 2005). According to this study, one of these estates, located near the city belonged to the family of the Claudii Polemones in the second century CE. The second estate, however, located in the land of a native Anatolian people called the Ormeleis near the village of Alassos to the north of Kibyra, was the property first of the Calpurnii (mid-second century CE) and subsequently the Ummidii, both elite Roman families (late second century–late third century CE). The estate of the Claudii played a major role in the economic life of Kibyra, whereas the estate of the Ummidii had no major economic role in the city. The estate of the Ummidii relied on the market of Alassos rather than the more distant city of Kibyra. Rich landowners apparently lived in villas located in rural areas. Over thirty inscriptions from Kibyra and its territory relevant to these private estates help us sketch the patterns of land management. For instance, the inscriptions related to the estate of the Ummidii show that the management of the estate was transferred to an administrator (Corsten 2005, p. 11). This estate was divided into three parts, each of which was rented to a tenant who was often a member of the indigenous farming population, who in turned rented single plots to smaller farmers. The epigraphic evidence overall also show that the rich landowners relied mainly on freedmen and slaves to manage their lands, and that the farmers renting the land paid their rent in cash by selling their products in local markets. As the inscriptions show, the land of the native Anatolian people of the so-called Ormeleis, where the Ummidii had their estate, was characterized by agricultural settlements of various sizes, including small villages, hamlets, and single farms. The evidence from Kibyra and its territory overall clearly represents the best extant evidence for land management in Anatolia.

The pattern of organization and exploitation found in Kibyra and its territory has also been attested in other parts of Anatolia in the Roman era. The epigraphic data proves that there might have been prosperous but modest estates within easy reach of the cities of Galatia in the heart of Anatolia (Mitchel 1995, p. 150). Some of these estates, located in the immediate environs of cities such as Ancyra, Neapolis, and Iconium, were owned by Roman citizens. Epigraphic evidence from remote parts of Galatia reveals a different land management pattern that involved large estates such as the non-Anatolian Roman senatorial family of the Sergii Paulli, who might not have had close relationships with nearby cities (Mitchell 1993, p. 151). It seems that Roman families first began to establish estates in Galatia following the Augustan period. Native central Anatolian aristocratic families from cities such as Ancyra also benefited from this process by establishing estates in the region. Many of these estates evidently passed into the hands of Roman emperors in the second century CE.

Agricultural Tools and Equipment

Actual archaeological evidence regarding the equipment used in cereal cultivation is rather thin in Anatolia, although indirect evidence derived from artistic representations help us picture them. For instance, the gravestones, dedications, and altars erected by farmers, particularly from Phrygia, Bithynia and Mysia, often bear artistic representations of mundane farming implements and activities (Cook 1925, p. 836; Cox and Cameron 1937, p. 29; Waelkens 1977; Pfuhl and Möbius 1977, p. 283; Cremer 1992, p. 84). These scenes include plows, a pair of oxen, two ox-heads (often yoked), a single ox-head, farming equipment used in tillage and harvesting, and the crops that were cultivated in the form of ears of wheat, a bunch of grapes, and wine leaves. Perhaps these figures on gravestones, dedications, and altars were intended to reflect their dedicators' occupations, which local deities were asked to protect. The artistic representations show that the tending of the land was accomplished by a simple wooden plow (ard), the tip of which was often strengthened with a metal point in order to break up the ground, which was essential for sowing the seeds. The most common scene depicts a man standing behind a plow holding a long stick with which he steers two yoked oxen. This scene was often accompanied by other farming tools such as pruning hooks, reaping sickles, and pickaxes (Figure 17.1).

Plows also occur frequently on coins minted by the cities of Roman Anatolia. The scene depicting a priest or a founder plowing a pair of yoked oxen appears on coins from the Troad city of Parium. In the case of coins of Ninika-Klaudiopolis in Cilicia, either a colonist or the emperor as founder appears plowing a pair of oxen. Trajanic coins from the same city occasionally depict yoked oxen unattended. The use of a plow as a symbol on coins clearly had its roots in the early Hellenistic period, as the coins of Alexander the Great from Tarsus in Cilicia suggest (Mørkholm et al. 1991, p. 49).

Artistic representations also provide us with useful insights regarding farming implements, since manpower might also have been required by poor farmers or those who possessed sloping land unsuited for animal traction. Hand cultivation by agricultural implements such as hoes and pickaxes might also have been common since their representations frequently appear on gravestones. These simple implements were probably utilized in tasks such as tillage, and smoothing out the field after plowing, and weeding. Another agricultural implement common among artistic representations on gravestones is the curved sickle used to reap cereals.

The pattern of working is quite different in the Pontic region of the Black Sea. The first-hand examination of ethnographic data in this environment dominated by steep sloping fields shows that the farmers had to depended on muscle power and inherited practical knowledge

Figure 17.1 Gravestone erected by Paulinus in memory of his father Trophimus. The lower scene depicts double oxen dragging a plow. Note the pruning hook to the left and a pickaxe and a reaping sickle on the right. Courtesy of Çanakkale Archaeology Museum.

that had been passed down from generation to generation. For spring sowing of crops such as barley, beans, and maize, many open fields were created through the clearance of the grasslands in the steep terrain of the Black Sea region and tilled by farmers using a two-pronged digging fork, which was forced into the ground by one foot. Another person followed behind with a mattock in order to both loosen the soil and dislodge roots that the two-pronged digging forks were not able to dislodge.

Although not yet attested among artistic representations, the threshing process might often have taken place on carefully paved stone floors encircled by a low rim of stones. Recent surface investigation conducted in Cilicia identified archaeological remains of such carefully constructed threshing floors (Aşkın 2010a, p. 242, note 3). Over such floors, horse- or ox-drawn threshing sledges with chipped-stone flakes attached to their lower surfaces operated, usually in an anticlockwise direction. This was followed by the winnowing process conducted with a winnowing basket and a wooden shovel. The grain and chaff left over from threshing were separated from each other by throwing them upward with the help of a wooden shovel against a soft breeze, and subsequently the heavier grain was caught when it fell down with a basket as the lighter chaff blew away. Available archaeological data, supplemented by ethnographic evidence, indicate that farmers often had to thresh their wheat on floors deliberately placed near the fields where the crop was grown it in order to prevent the grain falling out during transportation.

Apart from artistic representations, archaeological excavations and surveys conducted in Anatolia also yielded evidence related to farming equipment used in the processing of olives and grapes for olive oil and wine, respectively, carried out both at domestic and industrial levels. These installations attesting to industrial production were commonly found in or near the outskirts of cities. The sixth century BCE olive oil workshop containing a lever and weights press as well as related features identified at the western sector of the Ionian city of Klazomenai has so far offered the earliest surviving example of such structures related to industrial production in Greek cities (Koparal and İplikçi 2004). This workshop, represented by two architectural phases and preserving features related to crushing, pressing, and separating the olive oil, provides nearly a complete picture of olive oil production. The first phase of the workshop is particularly significant as it reportedly contained an early form of a crusher operating with rotary motion and a small wooden lever press.

A similar picture emerges from excavations conducted at Old Cnidus at the tip of the Datça Peninsula in Caria, where numerous isolated structures related to wine-making have been found in the outskirts of the city near the harbor (Tuna et al. 2010; Koparal et al. 2014). One of them is a Hellenistic winery containing traces of a weight press, stone basins with collecting vats, a room for treading grapes, and related storage facilities. This area was highly suitable for viticulture, and the city of Cnidus successfully took advantage of it. The rise in the level of trade in wine, particularly during the Late Classical and Hellenistic period, evidently increased the prosperity of Cnidus. Archaeological surveys conducted in other parts of Caria yielded significant amounts of crushing and pressing equipment used in wine-making.

In the Hellenistic period, field houses or country houses of modest size containing installations related to olive oil and wine-making were also constructed in the immediate vicinity of cities in western and southern Anatolia. Finds related to crushing and pressing installations such as the lever and weights presses were often found along with such features as collecting vats, stone weights, and storage vessels. In contrast to specialized workshops producing on the industrial level, smaller-scale domestic installations related to olive oil and wine making casually turn up in the archaeological record of the countryside in the Hellenistic period. For instance, a recent systematic survey conducted in western rough Cilicia identified numerous press complexes, implying that large-scale demand already existed for Cilician wine before the Roman period (Rauh et al. 2006). A similar pattern has also been attested in eastern rough Cilicia, where small rural sites with features related to olive oil and wine production dating to the Hellenistic period were identified in the territory of Corycus during the surface investigations (Aşkın 2010b).

In the Roman period, nevertheless, isolated installations related to small-scale olive oil production and wine making with or without any association with a field house or farmhouse are ubiquitous in the agricultural landscape. Installations such as the *trapetum*, *mola olearia*, and *solea et canalis* cut from natural boulders or hewn into the bedrock frequently appear in the fields devoted to olive and grape cultivation in the countryside of most cities in western and southern Anatolia. Crushing beds were predominantly identified in association with press beds, press weights, and collecting vats. There are also cases in which small buildings were specifically built to house the equipment. The rationale for processing olives and grapes in fields was probably based on reducing the cost of production. In contrast, the paucity of information with regard to installations for large-scale industrial production on the outskirts of cities in the Roman period might be due to the nature of urban-centered excavations being conducted in Anatolia. It is also difficult to know with certainty whether these isolated places with olive-oil-making and wine-making equipment belonged to small landowners, tenant farmers, or wealthy large property owners who used them for domestic consumption needs or exchange. We get a glimpse of what these installations, located in small rural sites, may have been used for from a survey conducted in eastern Rough Cilicia (Aydınoğlu 2010). This study demonstrates that new isolated rural sites were established around the major urban centers near the main land-based routes that link the interiors with the coasts. Some of these rural sites with facilities for wine and olive oil production probably served as regional processing centers before the export of products.

Ethnographic studies also demonstrate that installations and implements used in wine making by small-scale producers could be found near the seasonal field houses located in the vineyards, though there are cases in which the grapes were taken to special press rooms located at villages or towns in the Troad (Kaplan 2007). This is because when wine production is geared toward the fulfillment of local, often household, consumption with only infrequent instances of exchange, processing of grapes for wine could take place in traditional installations located in the vineyards. Such a pattern can also be demonstrated for small-scale domestic olive oil production through ethnographic data in Caria. Here, traditional olive processing installations are encountered near the rural field houses that are located in the olive groves far from the settlements (Diler 2004).

Divine Protection

The rural inhabitants exploiting the land around their settlements for agrarian purposes in certain parts of the Anatolian hinterland in the Roman period often wanted to put themselves under the divine protection of gods that served as patrons of farming. An increasing number of sepulchral-dedicatory inscriptions recovered from archaeological surveys in a large area encompassing Phrygia and Bithynia indicate that Zeus Bronton was the most prominent local deity, whose wrath was much feared by farmers in the second and third centuries CE. Examination of over three hundred dedications with Greek inscriptions set up by farmers from such sites as Dorylaeion, Nakoleia, Cotyaeum, Aezanoi, and many other sites suggest that Zeus Bronton was believed to protect crops and livestock in this period (Cox and Cameroon 1937, p. 34; Cook 1940, p. 1160; Drew-Bear and Naour 1990; Akyürek-Şahin 2006a). Farmers also wanted to avoid his displeasure lest he devastate their means of livelihood through drought or storms. Zeus Bronton probably had chthonic aspects as well (Figure 17.2), since peasants often purposefully included his name on graves to claim his protection in death, thus also rendering the graves inviolable against robbers.

The nature of the powers bestowed upon Zeus Bronton by farmers can readily be seen in the prayers offered on sepulchral-dedicatory inscriptions and votive altars. This is best observed on an example from northern Phrygia, which reads: "Manes, son of Apollonios, (dedicated) to Zeus Bronton for the health of his cattle and produce (in fulfillment of) a vow" (Akyürek-Şahin 2006b, p. 90). Besides Zeus Bronton, there were numerous other local deities that could have been revered as the patrons of farmers in Phrygia. For instance, farmers in central Phrygia dedicated votive reliefs and inscriptions at a rural sanctuary near the town of Phyteia, southwest of Amorium, to honor their local deities Zeus Alsenos and Zeus Petarenos. Similarly, rural sanctuaries have also been documented in the territory of Appia in northern Phrygia, this time honoring Zeus Ampeleites and Zeus Thallos (Drew-Bear et al. 1999). The farmers probably asked for the protection of their local deities throughout the agricultural cycle, including the plowing of fields, the sowing of seeds, and the harvesting of crops. They likely gathered in small rural sanctuaries or sacred spaces scattered across the countryside or in close proximity to urban centers to honor these agrarian divinities (e.g. Akyürek-Şahin 2006a). A general assessment of these gravestones, altars, and dedications suggests that these peasants or farmers seeking divine protection could have well been either

Figure 17.2 View of four sides of a Roman gravestone of possibly a landholder named Publius from the Lydian countryside mentioning chthonic deities. Note a pair of oxen on each side of the gravestone. Source: Courtesy of Manisa Archaeology Museum.

small private landowners or tenant farmers who worked the lands of rich Roman estate owners as sharecroppers.

The recovery of gravestones, altars, and dedications with agricultural scenes in Lydia shows that such a tradition was not peculiar to neighboring Phrygia, Bithynia, and Mysia (Figure 17.2). It is clear from the inscriptions that the Lydian peasants or farmers also believed in agrarian divinities similar to their eastern neighbors and sought their protection for the safety of their crops (Ricl 2003, p. 78, note 4). This may have also been true in the Troad, where gravestones depicting a farmer plowing with a pair of oxen were also common. One good example is part of a gravestone found in the inner regions of the Troad near Mount Ida (Tanrıver 1999, no. 4; Takaoğlu 2017, figure 20) (Figure 17.3). Such gravestones, already carved with agricultural scenes in relief, were probably manufactured in one of the workshops near Cyzicus in Mysia. The inscriptions were added later, since near-identical gravestones with different inscriptions are commonly attested.

The farmers of Anatolia also invoked gods and made vows to certain local deities to protect their agricultural fields and livestock against the threats of field mice, pests, and locust swarms (Nollé 2005). The sanctuary of Apollo Smintheus ("lord of mice") at Chryse on the west coast of the Troad was a notable sacred place frequented by both village communities and individual farmers who sought protection against rodent-borne plagues. The cult of Apollo Smintheus mentioned here probably had its roots in pre-Classical times since it plays an important role in the opening lines of the *Iliad*. Such was also the case with Apollo Parnopius ("expeller of locusts"), who was worshipped as a tutelary god and protector of crops from swarms of locusts in Aeolia (Strabo, XIII.I.64). Another local deity to be mentioned is Apollo Lykeios, who was a protector of flocks against wolves (Nollé 2005, p. 65, note 97).

The idea of venerating such local deities was apparently to keep peace with the gods in order to protect family and produce from misfortune and increase the yields from agricultural lands and livestock. The notion of Zeus being the most prominent deity of Roman farmers in Anatolia in this context probably had its roots in the Late Bronze Age, when the Hittite god Telipinu served as the patron god of farming a similar fashion. Telipinu, with the

Figure 17.3 Lower part of a broken Roman gravestone of Metrodorus erected by his son. The scene depicts a man standing behind a plow holding a stick with which he steers two yoked oxen. Surface find from the Troad interior, near Mount Ida. Source: Courtesy of Çanakkale Archaeology Museum.

power to stop havoc and devastation, may also have been a storm god (Beckman 2012). It is possible that this deity continued to be worshipped in the Anatolia hinterland throughout the Roman period.

Concluding Comments

Our understanding of Anatolian agriculture during the Hellenistic and Roman periods began to change after the discipline of classical archaeology in Turkey gradually started to move away from its classificatory-historical phase with a descriptive preoccupation toward an explanatory phase with an anthropological orientation. This new approach first appeared in projects conducted at sites such as Sagalassos and Gordion, where explaining agriculture became a major part of their archaeological agendas. This new orientation was also deeply felt in various field surveys designed specifically with agricultural questions in mind, particularly in southern Anatolia during the last decade or so. These studies dealing with human and land interaction demonstrated that the Roman period is marked by the intensification of agriculture, though Roman agriculture in Anatolia rested upon a long-lasting tradition going back to the times of Persian hegemony and the Hellenistic kingdoms. The Romanization process represented basically an upheaval in terms of finding better ways to adapt to the diverse topography and climate of Anatolia. In the Roman period, the lands surrounding cities began to be filled with various sizes of agricultural buildings such as seasonal and/or permanent field houses, farmsteads, hamlets, and agricultural villages. The preponderance of local deities serving as the patrons of farming particularly during the second and third centuries CE, on the other hand, demonstrate that the Anatolian farmers of the Roman period also sought divine protection for the safety of their crops and livestock. This led Roman Anatolian farmers to build rural regional sanctuaries devoted to these local farming gods.

GUIDE TO FURTHER READING

A thorough account of Roman rule as well as the Hellenistic period in Anatolia can be found in Magie (1950). Another general work for anyone dealing with questions from the time of Alexander the Great to the beginning of the Byzantine period is the valuable and comprehensive study of Mitchell (1993). A detailed overview of the theoretical approaches to the study of the Roman economy in Anatolia appears in Mitchell and Katsari (2005). Information regarding the agricultural resources of Anatolia in ancient literary sources is to be found in Broughton (1938). In particular, the role of olive growing in the economy of Roman Anatolia is to be found in Mitchell (2005). For useful information regarding how anxieties about crops and livestock were reflected in epigraphic forms and terminology, see Schuler (2012). Issues related to the society and economy of rural sanctuaries were presented in a regional study by Ricl (2003). Artistic representations of agricultural life and equipment on gravestones, altars, and dedications can be found in Cox and Cameron (1937), Cumont (1942), Pfuhl and Möbius (1977), Waelkens (1977), and Cremer (1992).

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CHAPTER EIGHTEEN

Agriculture on the Shores of the Black Sea

Smaranda Andrews

"How do you think I feel, lying here in a vile place, among Getae and Sarmatians? I can't stand the climate, I am not used to the water, and the land itself, I don't know why, displeases. There's no house here suitable for a patient, no food that's any use, no one to ease his pain with Apollo's art, no friend to bring comfort …"

Ovid, *Tr.* 3.3 (translated by A.S. Kline)

Introduction

This chapter covers an area whose dimensions are quite vague, defined by the Black Sea at its center but whose outside borders or frontiers expanded and contracted throughout history like storm waves on a beach. There are no well-defined or distinctive features to describe agriculture on the shores of the Black Sea. The coastal regions are fertile and suitable for growing a variety of crops from cereals to fruit and vegetables and other plant products (e.g. hemp for ropes and clothing or medicinal herbs). Where the land was not particularly good for crops, people raised livestock or acquired meat protein from fishing and hunting.

The Black Sea is the world's largest marginal sea with a coastline that today embraces six countries. Its waters are the product of several large rivers: the Danube, Dniester, Dnieper, Don, and Kuban (see map). The sea has a curious ecology dating from the time of its formation when salty waters streamed in from the Mediterranean and settled down to the bottom, creating an anaerobic environment. This means the sea is composed of layers of waters that do not mix, like the layers of a cake. There is almost no water exchange between the top layers and the bottom ones. Currents are strong and so are the northern winds which blow most of the year, making it relatively difficult (but certainly not impossible) to reach this body of water from the south (Labaree 1957, pp. 29–33; Tsetskhladze, 1994). The shallow and narrow Bosporus Strait is also the only way to and from the Mediterranean Sea. For many years, scholars argued that the difficulty of reaching the Black Sea via the Bosporus slowed down or even delayed the Greek colonization of its shores. A robust surface current runs

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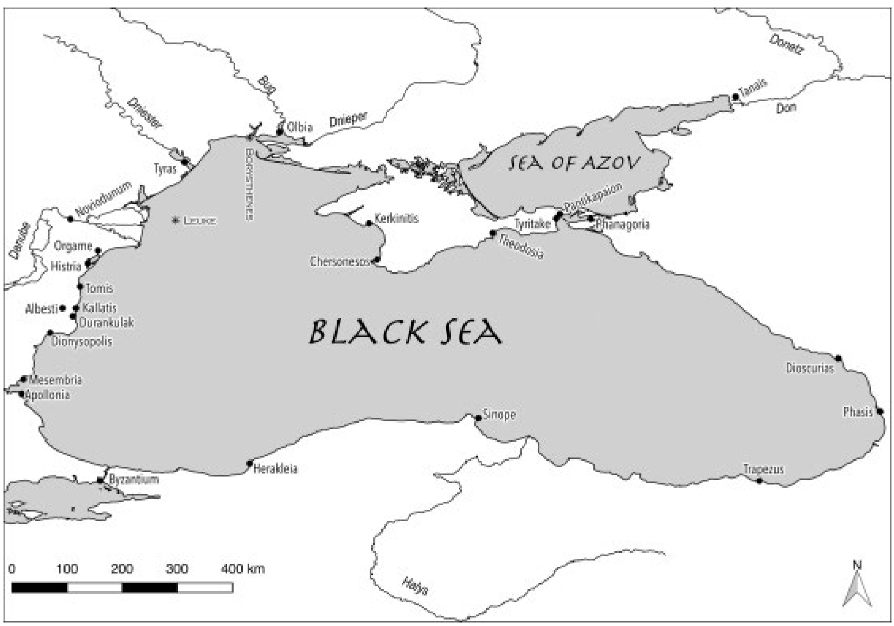

Figure 18.1 Map of the Black Sea. Source: Map by David Hollander using QGIS and map files from the Ancient World Mapping Center. "openwater.shp," "coastline.shp," "ba_rivers.shp," "awmc_rivers.shp," "awmc-osm-rivers.shp," and "suppleRivers.shp". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm]

counterclockwise along the shores, with two other surface currents running through the middle, splitting the sea in two. This midriff current made the journey from south to north or from north to south possible without hugging the shoreline (Doonan 2006, p. 49) (because of the presence of this current, Strabo talks about two seas, 2.5.22) (Figure 18.1).

Written sources from antiquity lament the unfriendly climate of the region. Herodotus (4.28.1–2) describes the unwelcoming land of the Scythians as having "such harsh winters that for eight months the frost is intolerable … and the remaining four months of the year are cold here, too." The Latin poet Ovid, living in exile at Tomis, on the western shore of the sea, has similarly harsh words: "Snow falls and once fallen, no rain or sunlight melts it" (*Tr.* 3.13.). Ovid, understandably bitter given his exile from Rome, also complains in *Tristia* and *Epistulae ex Ponto* about the landscape, the wormwood, the gray prairie, and the lack of vines and orchards (e.g. *Tr.* 3.10.71–75; *Pont.* 1.3.55, 3.12.14–16). Askold Ivantchik (Ivantchik 2017) puts forth the idea that the Greeks associated the Black Sea with the Ocean, a place that terrified them, ruled by chaos, near the realm of the dead, and therefore neither an easy place to explore nor suitable for settlements and agriculture.

The study of agriculture on the northern and western shore of the Black Sea during the Greek and Roman periods is a relatively recent field of research. Extensive archaeological research has been done on the major Greek and Roman sites with several major surveys and studies of the rural territories of Greek colonies. Focus on ancient agriculture has been difficult due to the lack of ancient written sources on the subject. Literary and numismatic sources tend to emphasize specific aspects of agricultural production, mainly grain, and omit the day-to-day diet of ordinary people or the description of the agrarian landscape. In addition, as it was in many cases in the Eastern European countries bordering the Black Sea, the lack of funding for historical and archaeological research, the dearth of scientific support for in-depth studies, and the often nonexistent dialogue between researchers makes the region seem like a puzzle with many missing pieces. Furthermore, many archaeologists published in languages that are not easily accessible not only to one another, but for Western scholars as well. This does not mean that agriculture and, more broadly, economic issues were completely ignored. On the contrary, there are articles and books that go beyond catalogs of artifacts, descriptions of sites, and the interpretation of literary sources (Baumann 1983; Bărbulescu 2001). What is new and exciting is the addition of studies that apply new research methods, such as analysis of oxygen isotope data, satellite imagery, or magnetic surveys in tandem with long-term collaboration among scholars from different countries (Keenleyside 2006; Smekalova 2016; or the series of books published by the Danish Center for Black Sea Studies at Aarhus University).

Geography and Climate

The Black Sea lies between southeastern Europe and Asia. Leaving aside the Sea of Azov, the Black Sea occupies about 168 500 square miles. It is connected to the Aegean Sea through the Bosporus, the Sea of Marmara, and the Dardanelles, and has been of critical importance to regional commerce throughout the ages. Today, this inland sea is bordered by six countries: Romania and Bulgaria to the west, Ukraine, Russia, and Georgia to the north and east, and Turkey to the south. Furthermore, another 10 nations have access to it through the five major rivers that empty into the Black Sea, the largest of which is the Danube. The Black Sea coast is fairly regular with the exception of the Crimean Peninsula, which thrusts from the north out into the sea. The small Sea of Azov is connected to the Black Sea by the narrow Kerch straits. Greek myths referred to the sea as inhospitable, where the Islands of the Blessed were located, the mythological Elysium, the realm of the dead. The Argonauts sailed here, and over the Ocean (Homer, *Od*. 12.70), a journey associated with the Underworld and all sorts of dangers (Ivantchik 2017, pp. 7–25). But by the fifth century BCE, the sea was well known to Greek sailors and much friendlier with cities, harbors, and emporia around it resembling, according to Socrates, frogs or ants around a pond (Plato, *Phd*. 109b).

The littoral of the Black Sea is mildly notched with a few well-protected harbors. On the western shore, low mountains belonging to the Balkan range slide toward the sea, and the landscape flattens out into a plateau toward the north that gives way to the Danube Delta. The area has, for most part, good farmland and is relatively close to the main urban centers of the Greek world, enabling a robust exchange of goods between the Greeks and locals as soon as the first colonists reached the region. The northern shore is low and cut by numerous ravines, valleys, and rivers with sandy, shallow mouths; the only cliffs are the ones that belong to the mountains of southern Crimea, creating some of the best natural harbors. To the east and south, the coasts are steep, while near the Bosporus straits the shoreline is more moderate but still abrupt. The sea is a non-tidal, landlocked basin. The Black Sea has only a few islands of which, in ancient times, Berezan at the mouth of Dniester River and Leuke near the Danube Delta were probably the most significant. Berezan was the site of the first Greek colony on the northern shore of the Black Sea (Solovyov 1999), while Leuke sheltered a temple of Achilles built in the middle or the second half of the sixth century BCE (Okhotnikov 2007). Today the climate around the Black Sea can be characterized as continental, subject to pronounced seasonal temperature variations and in many parts controlled by the shoreline relief. The northwestern shores, with a steppe climate, are influenced by air masses from the north; winters are cold while summers are hot and dry. Occasionally, in the winter, cold air seeps down from Siberia, and the sea and rivers freeze over (Hdt. 4.28, 1–2). The southeastern shores enjoy a humid subtropical climate with abundant precipitation, warm winters, and humid summers. Winds are strong in the winter everywhere around the sea, sometimes with gale force, and make it difficult to sail for several months of the year (Carpenter 1948; Labaree 1957).

At the time of Greek colonization, the climate on the western and northern shore of the Black Sea was somewhat different from today. The area was cooler and more humid but not as harsh and hostile as Herodotus and Ovid would lead us to believe (Buynevich 2017). Regarding the sea levels, it is commonly accepted that at the time of Greek colonization the sea level was 8 to 10 m lower than it is today, especially along the western shoreline. The western shore is also prone to strong seismic movements which shifted the ancient layers to greater depths (Damianov 2007). Moreover, the five major rivers that empty their waters into the sea have seen significant changes throughout history that altered their courses and shifted the landscape. For the southern shore of the Black Sea, see Chapter 17 in this volume. This chapter will mainly concentrate on the western and northern shores of the sea.

Archaeological, Textual, Epigraphical, and Numismatic Evidence

It is not always easy to reconstruct agricultural practices from archaeological material, nor is it always possible to entirely rely on the written evidence. If we are to believe Herodotus and Ovid, growing crops on the western and northern shores of the Pontus would have been difficult, almost impossible. Yet, there is abundant evidence the region was more than suitable for agriculture and was rich in the kind of products that, in the Mediterranean region, were already in short supply by the time the Greeks settled in the area (Montgomery 2007, pp. 49–81). Many factors probably contributed to the Greek settlement of the coastal areas of the Black Sea including political strife, overpopulation, or the desire to exploit the region's resources (Montgomery 2007, pp. 49–81).

We know the Black Sea region was rich in timber in the north (Hannestad 2007), rivers were abundant with fish (Hdt. 4.53), and, when local conditions were especially favorable, exports of agricultural and animal husbandry products reached the rest of the Mediterranean world (Dem. 20.31–20.32; Polyb. 4.38; Strabo 7.4.6; 11.2.3; Plin. *HN* 18.25). Written sources tell us that the most exported agricultural product was the so-called Pontic wheat, described as light in weight, not very productive, but well suited to the cool climate (Theophr. *HP* 8.4.5; Plin. *HN* 18.25). Archaeological sources and paleobotanical studies confirm that this type of wheat was grown in the region. Cereals were stored in pits, clay and ceramic containers, or woven baskets (Alexandru 2017). Pits for storing grain were found in many of the settlements excavated in the chora of Greek cities.

However, in describing the region, Strabo (7.3.7) talks about wagon dwellers and nomads who know nothing about storing food and are not sophisticated enough to know how to buy things, only to trade "wares for wares" in opposition to the refined and complex Greek lifestyle. On the other hand, Pliny the Elder mentions the Scythian plowmen or farmers (*Scythae Aroteres*) and lists their settlements (*HN* 4.44). Aside from crops like grain, other literary evidence, like Pseudo-Scymnos, talks about the rich pastures for livestock near the city of Tyras, located on the river with the same name, as well as its abundance in fish that makes trading profitable (Ps. Scym. vv.797–804).

Coins are a good complementary source of information on agriculture and its importance to the communities of the Black Sea. The iconography on some coins allude to marine resources (fish, dolphins) or are of religious character, while others picture local assets that describe the reputation and prosperity of a region or city. Representations of Demeter either as a full figure, sometimes seated, or just a veiled head with wreath of ears of wheat, were widespread, and so was Dionysus, accompanied by vines, bunches of grapes, cornucopia, wreaths of vines, baskets, or a *thyrsus* (Damianov 2007, p. 7; Iacob 2000–2001). Tyras, for example, minted its first coins in the second half of the fourth century BCE. The images chosen for the silver drachmas, the head of Demeter on the obverse and a bull on the reverse, testify to the importance of the cult of this goddess (Samoylova 2007, p. 447; Zograf 1957). The fourth century BCE gold staters from Pantikapaion and coins from Phanagoria or Tyras display ears of wheat. The image of Dionysus also appeared on a lead weight dated to the third to second century BCE in the village of Balgarevo, Bulgaria (Lazarov 1995). Lucian of Samosata describes how popular the Bacchic form of pantomime was in Ionia and Pontus, such that everybody stopped all activities to watch and partake in the festivities (Lucian, *Salt.* 79). The celebrations took place probably in spring as attested at Olbia (Dubois 1996). The flower/spring festival of *Anthesteria* (Thuc. 2.15), also associated with Dionysus, was popular at Histria, Apollonia, Odessos, and Olbia and marked not only the beginning of spring, but also the celebrated local benefactors as documented at Histria (*ISM* I, 58, r. 5–6, dated second century BCE).

Inscriptions are a valuable addition to our literary evidence and can be helpful in understanding issues related to land use, location of plots, border demarcation, size of rural territories, as well as agrarian and religious practices. There are a few unique epigraphic documents that define the rural borders of two Greek cities on the western shore, the *horothesia* of Dionysopolis (*IGBR*, V, 5011) and the *horothesia* of Labelius Maximus from Histria (Pippidi 1983, *ISM* I, no 67–68). Both documents, written during the Roman period, talk about the boundaries of the *chora* naming physical landmarks like rivers or other geographical elements or identifying border settlements in the territory (Avram 1988–1989). Surviving inscriptions also help us catch a glimpse of more than just the expanse of the *chora*. Crop failures, struggles to harvest a crop or protect it due to political unrest, or military conflicts have been recorded for posterity in inscriptions dedicated to citizen benefactors. An inscription from Histria (Pippidi 1983, *ISM* 1, no 12), dated around 200 BCE, honors Agathocles son of Antiphilos, who hired mercenaries to protect the *chora* and allowed the citizens to harvest their grain.

Crops Cultivated

Archaeological excavations in the Greek *chorai* have not unearthed any big surprises regarding crops cultivated in this region. Agriculture on the shores of the Black Sea meant growing grain and raising livestock and was done for more than just subsistence. In good years when crops were successful, the colonies were net exporters of grain and sometimes of wine. The inhabitants' diet was based on the so-called Mediterranean triad: wheat, wine, and olive oil. In the western and northern regions of the sea, oil was imported, since the olive tree does not thrive there. However, oils for everyday cooking were probably made from other seeds easily available in the region such as flax (*Linum usitatissimum*). Due to the proximity of the sea, an important source of protein came from seafood, which sometimes was exported in the form of salted fish and fish sauce (*garum*).

Human and animal remains from the Greek site of Apollonia (fifth to second century BCE), analyzed for stable carbon and nitrogen isotopes, paint an interesting picture of the inhabitants' diet. The results indicate that the colonists relied on a mixed diet of terrestrial and marine foods and that there was no variation in diet by age, sex, or burial type (Keenleyside 2006). One difference between the region around the Black Sea and mainland Greece is that food resources were abundant, whether they were wild game, wild berries, and other fruits, fish, and mollusks from the sea or the many rivers and lakes in the area. Herodotus describes the abundant resources around the Dnieper river as second only to Egypt and the Nile in terms of pasture, fish, and land for cultivation (Hdt. 4.53).

Wheat was widely cultivated by the local populations as well as the Greek colonists. The predominant varieties were the hulled wheat, *Triticum dicoccum*, or the naked (no hull) wheats, *Triticum aestivum* and *Triticum compactum*. Scythian tribes, for instance, cultivated mainly hulled wheat, whereas near the Greek colonies, bread wheat was more popular (Pashkevich 1999). A light and dwarf wheat, well adapted to the region and the agricultural techniques employed here, especially on the northern shores, is mentioned by Theophrastus in his *Enquiry into Plants* (8.4.4–8.4.6). This wheat variety is not very prolific, but two sowings can be made in one year, one in the winter and one in the spring. Pliny also mentions this kind of "light wheat" as being grown on the Pontus, especially in Chersonesos (Plin. *HN* 18.12). Wheat was clearly the preferred grain in the Greek colonies and was eaten as bread, mash gruel, or in porridge form and has been found in practically every site excavated along the shores of the Black Sea. Whether it was always produced in huge quantities is still open to debate (Braund 2007). Demosthenes famously said, in the fourth century BCE, that "the grain that comes to our ports from the Black Sea is equal to the whole amount from all other places" (Dem. 20.30). While this seems to refer to the region as a whole, Demosthenes is, in fact, referring to the Bosporan Kingdom when, under Leukon I, the grain export reached the impressive amount of 400 000 *medimnoi*, approximately 16 800 tons of grain/wheat (Dem. 20.31–20.32). Leukon I was also able, according to Strabo (7.4.6), to obtain an even more impressive amount of wheat from Theodosia – 2 100 000 *medimnoi* or about 88,200 tons – and send it to Athens.

This does not necessarily mean the Black Sea as a region always produced enough wheat for local consumption as well as for export. In fact, numerous inscriptions from Histria, for example, speak again and again of the constant struggle to feed the citizens and distribute "grain." While it is unclear if the grain was wheat, several inscriptions thank benefactors that either brought grain (in one case from Carthage) or lent the city money to buy grain from other locations to help ease famine in the city (*ISM* I no. 2, 9, 19, 20, 54). The same situation was also documented at Olbia (Krapivina 2007). Polybius was probably right to say that, when it comes to grain, sometimes it is exported and sometimes the Pontus colonies have to import it (4.38).

There are many sites at which grain storage facilities have been found, from a few pits to several hundred. We know they were used for foodstuff storage, mainly grain, as the clay lining indicates. Such was the case for the community near Kavarna (ancient Bizone) (Salkin 2007, p. 41), where archaeological surveys near the ancient port unearthed grain storage facilities dating from the fourth to the sixth century CE, proving that there was a tradition of storing and dispatching grain. In the territory of Histria, grain storage pits at Tariverde are an important clue that grain was either a commodity used in trade or was stored there for the winter, same as at Albesti, in the territory of Callatis (Bărbulescu and Buzoianu, 2008). A Greek inscription from Dionysopolis, which defines the boundaries between the territories of Dionysopolis, Kallatis, and the Thracian Kingdom ruled by Kotys III (Banev and Dimitrov 1985, pp. 34–37; Slavova 1998, pp. 57–62), states that "having learned this from the old documents we decide as follows: to leave this to the citizens of Dionysopolis and the redeemers from the Pontos, as for Aphrodiziona the citizens of Dionysopolis agreed to let king Kotys use it to send grain." Aphrodiziona is assumed to have been a Thracian settlement that used caves as granaries. This inscription dates from 15 CE when Dionysopolis and Kallatis joined the newly established Roman province of Moesia. The strategy of storing grain in pits worked for a short period of time as long as the anaerobic conditions were secured. Once the pits were opened, the grain had to be sold or consumed quickly.

Barley (*Hordeum vulgare*) was also cultivated, mostly for fodder but probably also as food for poorer citizens, or in time of famine. Barley has a shorter harvest time than wheat and is a drought- and frost-resistant grain. Strabo mentions that barley is "sown in the money bag" meaning that it always makes profit (Strabo 7.4.6) while also being a high-quality forage crop for horses. *Rye* (*Secale cereale*) appears in the third century BCE archaeological record, as reported at Olbia and Kerkinitis (Kutajsov 2006, p. 143). ***Millet*** and ***panic*** (both small seed grasses) are not present in significant quantities in the paleobotanical record in the Greek cities and do not appear to be important cultivars even though they are mentioned in the literary sources. Pliny the Elder declares that "there is no food held in higher esteem than panic by the nations of Pontus" (*HN* 18.25) and was probably referring to the local tribes, since millet was widely cultivated by the Scythians who also used this grain as fodder for cattle. A stable isotopic study from Apollonia seems to question whether millet or *legumes* were important sources of plant protein for the inhabitants of this Greek city (Keenleyside 2006). Unfortunately, the sample in this study is quite small, and more studies of this kind are needed before more conclusive observations about protein sourcing can be made. At Apollonia, significant amounts of protein came from marine food including pike, sturgeon, mullet, mackerel, turbot, and tunny. No doubt legumes like *beans*, *peas*, *lentils*, or *bitter vetch* were grown in every garden and for domestic consumption. Bitter vetch, which was used for animal silage, can also be consumed by humans if properly prepared. Wild fruits, nuts, and herbs were most likely added to the diet. A common weed, *Chenopodium album* (pigweed or lamb's quarters), was found in large quantities in sites belonging to Scythian tribes, a sign that the seeds were intentionally gathered and used either for poultry or ground into flour for human consumption, especially in time of famine (Pashkevich 1999). While *grapes* (*vitis vinifera*) were grown throughout the region, most vineyards (and grape processing facilities) identified on archaeological sites are located on the northern shore of the sea from Olbia to the Crimea and in the south, especially at Herakleia and Sinope.

Animal Husbandry

The western and northern regions of the Black Sea possess steppe-like vegetation and climate, quite suitable for animal husbandry. Polybius (4.38) writes that "it is an undisputed fact that most plentiful supplies and best quality of cattle and slaves reach us from countries lying around the Pontus."

The examination of the osteological materials from excavations in rural settlements or from the Greek colonies themselves, show that *cattle* (*Bos taurus*), *sheep* (*Ovis aries*), and *goats* (*Capra hircus*) were reared in almost equal numbers. Next were *pigs* (*Sus scrofa domesticus*), *horses* (*Equus caballus*), used mainly for transportation, and domesticated *donkeys/mules* (*Asinus domesticus*), as draft animals, all species directly tied to agriculture and household economies. *Dog* (*Canis familiaris*) bones are present at almost every site, with an increase in the first centuries CE (Haimovici 2007, p. 542; Krapivina 2007, p. 597). Dogs were probably used for hunting and herding. Since the paleozoological material contains ample amounts of cattle, sheep, and goat bones, we can assume that there were sufficient pastures and fodder to sustain these animals.

Based on the age of the animals, from young to quite old, we can safely assume they were reared for meat but also for milk, skins, and wool. Soft cheese (somewhat similar to cottage cheese), for example, was made in special ceramic vessels, many of which have been found in the Lower Bug area (Krapivina 2007, p. 597). Salted soft cheese keeps quite well and is transported easily; making cheese was an excellent way of converting surplus milk into a marketable commodity. Milk was also made into butter. We know from Anaxandrides' play *Protesilaos* (Athenaeus 4.131b–c) that the Thracians were butter eaters, while Strabo (7.3.7) confirms that the local nomads lived off their herds, drinking milk and making cheese. Sheep, goats, and particularly cattle need abundant forage, and there is evidence these livestock-rearing activities were performed on distant pastures. For instance, more than a dozen temporary herders' camps were identified, scattered in the *chora* of Olbia (Kryzickij 2006, p. 105). The Roman agricultural writers paid special attention to the improvement of cattle; indeed, the improvement of the *Bos taurus* species in the first centuries CE is documented in the zooarchaeological material from the rural territories of the Greek colonies on the western shore. Cattle became bigger, thus providing more meat as well as improved muscle power (Haimovici 2007, p. 350). An interesting study at Durankulak (Bulgaria), focusing on the temple of the goddess Cybele, has concluded that at some ceremonies worshipers consumed an impressive amount of meat, estimated at around 300 kg (Todorova 2007, p. 216). While this is an extreme example, sanctuaries would need to provide enough animals for sacrifices (Archibald 2013, p. 290). At this particular sanctuary, cattle were the preferred source of meat followed by horse, pig, donkey, sheep/goat, dog, and chicken. Sheep were kept for wool to make clothes, blankets, and other fabric items, and we can also assume their milk was consumed as cheese or butter and rarely in its raw form.

According to Polybius (4.38), during the Hellenistic period products of animal husbandry were exported to Mediterranean centers. These products may have included tanned hides/skins or even preserved meat. Tanned leather used for harness equipment has survived from the Roman period although we do not have specimens from this region other than the metal parts of the equipment (Baumann 2014). Strabo mentions (11.2.3) that at Tanais, Sarmatians traded hides and slaves for clothes and wine.

Fish and mollusks were also consumed; numerous finds of fish bones, fishhooks, and net weights speak to the importance of fishing. Literary sources describe the different kind of fish caught and associated fish products: Demosthenes mentions (35.34) salted fish exported from Pantikapaion to Theodosia; Strabo describes (7.4.6) what seems to be an old practice of exporting salted fish from the Kimmerian Bosporus while Polybius (31.25.5) speaks of Black Sea fish exported to Rome. The fish processing installations from Tyritake, during the Hellenistic Period, could handle up to 365 metric tons of fish simultaneously, while another estimate from the site of Zolotoe suggests 560 metric tons of fish processed at once (Hojte 2005, p. 145, 157). Tyritake, in the first to third century CE, had around 700 fish salting tubs located on the premises, which reveal the city's major role in the export of this commodity (Zinko 2007, p. 841). Sites that were thoroughly investigated on the northern shore, such as Elizavetova, Tyritake, Myrmekion, and Chersonesos produced an impressive array of remains from fishing equipment and fish remains to watchtowers (*skopiai*), vats for holding fish, transportation equipment, and pictorial representations on coins, sculptures, terracotta, and epigraphical documents (Hojte 2005, Lund and Gabrielsen 2005, Opait 2007, Wilkins 2005). Fish was also smoked/cured as proved by the pit used for this at the Elizavetova settlement near Tanais (Hojte 2005, p. 141). There is little archaeological evidence of fish processing on the western coast of the sea, though there is plenty of indication that on the northern shore installations for fish processing continued to thrive from the Hellenistic all the way to the end of the Roman period.

Agricultural Practices

Ancient agricultural practices in this region, as in the Mediterranean and elsewhere, depended on micro-local diversity in geology, pedology, hydrology, vegetation, and relief. The coexistence of crop cultivation and pastoralism was an approach that mitigated risk, a prudent response to environmental and social hazards. Another strategy was short- or long-range transhumance, which was practiced up until the nineteenth century. Landscape fragmentation and variation dictated or influenced what crops were cultivated and whether or how domesticated animals were reared.

Evidence of tillage, threshing, and storage are not always apparent, and those activities do not necessarily show up in the archaeological record. As a result, our understanding of agriculture around the Black Sea comes mainly from known panhellenic practices coupled with an awareness that the climate of the western and northern shores of the sea is quite different from that of the Greek mainland and even the northern Aegean. Literary sources supplementing the archaeological evidence for this region are not especially helpful. Strabo (7.4.6) talks about the extraordinary fertility of the soil in the Crimea (Chersonesus), but in his description of the land he does not concern himself with the details of agricultural practices. There is only scant literary evidence for how the Scythians or the Thracian tribes cultivated the land. The information coming to us from ancient sources talks about oddities, fantastic legends, and weird customs. Scythians are depicted as skilled horsemen living a nomadic life, but also farmers and warriors. Writers were fascinated with their peculiar fondness of drinking fermented mare's milk, which is a mild intoxicant, or their use of cannabis, which made them howl with pleasure (Hdt. 4.75), and seem less interested in the banalities of everyday farming.

As for the Greeks, at the beginning of colonization, when land was available in larger amounts, a shifting system of cultivation was probably employed. Less productive land, after being cultivated, was left fallow longer or used for grazing animals whose manure then replenished the soil. Undoubtedly this was not the case later, when land was less available due to the increasing number of inhabitants. On the northern and western shores, only the hardiest cereal types could tolerate the climate. Wheat, rye, barley, and millet were sown, employing the three field system: spring or winter wheat or rye, spring wheat or barley, after which the land was left fallow for a year (Kutajsov 2006, p. 143).

Vineyards and orchards are widely documented, especially in Chersonesos. Around the middle of the fourth century BCE, the land here was carefully divided into plots, terraces were built where needed, the rocky soil improved, and land prone to erosion was left fallow or used for pastures. This is also the time when it seems the inhabitants decided that grapes were the best cash crop to be cultivated in the rocky soil and proceeded to alter the landscape accordingly. The north and northwestern part of the Heraklean Peninsula had large fortified farms with towers and wineries with spacious cellars. The wineries were located near roads leading to the port or in the immediate vicinity of the port (Nikolaenko 2006, p. 165; Opait and Paraschiv 2013). An interesting feature of the vineyards in Crimea is the parallel stone walls that were constructed by digging trenches which were then filled with rocks. The grape vines were planted between the walls which had the double duty of supporting the vines and providing the necessary moisture for the plants by condensing dew and directing rainwater to the roots (Smekalova 2016).

The equipment used for agricultural activities was basic. Plowing, weeding, and digging were done using wooden or iron-tipped plows, mattocks, and hoes. Wealthier farmers used oxen to plow their fields (Suceveanu and Barnea 1991 and *ISM* V, 77). The harvest of grain was done with sickles and then winnowed and threshed on stone or earth floors. Most published agricultural tools are from sites dated after the first century CE (Baumann 2014).

Land Use and Settlement Patterns

Not much is known of the agricultural landscape before the arrival of Greek colonists, who settled around the Black Sea beginning in the seventh century BCE. Paleolithic and Neolithic sites are numerous in the region, but little is known of agricultural practices during those periods. Early Iron Age sites are also well documented. After the arrival of Greek colonists, there is a rapid growth of agricultural activities on both the western and northern shores. Thousands of rural sites have been identified in surveys around Histria that have never been methodically explored (Buzoianu, 2001, passim). There is no clear understanding of what types of settlements these were, or their relationships with other sites rural or urban in the vicinity. One site, Tariverde, dating from the first quarter of the sixth century BCE, contained numerous bell-shaped pits grouped around dug-out dwellings. These pits are believed to have been used to store grain that was later transported to Histria and beyond (Preda 1972).

The nature of early Greek settlements is ambiguous. Excavations of sites from this period find indigenous-type dugouts with Greek and "local" hand-made pottery. The increase in rural settlements in the Classical period corresponds with a more archaeologically visible pattern of land use. The *chora* of most colonies, on both western and northern shores, becomes a single entity divided into plots, marked sometimes by walls, and connected with roads that either radiate from the city or follow the landscape for the best route to and from urban areas. Plots varied in size, smaller at Olbia (0.2–0.3 to 3 to 5 ha) and up to 53 ha in the Tarchankut Peninsula (Smekalova and Smekalov 2002, pp. 207–240). The Heraklean Peninsula was divided in the fourth century BCE into 2360 lots of 4.4 ha each. Stone walls were used to divide each square, an impressive feat of labor and political influence (Carter 1995, 2006). Other means used to divide lots were ditches and low walls made of earth as employed in the *chora* of Kerkinitis, where lots were often trapezoidal in shape (Kutajsov 2006, p. 142). Not all Greek cities had an extensive program of rural division and organization like the one documented in the *chora* of Chersonesos (Carter 2000).

The cities on the western shore employed a less geometrical pattern of partition that did not alter the landscape but rather followed its contours. On the western shore, at Histria, aerial photography identified roads, tumuli, and walls but not a clear division or allotment of parcels (Alexandrescu 1978, pp. 331–342; Avram, 2006, p. 65; Dorutiu-Boila 1971). At Olbia, traces of plots are visible, but archaeologists have concluded that the division was "spontaneous" rather than the result of a thought-out plan and process (Kryzickij 2006, p. 103).

But where do the "farmers" live? Is there a clear settlement pattern we can use to describe the landscape? While the rural territories of the Greek colonies on the western and northern shores of the Black Sea have been surveyed for over 100 years, we cannot make a sweeping generalization regarding how the territories were divided all around the sea. There is nucleation in the settlements on the western shore where inhabitants lived in villages or hamlets, along navigable rivers, near freshwater sources, along flat plains, or on hillsides (Bâltâc 2011). However, in Crimea, for example, farmhouses were built on individual plots, close to each other and a short distance from the city, as Aristotle recommended (*Pol.* 1327a). The excavation of farmhouses gives us a good look into ancient rural life, agricultural practices, and patterns of habitation. From dugouts to fortified farms with interior courtyards and towers, the region has examples of a variety of rural structures. Systematic excavations have revealed modest abodes and architecturally elaborate farmhouses with multiple rooms, paved or pebbled floors (Samoylova 2007, p. 441). Xenophon, when describing the ideal architecture of a farm in Greece, suggested houses should be built with windows to the south so they can benefit from the sunshine in the winter when the sun is lower in the sky. The northern side of the house should be lower to keep it protected from the northern winds and cold (Xen. *Mem.* 3.8, 9; *Oik.* 9.4–9.5). Most likely this advice was applied in the Pontic colonies as well. The northern part of a house was used as storage since foodstuffs and wine could be kept cooler in those spaces. One of the more interesting features of the Pontic farmhouses was the tower. Round or sometimes rectangular, the tower is an architectural element found on both the western and northern shores. Their purpose was either part of a defensive system or storage facilities (Morris 2001). At Albesti, in the *chora* of Kallatis, there was a fortified farm in the fourth century, and the purpose of its tower could have been for defense (Alexandru 2016). The *phrourion* at Albesti had an economic function, possibly having been a point of exchange of goods or merely the storage of grain. The number of amphorae found here, together with structures classified by archaeologists as granaries, point to the fact that this site might have been an important center for agricultural activities. While the tower construction at Albesti could have been used for defense or refuge, that does not seem to have been the case in Chersonesos, where towers were used for farming activities or living quarters at least until the third century BCE. After this date, the first fortified farms appear as a reaction to an increase in Scythian raids in the region (Saprykin 1994, p. 74).

Rural sites, used for agricultural purposes, are not all necessarily "stationary" locations. Temporary or seasonal herder camps or fishing points are places where we do not find buildings or other obvious remains, but these sites are nevertheless important loci of rural economies.

Pontus and the Roman World

After the death of Mithridates VI Eupator and especially by the middle of the first century BCE, the Black Sea region was pulled into the Roman world. But even at the height of Roman control, the empire never included the whole Black Sea coastline, and the boundaries were not always clearly established. The Black Sea was never a Roman lake. Roman expansion in the region happened rather slowly. In 89 BCE, the Romans interfered in the region to try to stop Mithridates' influence and the Bosphoran Kingdom became a client state in 42 BCE. In 46 CE, Thrace became the province of Thracia, while in 64 CE Roman legions established themselves in the Crimea, and the region between the Balkan Mountains and the area between the Black Sea and the Danube (Dobrudja) were added to the province of Moesia. The military campaigns of Trajan in Dacia (101–102 and 105–106 CE) and Armenia (ending in 114 CE) were the last great attempts to expand Roman influence in the region.

The Romans brought about direct and specific changes in all aspects of life. The necessity of supplying large amounts of food, water, and raw materials to support the Roman armies based in the region meant radically transforming the countryside. The sea, the coastlines, and the hinterland were now the Roman frontier with fish, grain, and other raw materials from the region benefiting the empire in general and the Roman army in particular. The arrival of the Roman army altered the landscape and redefined the rural experience. New fortifications, roads, and aqueducts were built, together with civilian settlements depending on and working for the benefit of the Roman army. Civilian settlements sprung up almost immediately around military camps and were inhabited by the solders' family members, artisans, and merchants.

At the time of Ovid's residence in Tomis, the Greek cities still followed their customs and retained their institutions. For instance, Histria's rural territory was divided into the *chora* where the lands belonged to the citizens close to the city, and a larger area, the *regio Histriae,* under the control of the Roman administration. The *regio* was populated with veterans and Roman citizens who lived in villages, cities, and *villae rusticae*. In Dobrudja as a whole, archaeological surveys have identified at least 26 villages and 68 *villae rusticate* (Bărbulescu 2001).

We know that most rural settlements were placed along main roads, and in the case of Dobrudja, along the Danube. However, the lack of systematic archaeological investigations does not allow us to define clearly all types of rural settlements, the architecture of houses, what their outbuildings would have been, nor do we clearly know the relationships between the rural and urban centers. There are examples, though, of rural areas that became quite successful after the arrival of the Roman legionaries. The Telita Valley, for example, located south of Noviodunum and home to the Classis Flavia Moesica, flourished starting in the first century CE (Baumann 1984, 1995). Archaeological surveys have located several farms, and systematic excavations unearthed buildings with annexes used for producing metal agricultural tools and tools for woodworking. While tools published from these sites belong to the fourth century CE, there is no doubt northern Dobroudja had been a site for tool making since the Iron Age (Baumann 2014). Among the agricultural tools excavated at Telita, researchers have identified sickles, hoes, and a variety of blades and knives to cut grapes off the vines. Some farms also built kilns for the production of bricks and roof tiles (Baumann 2017). Unlike the rest of Dobroudja, the Telita Valley is hilly, wooded, and less suitable for growing cereals on a large scale, but the proximity of Noviodunum, estimated to have quartered 2000 Roman sailors (Petculescu 2005), gave the area a big economic boost. While most of the agricultural production never entered the markets and was consumed within the households, there is also proof that some commodities were produced in large quantities and were meant to be sold mainly in the local market. One commodity in particular, local wine, is well documented (Baumann 1989; Opait 2013), produced especially in northern Dobroudja by the local farms of the Telita valley.

Under Roman influence, exchange networks developed in the Archaic and Classical periods diversified and became more stable. Patterns of connectivity dating back as far as the Neolithic were enhanced, and local economies thrived.

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FURTHER READING

The fall of Eastern Europe's communist regimes brought forth the possibility of new research, collaborations, and advances in knowledge regarding the ancient history of the Black Sea region. Unfortunately, political unrest, illicit excavation, and lack of funding have hindered progress and remain major obstacles to this day. A trove of information, regularly published in journals dating back to the early 1900s, awaits researchers interested in the ancient agricultural history of the Black Sea region, but unfortunately most of this work is hard to obtain and written in languages that are not widely known by Western scholars. Some journals are available online and contain articles written in English, French, or German. For information on the area between the Black Sea and the Danube (Dobrudja), two periodicals accessible online are *Pontica,* published by the History Museum in Constanta (ancient Tomis), and *Peuce,* edited by ICEM Tulcea (ancient Aegysus).

Beginning in the 1990s, east–west collaborations brought about an important series of books and edited volumes. However, they are not specific to ancient agriculture, and the interested scholar has to sift through a massive amount of information to find pertinent material. The volumes published in the *Colloqiua Pontica* series, edited by G. Tsetskhladze, focus on the archaeology and history of the Black Sea. The Center for Black Sea Studies, established at Aarhus University in 2002, edited and published 16 volumes, all available electronically on the center's website. One of the volumes, *Surveying the Greek Chora: The Black Sea Region in a Comparative Perspective* (2006), edited by Pia Guldager Bilde and Vladimir Stolba, focuses entirely on the *chorai* of (selected) Greek cities. In 2007, two massive volumes, organized topographically by Greek city and edited by D.V. Grammenos and E.K Petropoulos, were published under the title *Ancient Greek Colonies in the Black Sea 2.* These volumes contain articles that focus not only on the Black Sea colonies but also contain a fair amount of information on their territories. Saprykin's *Ancient Farms and Land-Plots on the Khora of Khersonesos Taurike* (1994) is a great source of information on archaeological research done between 1974 and 1990. For the area between the Black Sea and the Danube, there are several books in Romanian that are essential to understanding the rural landscape especially after the arrival of the Roman army. Maria Bărbulescu's *Viata Rurala in Dobrogea Romana* focuses on the epigraphical sources, while Victor Bamann's *Ferma Romana in Dobrogea* mainly examines the *villae rusticae* located in the northern part of Dobroudja.

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CHAPTER NINETEEN

Agriculture in Iron Age and Archaic Italy

Laura Motta and Katherine Beydler

Introduction

The beginning of the first millennium BCE is a period of major transition and, at the same time, continuity. While most of the commonly exploited agricultural products and livestock had already been introduced to Italy during the Neolithic and Bronze Age, new technological innovations, including the shift to iron tools, as well as sociopolitical changes, led to a progressive intensification of agricultural production and a reorganization of farming practices. The Iron Age in peninsular Italy was characterized by new economic and political systems and by the development of specialized social hierarchies. The archaeological record attests to the emergence of aristocracies that were connected in complex long-distance trade networks. Settlements became bigger and, in some areas, developed into Italy's first cities. These trends are visible throughout the peninsula; however, it is difficult to describe Italy as a cultural or economic unit during this period. Italy has many micro-regions, with climate, geology, elevation, and vegetation differing throughout the country (see Chapter 20 in this volume). The two coasts had access to different resources and participated in different trade routes. There is a considerable regional variation not only in the physical environment but also in the political and socioeconomic organization of the many cultures that inhabited the peninsula. This chapter, therefore, will not discuss all the different Italic populations and socioeconomic developments that distinguish these diverse environments. Instead, it will first provide a summary of the most important advances in farming in previous periods and various areas of the peninsula; then it will focus on Central Tyrrhenian Italy (see Figure 19.1), more specifically on the Latin and Etruscan cultures, covering the Iron Age (IA, tenth–seventh century BCE) and the Archaic period (sixth century BCE).

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

Figure 19.1 Map of Italy. Source: Map by David Hollander using QGIS and map files from the Ancient World Mapping Center. "openwater.shp," "coastline.shp," "ba_rivers.shp," "awmc_rivers.shp," "awmc-osm-rivers.shp," and "suppleRivers.shp". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm]

Agricultural Origins and Developments in Peninsular Italy from the Neolithic to the Iron Age

By 6000–5800 BCE, the first domesticated plants and animals arrived in Southern Italy, where the earliest Neolithic villages are found in Puglia, Calabria, and Basilicata (see Figure 19.2). Domesticated plants and animals were also brought to Northern Italy from Eastern Europe and the Danube plain through the Alps. Plant material recovered from Italian Neolithic sites shows that the main cultivated cereals were hulled barley, emmer, and einkorn. Free-threshing wheat is only occasionally represented in the North, and it was a more important crop in Central and Southern Italy. A range of pulses was also grown, including lentils, peas, grass peas, bitter vetch, and broad bean. A difference is, again, noticeable between Northern and Southern Italy, with broad bean prevalent in the south only (Rottoli and Pessina 2007). This pattern of crop preferences lasted for millennia until the Roman age and even into the Medieval period.

During the Late Neolithic, there is an increase in the occurrence of opium poppy and flax, suggesting the use of these crops for fiber production (Rottoli and Castiglioni 2009). Domestic cattle, sheep, goats, and pigs were the animals introduced with the first farming

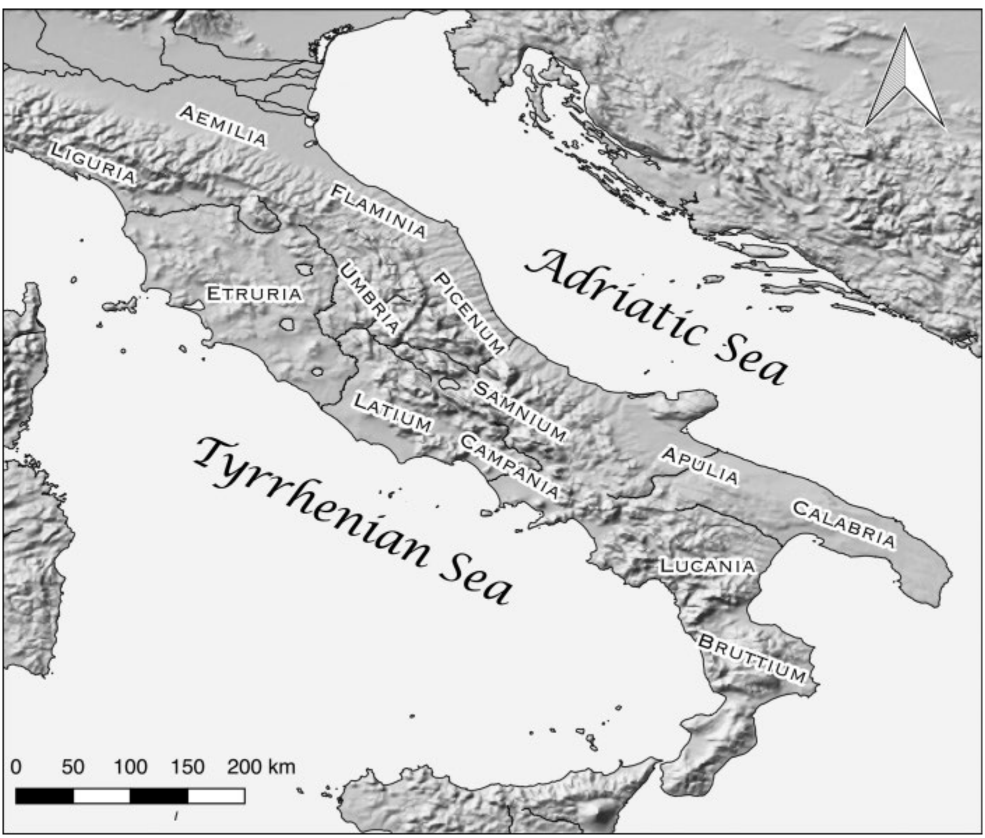

Figure 19.2 Map of the regions of Italy. Source: Map by David Hollander using QGIS and map files from the Ancient World Mapping Center. "openwater.shp," "coastline.shp," "ba_rivers.shp," "awmc_rivers.shp," "awmc-osm-rivers.shp," and "suppleRivers.shp". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm]

systems. The process of livestock diffusion has been recently reassessed: DNA analysis of cattle and pig remains from two Neolithic sites in Northern Italy clearly indicates the adoption of non-European species (Pearce 2013), while DNA sequencing of wild Italian cattle provides some evidence of interbreeding episodes between Near East domesticates, African varieties, and local wild animals (Beja-Pereira et al. 2006).

Plants, animals, and farming systems introduced during the Neolithic became well established during the Bronze Age (BA; see Chapter 12, Table 12.1 in this volume for the chronological definition of Early (EBA), Middle (MBA), and Late (LBA) Bronze Age). In this period, the Italian landscape was dotted with small villages, mostly situated on hilltops, close to wet areas, and/or in defensible locations. Agriculture expanded in upland areas with suitable crops and seasonal herding and shepherding activities. Subsistence economies focused on animal husbandry and pastoralism, as suggested by zooarchaeological remains (De Grossi Mazzorin 2004). The first appearance of specialized pottery containers connected with cheese-making activities, such as milk strainers, supports this interpretation. Sheep and goat herding played an important role in the hills and mountain range that form the spine of the peninsula, and in some areas, such as Samnium, it remained the basis of the economy until the Imperial Period (Barker et al. 1991). However, in other regions, the emphasis on the importance of animal husbandry might be the result of biases in the archaeological data (see the ratio of published research on animal bones versus plant material in De Grossi Mazzorin, Curci, and Giacobini 2013). With the improvement in the quality and quantity of archaeobotanical investigations in different areas of the Italian peninsula, such as the pile dwellings at the foothills of the Alps, the mound settlements in the Po Plain, and several villages in southeast Italy, the role of crop cultivation and, specifically, the prominence of cereal staples in the subsistence patterns of BA communities has been re-evaluated (Fiorentino et al. 2004).

In particular, in Northern Italy, it is possible to see interesting transformations in agrarian practices, accompanied by the adoption of new crops. The landscape was densely occupied with a wide range of differently sized settlements, possibly reflecting a hierarchical organization. A wealth of waterlogged botanical material indicates well-integrated mixed farming, supplemented by hunting, fishing, and gathering (Jones and Rowley-Conwy 1985; Mercuri et al. 2006). There is evidence, as early as the EBA, of the introduction of millet from Central Europe. Isotopic analysis shows that, in the Po Plain, this crop becomes an important part of the human diet and, by the MBA, it takes on major significance (Tafuri, Craig, and Canci 2009), while in Central Italy it was introduced in the MBA (Varalli et al. 2016).

In Southern Italy, instead, there is a further increase in the prevalence of free-threshing wheat, and isotopic analysis on human bones from two sites in Calabria suggests that cereal cultivation was more important than pastoralism in those local economies (Tafuri et al. 2009). In SE Italy, plant remains from recently investigated settlements in Puglia show a shift in subsistence practices and farming systems, with the application of crop management to allow for two harvesting periods, the gathering of wild fruits such as acorns, figs, and olives that could be stored for long periods, and the improvement of storage systems. Some scholars suggest that these changes in subsistence could have been a response to climatic instability and environmental constraints that led BA communities to establish buffer strategies to ensure the supply of foodstuffs (Primavera et al. 2017). In addition, the development of sociopolitical complexity during the LBA seems to have led to further change in agrarian strategies, this time in order to accumulate surplus. These strategies increased productivity by focusing on the cultivation of free-threshing grain, maintaining the two harvesting seasons already implemented in the previous period, and managing olive trees and storage systems to deal with surplus production and redistribution (Primavera et al. 2017). The archaeological evidence of large storage structures that well exceed the needs of a nuclear family (Schiappelli 2006) together with the pollen data, which record an increase in olive trees in this region by the LBA, corroborate these economic transformations. However, archaeological and archaeobotanical data from Calabria indicate that the cultivation of olives, and possibly grapevine, declines to household levels by the very end of the BA, when trade routes with the Mycenaean world were disrupted (Lentjes 2016). These crops, which require considerable investments, were not regarded as staple resources, but valuable cash crops; they recovered their economic importance once exchange networks were flourishing again, in the Archaic period.

Special attention should be paid to the evolution of grape exploitation and wine production in the farming economy of this period, since new research seems to disprove the still common assumption that Greek colonies introduced wine making in Italy during the IA. Wild grapevine occurred spontaneously in the peninsula (Di Pasquale and Russo Ermolli 2010), and it was exploited as a food resource at least from the Neolithic onward. Molecular analysis, coupled with morphometric observations, suggests that cultivated varieties already exhibit domesticated traits in some Southern Italian locations during the Neolithic (Gismondi et al. 2016), a process also observed in Sardinia and Northern Tuscany, where the domestication of local cultivars started in the MBA (Aranguren and Perazzi 2007; Ucchesu et al. 2015). A survey of the BA evidence in Italy shows an increase in the diffusion of the grapevine during the second millennium BCE. The long-term and continuous management and, possibly, the introduction of improved allochthonous varieties from the Eastern Mediterranean, must have led to a more knowledgeable utilization of this plant (Marvelli et al. 2013), including the production of fermented drinks indicated by the remains of grape and cornelian cherry found in the mound settlements of the Po Plain (Cardarelli et al. 2015). Grape pressing residues discovered at a ninth century BCE village on the banks of the river Sarno (Cicirelli et al. 2008) prove that viticulture and wine making were a well-established local tradition in those areas of the peninsula where grapevine was native. Arboriculture of other indigenous trees such as fig, chestnut, and walnut is confirmed by pollen analysis (Russo Ermolli et al. 2011; Mercuri et al. 2013; Pollegioni et al. 2017), even if the process of their domestication and increased exploitation is difficult to assess due to the lack of archaeobotanical evidence.

Starting in the eighth century BCE, the Greeks established colonies on the coasts of Southern Italy, bringing, indeed, different agricultural practices and techniques with them. This is particularly apparent in the territory of Metaponto, where other varieties of livestock, including a new breed of sheep and larger cattle, accompanied the arrival of Greek settlers (Bökönyi 2010). In the following two centuries, there was a remarkable reorganization of the landscape and agricultural expansion, attested by the striking increase in the number of new settlements. The colonies formalized and organized their rural hinterland, filling it with small farms. Meanwhile, new indigenous settlements were established in previously unexploited areas further inland on fertile and well-watered arable land (Lentjes 2016).

The transition between the BA and the IA is marked throughout the peninsula by the emergence of elites and by the formation of locally differentiated cultural groups with distinctive political trajectories. In particular, the Tyrrhenian coast of Central Italy witnessed the appearance of the Etruscans north of the river Tiber and of Latin-speaking people south of it; these two cultures shared similar socioeconomic developments and, by the eighth century BCE, their newly formed ruling aristocracies were participating in complex social hierarchies. The increase in sociopolitical complexity is associated in Ancient Latium and Etruria with economic specialization and urbanization processes. A clear shift from a dispersed to a highly nucleated landscape is noticeable: many of the small hilltop villages of the BA were abandoned, and their inhabitants moved into clusters of settlements which eventually coalesced into single urban sites. In the Archaic period, this coastal region, rich in fertile volcanic soils, became packed with an impressive number of city-states. Some of the main polities, including Rome itself, controlled a territory organized with a centralized hierarchical settlement system of smaller settlements and farms (Pacciarelli 2017). The social and political dimensions of the process of urbanization cannot be divorced from the agricultural economy and farming practices: control over staple resources, supply of the budding urban communities, land ownership, food redistribution, and technical innovation are all tied to the development of these first cities. At the same time, communication between these settlements and the Mediterranean intensified, leading to new possibilities in trade and newfound exchange networks.

Farming in Central Italy During the Iron Age and the Archaic Period

Evidence for the events discussed above is mostly archaeological; a few later textual and epigraphic sources refer to IA and Archaic practices retrospectively, but they must be read with caution. Some Etruscan and Latin early urban centers have been investigated in recent times with modern excavation techniques involving zooarchaeological and archaeobotanical analyses. Field survey and environmental data have allowed a better understanding of their hinterland and rural landscapes. Pollen indicators of anthropic clearance activity start in the late BA, rapidly increasing after 1000 BCE (Sadori et al. 2011) and have been explained with demographic expansion in the countryside and intensification of land exploitation. Indeed, the beginnings of the process of rural infill that peaked in the Republican period are indicated by the marked rise, in the sixth century, in the number of rural buildings. This process has been linked to new agricultural practices and, for some scholars, to different types of land tenure and ownership (Cifani 2009; Bietti Sestieri 2010). The social implications of these changes are still a matter of debate; they did, however, result in a variety of situations as implied by the mosaic of small isolated farms, medium-sized rural buildings, and bigger elite productive compounds, the best examples of which have been excavated at Torrino, Acqua Acetosa, Laurentina, and at the Auditorium site, all located in the ancient territory of Rome. Some differences can also be observed in the local outcomes of this rural reorganization; for example, in the hinterland of Caere (see Figure 19.3), there is a considerable increase in the number of farm sites between the seventh and the sixth centuries BCE, while Tarquinii (see Figure 19.1) shows a multiscale settlement system with a less dense rural occupation but with a number of small towns inbetween the urban center and the farmsteads (Cifani 2015).

Agricultural production focused on staple resources, but with the Archaic period there was also a new interest in market-oriented specialized crops. The animal economy maintained the pattern identified in the BA and was primarily dominated by ovicaprines and cattle, with pigs becoming progressively more important over time (De Grossi Mazzorin 2004). This trend is common to Latium and Etruria, where the number of pig remains start increasing in the eighth century BCE. However, Rome shows a distinctive character compared to other minor Latin centers such as Ficana and Fidene. Here, the striking prevalence of pig remains is especially remarkable and possibly reflects a growing demand for supplied meat. Pigs are among the most prolific domestic animals, often raised exclusively as meat producers, and they became an important part of the diet of urban people. In contrast, the low number of adult cattle is consistent with the prevailing use of these animals for milk production and traction, together with horses and donkeys. Chicken was introduced in the EIA, but became a common component of the diet only in the Republican period (De Grossi Mazzorin and Minniti 2017). The oldest evidence comes from a cremation burial at Castel Gandolfo dated to the ninth century BCE; it also appears in Etruscan wall paintings from Tarquinia in the late sixth century. It does occur, though not commonly, in zooarchaeological assemblages throughout

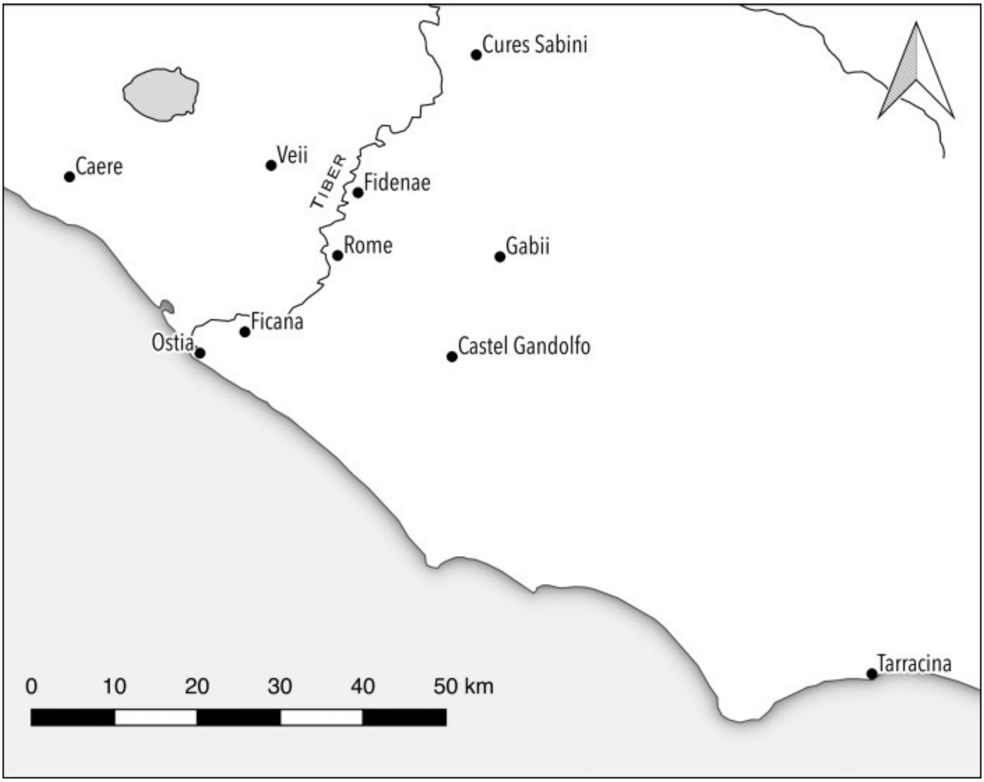

Figure 19.3 Map of the neighborhood of Rome. Source: Map by David Hollander using QGIS and map files from the Ancient World Mapping Center. "openwater.shp," "coastline.shp," "ba_rivers.shp," "awmc_rivers.shp," "awmc-osm-rivers.shp," and "suppleRivers.shp". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm]

Italy by the Archaic period. Like pigs, whose numbers increased as settlements grew denser, chickens are ideal animals for urban environments.

As in the previous periods, the primary staple crops in IA Tyrrhenian Central Italy were cereals, particularly emmer and barley. Einkorn, spelt, free-threshing wheat, and millet are also occasionally attested in the archaeobotanical record but do not usually represent crops of major economic importance. These dietary staples were supplemented by growing legumes and garden vegetables. Interestingly, local variations in the choice of preferred cereal and pulse crops can be observed even in settlements situated in close proximity. In Etruscan Caere, emmer is more frequent than barley, while bitter vetch is favored over fava beans (Stevens in Izzet 2000); there is no evidence of other wheats or millet in the few samples analyzed from the LIA-Archaic period. At the Latin city of Gabii, barley is the main cereal, followed in importance by emmer and millet. Extremely abundant are also bitter vetch and fava bean. In contemporary contexts at Rome, emmer is the most common cereal, while barley decreases in frequency from the eighth to the sixth century, and millet has been found in one sample only. Fava bean is the preferred pulse, while bitter vetch occurs in much lesser quantities (Motta 2002). The similarity throughout the region in soil, water availability, and climate do not support a reliable environmental explanation for the observed differences, which, instead, must be understood in terms of multiple local cultural traditions and trade networks.

Cultivation of grapevine and olive tree is definitively confirmed by the growing body of remains of pips and olive stones. Nevertheless, excluding several instances of rock-cut vats throughout the peninsula that are difficult to date, the first compelling evidence for the development of a pressing technology for the production of olive oil emerges during the sixth century when the first archaeological remains of presses are found in rural settlements (Cifani 2015). Accordingly, the pollen records show an increase in olive trees and grapevine at the beginning of the first millennium BCE (Drescher-Schneider et al. 2007). Excavated sites such as Podere Tartuchino in Etruria illustrate the kind of small farms that were involved in wine production (Perkins and Attolini 1992). On the other hand, the industrial compound at Sant'Antonio-Marsiliana d'Albegna was probably a kiln for the production of wine amphoras, attesting to the importance of the commercialization of this product (Zifferero et al. 2009). The economic relevance of the commercial exchange of agricultural goods is reinforced by the findings at the Casa delle Anfore, a nearby large rural building with a number of storage containers for food processing in the courtyard and rooms dedicated to the deposit of transport vessels. Organic residue analysis on some of the containers has revealed fish components and possibly olive oil (Zifferero 2010). The long-distance trade of luxury products such as wine and olive oil became a significant part of elite wealth accumulation strategies, and it is demonstrated by the number of shipwrecks transporting Etruscan amphoras found throughout the northwestern Mediterranean (Gran-Aymerich and Turfa 2013). By the Archaic period, the Etruscans were major competitors of Greek and Phoenician traders (Perkins 2012), while in Latium, there is much less evidence for the production of specialized shipping containers, possibly indicating a short-range distribution of these goods (Volpe 2009).

Tools and Technology

One of the most important technological advancements in farming for this period was the introduction of iron in place of bronze for tools and other implements. While plows, goads, flails, winnowing fans, and many other important agricultural implements were probably made mostly of wood, they would have had iron components, like a plow-shoe; others, like sickles and hoes, were made largely from iron. Instruments made completely of wood and other perishable material would have not been preserved except in exceptional situations, like the EIA yoke found in Lago di Bolsena. For this reason, the vast majority of the surviving wooden tools have been recovered in BA waterlogged sites in Northern Italy (Coccolini 2006). Iron agricultural tools, instead, once broken and inoperable, would have been either modified or the valuable metal re-cast. However, there are some examples of pruning hooks, used for viticulture, and sickles dated to the IA and Archaic Period throughout the Italian peninsula (Bartoloni 1987) often, unfortunately, retrieved without contextual information. Many graves also include tools that could have been used for tasks related to agriculture, and most of them come from elite male burials (Iaia 2006). Despite their scattered and infrequent nature compared to other types of prestige goods, these finds indicate the importance of iron farming tools in elite culture as well as everyday use. The manufacture of pottery also changed during the IA. The introduction of the fast wheel allowed for a greater standardization of shapes and faster production of vessels, and new kiln technologies provided different finishes (Bietti Sestieri 2010), facilitating, among other things, large-scale production of storage and shipping containers.

The Archaic period saw new practices in land reclamation and water management (Cifani 2002). While the region is well suited for rain-fed agriculture, the creation of drainage systems and water structures point to a renewed investment in the arable land. The remains of hundreds of kilometers of water channels provide evidence for the draining of marshy ground and for land irrigation. These structures, a typical feature of volcanic plateaus in Etruria and Latium, are called *cuniculi*. They are usually narrow tunnels with a vaulted roof excavated in the soft bedrock; they served many purposes both inside the settlements and in the countryside, including the collection and filtration of groundwater as well as the regulation of excessive dampness and water diversion. A significant example is the large system of *cuniculi* that run along little valleys and streams in the hinterland of the Etruscan city of Veii, acting as control of groundwater levels or, alternatively, rerouting the streams themselves (Judson and Kahene 1963).

Textual Sources

Even if the first forms of written record begin in Italy in the late IA, there are no literary sources on agriculture surviving before the Republican period. The oldest source in Latin to discuss the practice of agriculture are the Twelve Tables, a law code established during the mid-fifth century BCE in Rome and probably edited by the Romans over time (Manzo 1995). The extant portions of the document describe a primarily agrarian society and laws that are specifically concerned with protecting one's land from danger (whether magical or physical), property damage, theft, and defining mutual rights of neighbors as well as with settling disputes of inheritance and land use on a civic and personal level. The Twelve Tables are indirect evidence of the processes of increasing social complexity occurring in the nascent Roman state and seem to imply the existence, at least from the mid-fifth century BCE, of some small landholders. The laws illustrate the complex relations between private property and older forms of clan organization, representing a formalization of concerns over boundaries, land ownership, and property rights, issues that have roots in the urbanization processes and institutionalization of wealth.

In addition, some literary sources from the late Roman Republic onward describe traditional agriculture, or claim to reflect on the origins of farming at Rome, including Cato, Varro, and Columella (see Chapters 20 and 21 in this volume). Their descriptions of the practices of early farmers probably reflect their own political and literary goals more than any kind of IA or even Archaic reality (Reay 2005). Despite this, however, they have been often used to make conjectures about the practice of agriculture not only in Latium but in other Italian regions and time periods. Still, they are useful to those interested in early agriculture, since the themes shared between them help explain how later Romans viewed their agricultural and environmental history.

Notably, most of the agricultural laws as well as the writings of later authors deal primarily with the production of cereal crops, viticulture, arboriculture, and draft animals, rather than with herd animals or pastoralism. Indeed, most animals mentioned by the Twelve Tables are work animals rather than those kept mainly for meat, milk, and other secondary products, like sheep and goats. Livestock were doubtless a key part in the economy of IA settlements, and pastoralism is connected with ancestral origins and the myth of the foundation of Rome. However, the emphasis in our sources on crop production, distribution, and land management showcases the importance of reorganizing crop-raising practices in growing urban communities and the ideological value of agriculture versus pastoralism for the emerging aristocracies.

The Agricultural Calendar

As in the Twelve Tables, the ritual celebrations of agriculture in the Archaic Roman calendar focus on the protection of crops and defense of land; these include festivals like the *Robigalia*, intended to keep fungal rust away from crops, or the *Terminalia*, which reinforced the borders around property. Only two of the approximately fifty fixed festivals in the Roman calendar specifically concerned pastoralism, the *Parilia* and the *Lupercalia*.

Even if it is impossible to know which one of the later Roman festivals already existed in the IA, earlier calendars would presumably have shared this emphasis on crops and arable land with yearly rites to commemorate agricultural activities. Before the Roman conquest of the Italian peninsula, there was no uniform calendar, but regional, culture-specific variations of a similar system based on a twelve-month lunisolar sequence (Rüpke 2011), associated with seasonal events and the growing phases of plants and animals. Very few fragmentary remains of late Archaic calendars are documented from Central Italy, such as the *Tabula Capuana*, an Etruscan ritual calendar from c. 470 BCE; most information about what a calendar might have looked like in the first half of the first millennium BCE comes from Roman sources. The early Roman calendar can be reconstructed on the basis of Late Republican and Imperial period epigraphic evidence (Scullard 1981) and Latin authors, including Varro, Ovid, and Macrobius. In their writings, they recognize and discuss the antiquity of some traditions associated with the agricultural year, most often by dating them to the time of the first Roman kings, either Romulus or Numa Pompilius. While that attribution is mythical, it indicates the older age of some festivals as well as their relationship to the formation of the Roman state and identity in the Imperial imagination. For example, Macrobius tells us that the *Nundinae* were established during the monarchy to allow farmers and rural dwellers to have a day of rest from work and to be able to go to Rome to trade their products and engage in urban matters such as legal and political events (Ker 2010). These multifunctional market days can be explained in the context of the complex relations between the forming city-state, its countryside, new rural citizens, and farming activities. It is the addition of civic and religious layers to the agricultural almanac that eventually produced the Roman calendar, as a culturally embedded form of timekeeping.

Demographic Growth, Urbanization Processes, and Agriculture

Increasing population has often been used to explain increasing settlement size and the resulting intensification of agricultural production. Demographic growth in itself is probably too simplistic a model because it fails to account for the visible heterogeneity in settlement patterns and for processes of greater aggregation of a stable population. It is more appropriate to consider larger sites, the spread of farming, and the intensification of food production as interrelated developments that occurred during the IA and Archaic Period and contributed to the urbanization in Central Italy; their precise causal links, however, are far from clear, and they will need much more data to be elucidated.

Whatever the mechanism, during the sixth century BCE, Central Italy became one of the most densely urbanized areas in the Mediterranean, with many independent cities and smaller towns in competition with each other scattered in a very fertile, if limited, coastal area. Each urban polity functioned as a center with its delimited and circumscribed territory, which included a complex hierarchy of minor settlements. It is possible that over time, limited availability of land may have constrained the production and redistribution system, prompting, in some cases at least, a struggle for more arable land. Attempts have been made to calculate the population size and the extent of the territory controlled by the main centers throughout the IA and Archaic Period. There is a huge variability in proposed demographic figures, with scholars divided between low counts and high population densities (Smith 1996; Cardarelli 1997). Other scholars look at arable land productivity and yield estimates to evaluate carrying capacity with, again, conflicting results (Ampolo 1980; Viglietti 2011). Potential agricultural and land-use assessment methods have been applied to the Agro Pontino area (van Joolen 2003) as well as to Veii, where a solid agricultural base for the city has been suggested during the sixth century BCE (Schiappelli 2012). A recent analysis of the territory of early Rome combines settlement distribution with demography to specifically investigate its carrying capacity. The hypothetical population density, calculated for different periods between the end of the BA and the Archaic period, coupled with land productivity assumptions suggests that certainly by the sixth century, but probably already by the early seventh century BCE, the urban and rural population of Rome would have outgrown the agricultural resources provided by its territory (Fulminante 2014).

With these contrasting interpretative models, it is difficult to fully comprehend the relation between urban growth, demographic expansion, and the degree and pace of intensification of agriculture that is usually inferred from the rising number of farms in the countryside and land reclamation projects. However, regardless of the different assumptions about catchment productivity and carrying capacity, by the end of the Archaic period, the immediate hinterlands of some settlements could have become inadequate to supply the needs of the urban population, especially in bad harvest years.

How sustainable these early cities were is yet to be determined, but IA urbanization contributed to the development of redistributive food systems; with increasing social complexity and economic specialization, there was a need to allocate foodstuffs to members of the society not involved in agricultural production and to implement buffer strategies in times of shortage. Not much work has been devoted to investigating mobilization and control of staples. What little evidence is available, however, suggests that elites were tightly involved in managing the production and movement of agricultural goods and probably used the control of their local agro-ecological landscapes as a basis for power (Smith 2006; Terrenato 2011). The occurrence in elite burials of bronze and iron farming tools attested in EIA Etruria, instead of the more typical weapons and personal ornaments, indicates the important social role of leaders in food production and distribution, perhaps symbolizing the authority of the deceased person over the food resources associated with particular tools (e.g. sickles for grains, pruning knives for grapes). Furthermore, historical narratives describe how elites traditionally relied on staple food distribution to boost the power and prestige of their lineage group within their community (Drummond 1989). The increasing elite control of staples coexisted with a more general progressive transition from household-level toward more complex forms of production and provision. A trend toward greater centralization of crop processing, storage, and redistribution as well as specialization in food production seems to accompany political development in Rome (Motta 2011) although the degree of centralization cannot be compared with later Republican and Imperial strategies when the city was supplied by a Mediterranean-wide market system (see Chapter 21 in this volume).

Important Debates and Avenues for Future Investigation

The social dimension of agriculture has been the main and long-standing focus of research, since the Iron Age is often considered the starting point for the social and political developments that led to issues of landholding, tenancy, and management of *ager publicus* in the Republican period (Bernard 2016; see Chapter 20 in this volume).

The current discourse sees central Italian elites, organized in large lineage groups (*gentes* in Latin) that included kin members as well as individuals connected by social obligations, as the main actors in the transformation of agricultural systems. Their power and wealth were rooted in the control of land; indeed, some later sources suggest that land was owned by the group and the lineage leaders could assign arable lots to families, while pasture and woods remained for collective use. The tempo and mode of the transition from a more communal organization of rural resources, managed by these clan-like structures, to a system of small landholders and the diffusion of private property are still subjects of intense debate. For some, the mention in the Twelve Tables of rules regarding inheritance of land parcels and usucaption (ownership of property gained by possession) points to the existence, at least from the fifth century BCE, of small landowners recognized and protected by state laws in respect to traditional practices involving the clan (Cifani 2015). On the other hand, the same evidence has been used by other scholars to remark how these practices were still clearly frequently in use and lingering into Republican times (Terrenato 2011). Several other aspects of this transition need to be better understood. For example, we are still unsure to what extent the sudden rise in the number of farms in the sixth century is the result of political events and drastic social reorganization, and how much of it is due, instead, to bias in field survey visibility. The change in construction techniques in this period, from wattle and daub huts to houses with stone wall bases and tiled roof, introduced building materials that are easier to detect in the archaeological record and would make small rural buildings visible for the first time.

The link between elite emergence at the end of the BA, elite wealth economy in the Archaic period, and arboriculture is also under discussion, as is the contribution of Greek and Phoenician colonies to its development. Furthermore, is not clear what the status and economic role of the small productive farms was in relation to cash crop agriculture and elite control. A helpful starting point to unravel these overlapping lines of enquiry would be to critically investigate the blurred archaeological evidence that distinguishes exploitation at the household and/or local level from the intensive management of improved cultivars for trade and market economy. An extensive body of literature has been written on the beginnings of grape and olive cultivation, but only in very recent scholarship is there an attempt to differentiate biological changes connected to the domestication process, long-term local cultivation, economic development of large-scale production and, importantly, ideological discourse. For wine, in particular, this approach is especially valuable since it is possible to make domestic production of fermented juice from wild grape without elaborate technological know-how and major labor investment. Still, in the IA, different ideological values associated with wine consumption are apparent; the new aristocracies adopted Eastern Mediterranean behaviors, exemplified by standardized drinking sets that became a vehicle of self-representation and reinforcement of social hierarchies (Kistler 2017). It is in this participation in common elite identity practices throughout the Mediterranean that the contribution of Phoenician and Greek colonies needs to be framed.

If more research has been carried out concerning long-distance trade of luxury crops, we have yet much to explore regarding the scale of production of staple resources and, as said above, the function of the elite alliances and networks in their mobilization. The many episodes of wheat scarcity during the fifth century described by historical sources, in which Rome needed to import wheat from Etruria and Southern Italy (Northwood 2006), indicate that staples were moved not only at the regional level, but also through trade routes across the peninsula. Even less has been done in terms of environmental reconstruction. The study of the ancient climate is now providing a much-needed detailed chronological resolution that can allow correlation with historical events (Goudeau et al. 2015; Magny et al. 2013; Mercuri and Sadori 2012). Short-term and abrupt climate shifts are documented for the first millennium BCE, but whether and how they could have affected the farming economy and organization has not been fully explored so far. In addition, there is evidence of changes in seasonal rainfall patterns that could have had a substantial impact on the rain-fed agriculture in the region. Water availability as well as husbandry regimes can also be investigated with the study of ancient weeds and isotopic analysis. Then again, too many sites have been excavated without proper attention to the sampling of plant and animal remains and the collection of environmental data; future research will need to be more concerned about effectively integrating innovative scientific techniques into historical reconstructions.

FURTHER READING

The only comprehensive study, focusing on new archaeobotanical data integrated with zooarchaeological remains and field survey results to present an exhaustive reconstruction of land use and agricultural production, has been published by Lentjes (2016) for Southeast Italy. The Dutch school explored settlement patterns, people–environment dynamics, and land use in a diachronic and comparative perspective in three Italian regions (Attema et al. 2010). Barker (2005) provides a general overview of Mediterranean prehistoric agriculture and pastoralism, but with particular attention to peninsular Italy, following on his previous study on the Biferno Valley (1995). A very detailed and updated synthesis on the Etruscan countryside is offered by Stoddart (2015), while Cifani discusses rural landscapes and land ownership in Central Tyrrhenian Italy (2015). Fulminante (2014) and Terrenato (2019) deal with social changes and urbanization processes in early Rome, while the transition from household economy to centralized crop processing and distribution is explored by Motta (2011). Animal husbandry in Rome and neighboring areas is described in De Grossi Mazzorin and Minniti (2017); Trentacoste (2016) focuses instead on the Etruscan territory including the Po Plain. The debate on grape cultivation and wine production is presented in a multi-authored volume resulting from ten years of interdisciplinary research and international collaboration at the University of Siena (Ciacci et al. 2012).

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CHAPTER TWENTY

Agriculture in Republican Italy

Saskia Roselaar

Introduction

The Roman Republic was a period of great change. From a small city-state in central Italy, within five centuries Rome transformed into a Mediterranean empire. During this period, and long after, agriculture was the main source of subsistence for virtually all the inhabitants of Italy – even those who made a fortune in trade or investment were still dependent on the fertility of agricultural land. Recent scholarship has led to many revisions in our knowledge of the Republican economy, from a bleak picture of economic decline, to the recognition that the Italian economy was thriving as never before in the middle and late Republic. Still, the role of agriculture in the wider economic, political, and social developments of the Republican era has not been widely studied. It is assumed that everything remained more or less the same, while great changes only took place in the Imperial Period. To a certain extent, this is correct, but some important and significant developments already occurred in the Republican period, as will become clear in this chapter.

The Archaeological and Textual Evidence

The archaeological evidence for agriculture is difficult to interpret, since most aspects of agriculture, such as food items and animal remains, are degradable and have left few traces. Some information can be gathered from remains such as burnt wood, animal bones, fossilized excrement from sewers, and organic materials in amphorae and other pottery. Unfortunately, such remains are fairly rare and unequally distributed throughout the Italian peninsula. Archaeological evidence related to agriculture can also be gathered from pottery used to store and transport agricultural products, especially wine and olive oil, as well as cooking wares and other utensils. In the 1980s, ethnoarchaeological studies were carried out in parts of Italy which still used traditional techniques of agriculture, but it should be remembered that these cannot directly be related to Roman practice.

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

The clearest evidence comes from excavated farm sites – several dozens of farms from the Republican period have been excavated. However, sites discovered by these methods are usually large, while much agriculture, in fact, took place on small sites which have left few traces. Farm activities are also depicted on frescoes, reliefs, and other forms of art, but again these are skewed toward the larger establishments. Recently, the use of various types of geophysical survey has greatly increased; this methodology also detects smaller buildings, not only large *villae*. This has enhanced our knowledge of Republican agriculture, but many questions still remain.

One issue of debate is the history of the villa. This term is usually applied to larger buildings which produced for the market, but when these buildings appeared and what they looked like is still a matter of debate. This debate is partially caused by the most important literary work on agriculture, Cato's *De agri cultura*, dated to c. 160 BCE. It is a rather haphazardly organized collection of advice, covering issues such as how to establish a farm, when to undertake specific chores on the land, how to sell and buy equipment and crops, as well as recipes for food and medicine. However, it has been pointed out (Terrenato, 2001) that there seems to be a discrepancy between the villa as described by Cato and the finds that turn up in the archaeological record. Most archaeological sites dating from the second century cannot be equated with the "Catonian villa." Instead, from the third century (and in some areas even earlier), there appear sites which show evidence of commercial production, but seem to have been built on a much smaller scale than the villas described by Cato. For example, while Cato states that a villa should have five olive presses, no establishment with five presses has been found. Most second-century farms have only one press (Terrenato 2001, pp. 20–25). This has led to widespread debate on Cato's reliability.

There are several possible explanations for this: first of all, Cato's writings are only applicable to a fairly small region, namely, northern Campania, where not much archaeological research has been undertaken. Given the small number of *villae* that have been excavated in their entirety, it may be that estates of the type described by Cato simply have not yet been discovered. Another explanation is that Cato's work was influenced by Mago's treatise on African agriculture; in Africa, some farms with five presses have been found dating to the late third century. This does not mean that Cato's work in general cannot be applied to Italian agriculture; for the work to have any value at all, some of it must have been applicable to Italy. Most of the advice given by Cato seems reasonable for the second century BCE, and especially to larger commercial farms active in this period (Kron, 2000). In any case, Cato describes only large-scale commercial farming that was appearing in some parts of central Italy. Subsistence agriculture was still the most common method of farming in virtually all areas of Italy.

The second written source is Varro's *Rerum rusticarum*, dated to the mid-first century BCE. It gives a more structured description of the agricultural year and the tasks of the farmer. Its three books cover respectively agriculture, animal husbandry, and *pastio villatica*, i.e. the production of luxury foods, such as birds, fish, and small mammals. The reliability of his work has been debated, since Varro made use of earlier works, especially by the Greek Theophrastus. Nevertheless, the level of detail inspires confidence: Varro constantly gives examples of agricultural practice in specific locations, varieties in soil type, et cetera – he certainly did not copy his sources uncritically (Spurr 1986, pp. xi–xii; White 1970, pp. 22–24).

Another important handbook is Columella's *Res rustica*; this is dated to the mid-first century CE, slightly later than the period under consideration here. However, it is the longest and most comprehensive work, and much of its information is still relevant to the Republican period. Each of its ten books is devoted to one specific type of farming. Columella discusses soil types, wine and olive production, fruits, the breeding of large animals, small animals, birds, and game, and gives advice on the management of the household and the (slave) staff. He aims to give a comprehensive overview of agriculture, especially of large estates and specifically viticulture. His work is based on a variety of sources, but also displays great practical knowledge (White 1970, pp. 26–28).

Other works, such as Virgil's *Georgics*, the pseudo-Virgilian *Moretum*, Palladius' *Opus agriculturae* (fourth century CE), and the tenth-century *Geoponika*, mostly echo the advice of Varro and Columella. Information about the running of farms can also be gleaned from the letters of Cicero and Pliny the Younger. Technical and legal works can also be of value. The *Digest* and the works of the *Agrimensores* offer insights into a variety of issues that touch upon agriculture, such as the subdivision of large estates into small farms, the details of land measurement, and the damage done by forces of nature, e.g. floods and earthquakes.

Geography and Climate

The Italian peninsula enjoys a widely varied geography and climate. The coastal areas are mostly flat and extremely fertile because of alluviation from the rivers (see Chapter 19, Figure 19.2). Several volcanoes also create extremely fertile soil. The coastal areas are very warm in summer, with wet but mild winters. Still, some coastal lowlands were very marshy and therefore unsuitable for agriculture; the Ager Pontinus south of Rome was subjected to various drainage projects, but these did not succeed. These areas were often used as meadows. The most famous area for commercial agriculture was the land around Capua, the Ager Campanus. Here the famous wines of Italy were produced. Other fertile areas of Italy were the valleys of Etruria, especially the Tiber Valley, Campania, Apulia, and the Po valley, which all combined good soils with sufficient rainfall and relatively mild winters.

The Apennine range consists of wooded mountains and steep valleys, with small rivers that drain into the sea. In the summer, this area can be very hot, but in autumn the temperature drops quickly and snow sometimes falls as early as October. In some areas of Italy, such as Lucania and Bruttium, only a small amount of land is suitable for agriculture, since most of the territory is covered by steep wooded mountains. Very steep terrain was less fertile, since many nutrients ran off. Such mountains were used for timber and as summer pasture. Less steep areas also suffered from runoff, but since many of these consisted of limestone, they were still fairly fertile. They could be used for vines and orchards. In the valleys wheat, flax and vegetables were grown on fertile terrain, while poorer soils were used for legumes. Despite the fact that much land in Italy was not very fertile, most towns in Italy were surrounded by some agricultural land from which they provided the bulk of their food requirements.

It is important to note how mountains determined the geography of Italy. Mountains fragment Italy into a large number of small, sometimes fairly isolated units. Towns were usually located in the valleys or on the lower hills and were surrounded by arable land in the immediately surroundings. The surrounding mountains were often unsuitable for anything other than extensive animal husbandry. Even hills quite close to Rome, such as the Monti Lepini, were useless for agriculture.

The ancient writers pay much attention to the different soil types and explain in detail which crops should be planted where. Nevertheless, only specialized farmers could really take maximum advantage of local and regional soil types; small farmers planted the same crops in all types of terrain. Still, there is much variety in the landscape even over small distances: steep slopes and flat valleys, dry and wet areas, forests and river valleys can all be found very close to each other. Even small farmers could take some account of these local variations (Spurr 1986, pp. 3–5).

The climate was quite variable, leading to great variations in the weather. In general, more rain falls in the north and west of Italy, as well as in hilly areas. In the south, most rain falls in winter, while in the north rainfall most often occurs in the spring and autumn. The western part of the peninsula experiences fairly mild weather, with rarely any serious frost, but the east exhibits a higher variation in extreme temperatures. The variations in rainfall meant that water management, both irrigation and drainage, was important. Drainage channels are therefore attested in many places. Flooding was also a danger, especially in the Po valley and other river valleys. The greatest danger from water came in autumn, when the ground was dry and the soil would rapidly run off when it rained (Spurr 1986, pp. 17–21). Irrigation was used for meadows and for growing grain, legumes, and vegetables. Usually channels were constructed leading from a natural spring or a well (White 1970, pp. 152–158; Kron 2008).

Major Crops

A large variety of plants were cultivated in Republican Italy. The main crops were, as in other Mediterranean societies, cereals, olives, and grapes. Cereals provided the staple food for most people, while olive oil served as a preservative and was used in cooking. Wine was the most important alcoholic drink and was traded commercially, often over long distances. It is important to note that a great variety of cereals was grown, such as emmer wheat, bread wheat, barley, millet, and panic. The agricultural writers recommend maximizing the amount of cereal produced, indicating the importance of grain for subsistence in Italy.

The olive tree grows slowly, and its care is very labor intensive – the ground has to be plowed twice a year, the trees cleaned of moss, and the unproductive branches cut off. This meant that investment is high before any profit can be made. Furthermore, olives only give a full crop every two years. They grow on a variety of soils, but these must be well drained.

As for grapes, the time at which they ripen depends on the climate, so that careful organization of the work was necessary. They can grow in many soils, although soils with stones or pebbles produce the best wine; the steepness, rainfall (including dew), drainage, and wind also impact the wine quality. They can be grown on a variety of support systems, including on other trees. Vines need to be pruned carefully; it is also necessary to dig the soil around the vine three times a year. The harvest has to be done quickly; it was often contracted out, as Cato describes (*Agr.* 147–148).

Other trees cultivated were fig, nut (almond, hazelnut, walnut), apple, and pear. Pliny lists no fewer than 41 varieties of pear, 22 types of apple, and 28 different figs (Kron 2000).

Legumes also played a large role in Roman farming; some common legumes were peas, lentils, vetches, chickpeas, and broad beans. The latter were the most common legume in the Roman period and appear often in Roman literature. They were used for human consumption, while the stalks, pods, and chaff served as animal fodder. The climate was suitable for autumn sowing of beans in most cases; only in areas with very cold winters were they sown in spring. They grow best in fertile, well-drained soils, but can adapt to most soil types. Beans are also easy to grow: they could be sprinkled on unbroken ground and plowed under. They are harvested in June. Lentils were also grown widely, as they can grow in many soil types. Chickpeas require more specific soils and were therefore rarer. Other types of legumes, such as French beans and peas, are less able to withstand cold. Archaeological evidence for their cultivation is quite rare, although they are mentioned in agricultural texts. Lupines are also mentioned, especially as animal fodder and food for the poor.

Most farmers had a vegetable garden, in which they grew beans, peas, roots (turnip, swede, radish, carrot), cabbage, lettuce, herbs, et cetera. Farmers also collected wild plants, such as poppy, asparagus, nuts, and various herbs. Some plants could be collected from the wild and then transplanted to the garden, such as nut and fruit trees, brambles, and fennel.

Despite the commercial production that was practiced on larger estates, as described by Cato, such estates were also supposed to be self-sufficient in staple foods. The main products were wine and olive oil, but the farms also produced grain to feed the slave workers and many other products that were needed to support the farm and its laborers. Throughout Cato's work, it is clear that a wide variety of crops was produced. Not only foodstuffs, but many other items as well could be made on the farm, such as baskets, rakes, ropes, mats, et cetera. Cato's farms produced vine props and baskets, besides growing grain and wine for the laborers, and beans, lupine, and other animal fodder.

Many regions specialized to some degree in production for the market. In Republican Italy, the city of Rome quickly became the largest market and the most important location for the sale of specialized crops, which arrived here from all parts of Italy (Morley 1996, pp. 58–63). Some areas specialized in the production of specific crops; Apulia, for example, is fairly flat and moist enough to support large-scale growing of grain. There was a successful cattle breeding industry, as Varro states, in the Veneto and in some parts of southern Italy. Apulia was also famous for its horses and wool. Specialized breeding of cattle or horses could take place on a *pratum*, a carefully tended and irrigated meadow near the farm. In other cases, animals, especially sheep and goats, could be raised by transhumance. In this case, they were kept on the farm in winter and led out to summer pastures (*pascuum*) in the spring. Cato mentions transhumance over short distances; long-distance transhumance seems to have occurred only from the first century BCE onward (Kron 2000).

Cisalpine Gaul was far away from the market at Rome, and therefore its involvement with the market across the Apennines was limited. Still, in the first century BCE, it became famous for its breeding of pigs.

Livestock Breeding

Mixed farming seems to have been the norm on most small farms, with each farmer owning a few sheep or goats. It was easy to combine agriculture and animal husbandry. Animals such as sheep could be grazed on the fields after the grain harvest, where they ate the weeds. Fallow land could also be used to graze animals. These animals were mostly kept for the milk and wool they provided, but also for meat. There is very little mention in the sources of cattle raised for meat, but analysis of animal bones indicates that meat was widely consumed. The most popular type of meat was pork, but beef was also present on most sites, as well as lamb (Kron 2000). Large estates required animals for labor: Cato (*Agr.* 10.1) mentions 6 oxen and 4 donkeys as work animals for his olive yard, as well as 100 sheep kept for their wool. The vineyard had 2 oxen and 3 donkeys (Cato, *Agr.* 11.1); he also mentions a swineherd for both, as well as poultry. Donkeys and mules were often used for transport, either by carts or using panniers. Horses were not used for labor, but only for riding.

The most important purpose of sheep was for wool, which was the main fabric for clothes and other textiles. They were also kept for milk and manure. Surplus lambs were butchered for meat or used for sacrifice. The best areas to breed sheep were highlands with little rainfall. Cato mentions that sheep were kept on the farm all year; their care could be rented out and the proceeds shared. Mating took place from mid-May to mid-July, lambing from October to

December, and shearing from late March to late June. Goats were kept for milk, hair, skins, and meat. They were fed on leaves, buds, and young plants and herded in lightly wooded areas.

Pigs were used especially for meat, as well as for sacrifices and to produce manure. The animals were kept on the farm and led out daily to pasture in oak, beech, or chestnut groves, but could also be fed on other plants, such as beans and legumes, fruit, and nuts.

Poultry is discussed by Varro, especially luxury birds. Chicken were normally kept on farms for the eggs they produced, in flocks of up to 200 animals. Ducks and geese were also kept (Kron 2000).

The variety of crops used as fodder was fairly limited; Cato (*Agr.* 27) mentions hay, "green forage," clover, vetch, panic grass, lupines, broad beans, and bitter vetch. Lucerne (alfalfa) was introduced in the second century BCE. Leaves, such as elm, could be given when nothing else was available.

Manure was essential to fertilize the soil, although not all small farmers could gather enough manure to optimize their yield. Even on large estates, manure was always scarce. Varro (*R.R.* 1.38.2–1.38.3) mentions fowl, sheep, donkey, cattle, horse, pig, and human manure, in more or less descending order of usefulness. "Green manure" (growing plants such as vetches, millet, and grasses, which were then plowed under to fertilize the soil) was also used. It was also possible to add lime to the soil (marling), or to burn wood on the land and use the ash.

Some areas specialized in breeding specific animals. Horses need well-watered plains, e.g. in Sabinum, the Veneto, the Po valley, Apulia, and southern Liguria. The finest wool came from dry pastures, e.g. Apulia and eastern Lucania, and various areas in Cisalpina.

Animals were often well taken care of, judging by discussions on animal welfare in the written sources (e.g. Varro, *R.R.* 2.1.21). Advice often focused on maximizing reproduction rates, without harming the mother's health. It is well known that all types of animals in the Roman era were much larger than in the previous and later periods, indicating that they were well fed and cared for. The quality of some Roman types of wool was unsurpassed until the modern era (Kron 2000).

Fish was an important part of the diet for those who lived near the sea or a freshwater source. The evidence for fish farming on a large scale dates mostly from the mid-first century BCE (Kron 2008), which suggests that in most of the Republican era fishing was carried out with simple tools, such as fishing rods and nets.

The Agricultural Calendar

Most of the literary sources give detailed descriptions of the agricultural calendar. Although, as mentioned above, some of these works cannot be fully accurate, there is no reason to doubt their descriptions of the activities which took place over the year. Important sources for agricultural activities are the *menologia rustica*, a kind of almanac which included calendars of the year. These were often inscribed on walls, as in the case of the *Menologium Rusticum Colotianum* and the *Menologium Rusticum Vallense* (*CIL* VI 2305–6), both dating to the first century CE. An important part of the calendars are religious festivals and games, since many tasks on the farm were tied to specific festivals, such as the sowing and the harvest. Games were also often connected to specific events in the agricultural year.

These sources provide an overview of the main agricultural activities relating to the most important crops. They describe in detail which activities should take place in which part of the year, usually offering a small margin of time to accommodate for variations in the weather and seasons. Often the calendars describe the weather conditions necessary in order to begin a certain activity: when the snow melts and warm winds make the ground softer, the farmer should start plowing. They also give descriptions of smaller jobs which were essential for agriculture (such as waterproofing *dolia*) or for life on the farm, such as making mats and baskets, weaving clothes, and making cheese. These works, however, do not provide detailed descriptions of how these tasks should be carried out; it is assumed that farmers knew how to perform these essential tasks.

In brief, the agricultural year looked as follows. Sowing took place in spring and autumn, but the exact timing depended on the crop and the microclimate. In cold areas, crops were sown in spring, since they would not survive the winter. Warmer areas also sowed three-month wheat, which was sown early in the year. As the crop grew, it had to be weeded and hoed, which happened from mid-February. Hoeing was necessary to maintain a loose topsoil to maintain the temperature of the soil. The harvest took place in summer, usually after the summer solstice, but this depended on the area.

On short days, work continued after dark; in the summer as well, some jobs were done after dark, because the weather was less hot. Cato (*Agr.* 2.3) gives a list of tasks for rainy days, including hauling manure and making compost pits.

Tools and Technology

The tools used in agriculture were usually quite simple. While iron tools and especially pottery survive in some quantity, the many wooden tools have left little to no trace in the archaeological record. One of the largest tools was the plow. A wide variety of plow types existed, each adapted to a specific type of soil and the crop. These could be pulled by oxen, but also by mules or cows. Mountainous areas, which could not be plowed, were worked with hoes and mattocks. Sowing was often done by hand, after which the seed was covered using a variety of tools. Harrows are mentioned by Cato, and were used to finish a field after it had been sown. Weeding was done by hand, hoeing with a hand tool. Reaping was usually done by hand, using a sickle. Grain was threshed on threshing floors usually made of beaten earth or paved. The grain was separated from the ear by either pulling a flat board over it, or by having animals tread on it, or by beating it with sticks. Winnowing, i.e. the separation of grain from the chaff, was done by shaking the grain in a basket or by using a fan during a strong wind. Grain was milled either at the farm with small hand mills, or at a mill shared by several farms. For the pruning of vines, various special knives were used, such as the *falx*. Clothes were often woven at home, as shown by loom weights found in many parts of Italy.

A variety of storage vessels was used, such as *dolia* for wine and oil. Grain and legumes were stored in underground pits, or in jars, *dolia*, or amphorae in storage rooms. Grain was stored in granaries, often raised above ground and with vents to let in fresh air, and were sprinkled with olive lees against pests.

Cato confirms the simple nature of agricultural tools; he gives a long list of tools, mostly fairly simple hand tools, many of which could be produced on the farm from wood, rushes, or other materials (*Agr.* 10.3). Some small iron tools would have to be bought on the market, as well as larger equipment, such as mill stones. More specialized objects were usually bought; Cato mentions specialized producers of plows, crushing mills, spades, carts, et cetera (*Agr.* 135).

Despite the simplicity of the tools, the management of Republican agriculture was, in fact, quite sophisticated. Various types of crop rotation were used, e.g. three course (barley-millet-turnip, or emmer-fallow-spring beans), or two course (wheat-beans/legume, or emmer-beans/

legume). The purpose of this was to restore the fertility of the land after a grain harvest, by increasing the amount of nitrogen in the soil. This could be combined with winter pasture for animals, which provided manure. This meant that already in the Roman Republic farmers had achieved the level of production of the most effective European ley farming (convertible husbandry) of the early modern era. The practice of intercropping was widespread; this means that grain and other crops, such as legumes or vegetables, were sown between vines or olive trees. This maximized the use of fertile land, which was quite rare in some areas. Sheep could also be grazed between olive trees (Kron 2000; MacKinnon 2004, p. 113).

Political, Social, and Cultural Aspects of Agriculture

Agriculture was at the basis of Roman society. Everyone depended on it for survival, whether directly or indirectly. This meant that almost all political, economic, and social debate was in some way connected to access to (agricultural) land. This became especially apparent in the second century, when the brothers Gracchi received widespread support for their proposals for the redistribution of land to the poor. Older scholarly works argue that the poor were deprived of their land by the accumulation of land by the elite.

However, this view should be modified to take into account the size of the market. It has been argued that the size of the Italian market for agricultural goods was, in fact, quite limited. Jongman (2003, pp. 112–116) estimates the urban population of Roman Italy in 28 BCE at some 1.9 million people, including slaves. Considering the average nutritional needs of adults and the estimated yields of crops, he concludes that only 20 800 km^2 of land was needed to produce the grain, wine, and oil to feed these 1.9 million people, or about 20% of all arable land in peninsular Italy. In the second century, the size of the urban market was even smaller. Since the needs of the urban population could have been met by a relatively small part of the Italian countryside, competition for land among market producers would be limited. Especially in the fourth and third centuries, the market for agricultural products was small, and it would have been useless to exploit large tracts of land. In the second century, the market grew considerably, although it still did not become as large as is sometimes assumed, and large-scale commercial production occurred mainly in central Italy.

Furthermore, it must be remembered that "the rich" were not the only group producing for the market. In contrast to the ancient sources and the traditional picture, which uphold a strict division between "rich" and "poor," recent scholarship has drawn attention to the existence of a considerable middle class. Many small farmers regularly sold some of their produce on the market as well, and no doubt there were many farmers that we could classify as "middle class." One of the arguments to support this thesis can be found in the spread of slavery throughout society: to own slaves was not only a prerogative of the richest segment of society. The members of the third and second census classes were expected to own at least a few slaves (Morley 1996, pp. 80–81; Scheidel 2005; Rosenstein 2008). A small number of slaves sufficed to work a generous amount of land, as appears from Cato's work; and the group of people owning a few slaves can therefore reasonably be expected to have been engaged in market production. But if so many people were engaged in market production, the number of potential sellers was larger than just the elite, and the profit a producer could have expected to gain from his estates was much smaller than is usually assumed.

However, the demands placed on land were greater than just the needs of the urban population. Only 10% of the agricultural land in Italy was needed for the production of food for the urban population, but the population was, of course, larger than that. If one million people would have needed 10% of the arable land, then 4.5 million people would have needed about 45% of the arable land just for their basic subsistence. Moreover, land was not needed only for the production of basic foodstuffs; many other crops, such as vegetables and fruit, were also cultivated. Moreover, non-food products, such as flax and linen, had to be cultivated as well. Furthermore, we must not underestimate the importance of animal husbandry. Many animals were kept on farms; all these animals needed land for pasturing and fodder crops. There was also some export of Italian products, especially wine (Tchernia 1986, pp. 86–97). Finally, land was not used just for agricultural production; it was also seen as a safe investment.

In sum, it would seem that the available surface area of arable land in Italy was large enough to accommodate all these functions, without causing any shortage of land. It is therefore unlikely that demand for land by itself would have been sufficiently large to warrant the transformation of Italy into an area dominated by large slave-staffed farms. The archaeological evidence supports this assumption: although an increase in the number of *villae* for the commercial production of foodstuffs is already visible from the early second century, and in some areas even earlier, for most of the second century the size of individual buildings, and probably also the estates to which they were connected, was limited. Moreover, small sites, presumably held by subsistence farmers, were the dominant form of landholding in all regions of Italy during the Roman period (Frayn 1979, p. 22; Garnsey 1979, p. 2; Spurr 1986, p. ix). It is therefore unlikely that the picture painted by the literary sources – the rich expelling the poor from the public land because of their greed – can be applied to the whole of Italy.

Still, some competition for land occurred, especially in central Italy. It was important for commercial farms to be located in the vicinity of the market, because transport costs over land were high. Products from estates in central Italy could be most easily and cheaply transported to the market at Rome, either overland, by the Tiber, or by ship from the coasts of Etruria, Latium, and Campania. The presence of a market in central Italy meant that production for this market was practical only in the nearby countryside. It is likely, therefore, that competition for land was strongest in the *suburbium*. Not surprisingly, the number of estates producing in some way for the market was highest in central Italy, and the size of individual estates was largest in this area as well. We may conclude that increased competition for land played an important role in the second century, especially in central Italy. This may have made it difficult for small farmers in this area to hold on to their land, and may have led to their gradual displacement from the land. For central Italy, there may be some truth to the picture sketched in the sources.

In short, in the second century, we are still dealing with fairly small farms, which produced partly for subsistence and were worked by a small number of slaves. Even if some people owned several such farms, their total landed possessions will have been limited by the small size of the market, a matter to which we will turn shortly. The accumulation of land which is supposed to have occurred in this period, therefore, does not seem to have been as serious as the traditional reconstruction of events would have it. It seems difficult to uphold the idea that small farmers throughout Italy were expelled from the land by "the rich," as the ancient sources tend to claim (Roselaar 2010).

Changes in the Practice of Agriculture

The tools and techniques used in agriculture remained the same for most of the Republican period, at least for most farmers. They still used mostly wooden hand-made tools, with some additions of small metal items bought at the market. Small farms practicing mixed agriculture were dominant in most areas of Italy until the late Republic and beyond. Technical innovations, such as larger plows and larger olive and wine presses, mostly appeared in the early Imperial Period. The same goes for the appearance of *pastio villatica*, the commercial breeding of small animals such as dormouse, which were considered delicacies. This is widely attested from the mid-first century BCE, but not much earlier.

Despite the simplicity of the tools, it must be emphasized that agriculture in the Roman era, including the Republican period, was already quite advanced. As described above, the Romans practiced convertible husbandry (also called ley farming), i.e. the thorough integration of agriculture and animal breeding, in which each aspect strengthens the other. Thus, they were able to use sophisticated manure and grazing management, which helped to maintain the fertility of the soil (Kron 2000).

As stated above, an increase in the scale of agriculture took place in some areas of Italy. An increase in the scale of commercial production had already taken place in some parts of Latium in the fourth and third centuries. For example, in the middle Tiber Valley, the number of archaeologically visible sites declined after 250, but the sites that remained became larger, indicating an increase of market agriculture. Many of these *villae* appeared in the third century; a marked increase in larger farms in fact seems to have been a Mediterranean-wide development, which also occurred in Carthaginian Hispania and indigenous Apulia. Such establishments have been excavated in many parts of Italy, such as Giardino Vecchio and Villa Sambuco in Etruria, Via Gabina in Latium, Posta Crusta in Herdonia (Apulia), Moltone di Tolve in Lucania, and San Vito in Salapia (Apulia). The size of these buildings is limited to a few hundred square meters (Terrenato 2001).

After the Second Punic War, more farms appeared that were geared toward commercial production: small- to middle-sized, slave-staffed *villae* with specialized production of wine, oil, and cereals for the market. The large-scale production of wine, olive oil, and grain for the market at Rome took place mainly in Etruria, Latium, Sabinum, and Campania. The possibilities for commercial production for the market in Rome in areas further away were limited, since at further distances profits would be curbed by increasing costs of transport. However, some sites located far away from the market at Rome produced exclusive specialties, which were transported to the central market, no matter the cost (Morley 1996, p. 146). Some parts of Campania, especially the coast between Terracina and Naples, the Garigliano basin, the territory of Sinuessa, and the Ager Falernus (see Figure 20.1), had already been specializing in the production of wine, oil, and fruit since the third century (Marzano 2007, pp. 13–14).

In many areas in southern Italy, the second century saw an increase in the production of wine and oil on estates which were larger than they had been earlier. In general, estates in the south were smaller than in central Italy. In Bruttium and Lucania, the production of crops for the market during the second century was limited to coastal regions, from where products could easily be transported to Rome. In the interior, most agriculture was pursued in fertile valleys, such as the Tanager Valley, and was intended for local markets. The main economic importance of Samnium was as an area with summer pastures for transhumant animal husbandry. In most areas of Italy, villas producing for the central Italian market did not appear until the late second and early first centuries. The peak of activity in villa building took place between 140 and 25 BCE, especially after the 80s BCE. In this period, a large number of luxurious villas were built, and many older buildings were enlarged or embellished (White 1970, p. 388; Marzano 2007). For most of the second century, therefore, the size of individual buildings remained small. Although relatively small, they were markedly larger than would have been required by a subsistence farmer, and many show architectural elements which indicate the production of cash crops. It should also be remembered that very small farms are more likely to be overlooked in archaeological surveys, so that the recorded settlement

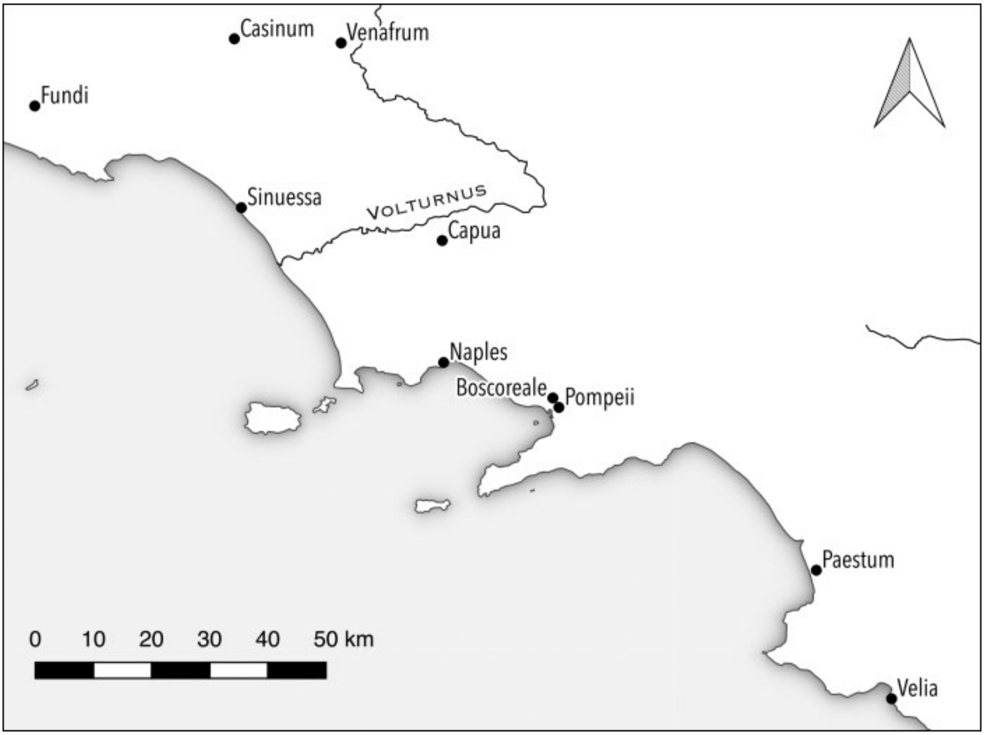

Figure 20.1 Map of Campania. Source: Map by David Hollander using QGIS and map files from the Ancient World Mapping Center. "openwater.shp," "coastline.shp," "ba_rivers.shp," "awmc_rivers.shp," "awmc-osm-rivers.shp," and "suppleRivers.shp". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm]

patterns are skewed toward the larger sites. This makes it difficult to reconstruct the fate of small farmers in the Republican period.

Avenues for Future Investigation

Many aspects of agriculture in the Roman Republic are still debated. This is especially the case with the social, economic, and political aspects of agriculture, such as the role of agriculture in the economic and political developments of the second and first centuries BCE.

The demographic developments of Republican Italy have been a hot topic in recent years. Basically, two theories have been proposed: a "high count," in which the population in the Augustan period would have been some 16 million people (Lo Cascio 1994), and a "low count," which assumes a maximum of 5 million people (De Ligt 2012). A "middle count" of some 8–9 million in the Augustan period seems perhaps more likely, but this is far from certain (Hin 2013). In any case, the size of the population would have directly impacted the practice of agriculture. A high population could not have been supported by the Italian peninsula alone, and would therefore have needed large imports of basic foodstuffs, especially grain.

The size of commercial farms is also under discussion. Most scholars have recently acknowledged that small farms remained the norm in most parts of Italy during the whole Republican period, as pointed out above. However, it is very difficult to reconstruct patterns of landholding by individual owners. A number of smaller farms might have ended up in the hands of one owner, who consequently accumulated a large amount of land, spread out over various locations. Roscius from Ameria, for example, owned 13 different farms in the Tiber Valley, and it is generally accepted that this was the normal pattern of landholding of the late Republican elite. Therefore, accumulation of land in the hands of the elite is not necessarily reflected in the archaeological record.

The connection between these fairly small farms and the market is also a point of debate. Some scholars think that these small farms could not have engaged in overseas trade in wine and olive oil. However, trade abroad certainly occurred, and since no larger farms appeared until the late second century BCE in most parts of Italy, it is likely that the smaller farms were engaged in commercial production. Many farms dating to the third and early second centuries show evidence of the commercial production of wine and olives, as is attested by the presence of amphorae, *dolia*, and wine and olive presses. We may conclude that these relatively small farms were producing for the market (Terrenato 2001).

In any case, the traditional classification of sites into "large" and "small" sites, as maintained, for example, by White (1970, p. 387) and Frayn (1979, p. 15), is unsatisfactory. Buildings came in all shapes and sizes, and many would have to be classified as "medium" sites. Since a family of four could be fed on the produce of no more than seven *iugera*, which they worked by themselves, it can be expected that many of those holding more land were engaged in production for the market. It should be remembered, moreover, that the size of an estate did not mean that profits could not be considerable. Varro (*R.R.* 3.16.10–11) tells a story of two brothers who had made great profits from a very small plot of land, on which they produced honey.

Another problem is the reliability of Cato's work on agriculture, our most important source for the Republican period. As discussed above, it is difficult to point out archaeological remains that exactly match his description. Nevertheless, it seems unlikely that the *villae* described in Cato's work would have had no relation at all with the reality of his time. The main problem lies in the fact that it is very difficult to determine what a "Catonian villa" actually looked like; Cato himself gives no clear description of the farm buildings. The "Catonian villa" as described by Cato himself seems to have been a very modest affair, in no way comparable to the later monumental villas. Another problem is that it is difficult to connect the size of farm buildings to the area of the land they served. For example, Cato's olive grove, although more than twice as large as his vineyard, did not require a larger number of slaves, and so the slave quarters would not have been larger (Terrenato 2001).

In short, many important issues concerning agriculture in the Republican era are still under debate. Nevertheless, considering the fundamental importance of agriculture in the economic, social, and political debates of the period, it is essential to elucidate the role of agriculture in this crucial period in Roman history.

GUIDE TO FURTHER READING

The three most accessible works on Roman farming are Frayn (1979), Spurr (1986), and White (1970). These are all rather old, and none discuss the Republican period specifically. Most are heavily based on the literary sources; they do discuss archaeological materials, but at the time these works were written the archaeological evidence was much more limited than today. For the reliability of the literary sources, see Diederich (2007).

Not all individual crops have been the subject of intensive research. Tchernia (1986) covers the production of wine; for animal husbandry see MacKinnon (2004). An advocate of the advanced nature of Roman agriculture is Geof Kron; his most important works are Kron (2000, 2008).

The population debate has sparked an enormous amount of work in recent years; the most accessible works are by Lo Cascio (1994), De Ligt (2012), and Hin (2013). The role of slavery in agriculture and its growth is discussed by Jongman (2003) and Scheidel (2005). Settlement patterns and labor relations are discussed by Garnsey (1979). For the size of the market, see Morley (1996) and Rosenstein (2008). For social and economic developments in the late Republic, see Roselaar (2010).

Recent archaeological work has shed light on the size of commercial farms, which were mostly quite small throughout the Republican period. Terrenato (2001) is a good introduction. Marzano (2007) offers a useful overview of all excavated villa buildings. Works on individual regions of Italy usually focus on the settlement patterns and socioeconomic developments on a larger scale, rather than on actual agricultural developments as such. Useful recent studies are Bradley (2000) and Isayev (2007). Many good recent works are also available in Italian, such as Franciosi (2002).

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CHAPTER TWENTY-ONE

Agriculture in Imperial Italy

Annalisa Marzano

Introduction

With the administrative reforms introduced by Augustus at the end of the first century BCE and the abolition of the provincial status for Gallia Cisalpina, the Roman territory of "Italia" came to coincide with the entirety of peninsular Italy, running from the foot of the Alps to Rhegium (mod. Reggio Calabria) in the far south (for maps, see Chapter 19, Figures 19.1–19.3, and Chapter 20, Figure 20.1). Italy presents a varied geography, with rolling hills in Etruria, the major alluvial plain of the Po Valley in the north, and arid flatland in Apulia. The north-south Apennine mountain range, which runs for the length of the peninsula, is a defining physical feature, which also demarks regions with different types of sociocultural developments: higher urbanization rates and agricultural production predominantly focused on viticulture and arboriculture on the Tyrrhenian side; cereals and animal husbandry, with prevalence of sheep rearing on much of the Adriatic side. The geographic and climatic diversity of Italy together with its different sociopolitical history for the period predating the Imperial era means that it is not possible, within the constraints of this chapter, to account for the different regional "agricultural histories" of Roman Italy (on climate and geography, see also Chapter 20). This chapter will therefore focus on a selection of major themes; the main focus will be the period up to the early third century CE, but the chapter will also consider the major changes that occurred in the following centuries, down to the fifth century CE.

The Textual Evidence

Ancient textual material such as the works of the Latin agronomists has been at the core of modern discussions on Roman agriculture, while historians such as Livy have been the source for reconstructing the role agriculture played in the Roman sociopolitical organization and economy. While we use the extant agricultural treatises as a source of information on ancient

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Roman agriculture, the fact that these works were not strictly speaking technical manuals but literary works imbued with ideological values ought to be kept in mind. As discussed below, a growing body of archaeological data and the application of new methodological approaches are complementing the picture drawn from literary material, often forcing a reconsideration of long-held theories.

For the Imperial period (see Chapter 20 in this volume for a discussion of the agronomists Cato and Varro, who lived in the Republican period) we have two extant agricultural treatises which constitute our main source of information on the agricultural practices of the time, Columella's *De Re Rustica* (*c.* 4–70 CE; the treatise in 12 books, of which Book 10 is in verses, was written in the mid-first century CE) and Palladius' *Opus Agriculturae* in 14 books (Book 14, entitled *de veterinaria medicina*, contains advices for the care of farm animals) dated to the late fourth–early fifth century CE. In both works, viticulture has considerable prominence, but a range of other crops and animal husbandry are discussed too, including, in Columella, *pastio villatica* (production on villa estates of high-quality fresh food for the urban market, including fowl, fish, and game animals). These treatises, which advised on how to successfully engage in market-oriented agriculture, did not contain advice limited to Italy alone. Indeed, Columella probably came from Gades (mod. Cadiz) and Palladius from Gaul. They do, however, broadly reflect some first-hand knowledge of farming in Italy and addressed an elite audience largely residing in Italy, or owning land in Italy, or aspiring, in their provincial villa estates, to follow certain practices in managing their estates and a type of lifestyle that ultimately stemmed from Italic soil. These practices were inspired by – and constantly reinterpreted – cultural Italic traditions and the works of the like of Cato and Varro. Columella and Palladius used these and other earlier authors as their sources, many of which do not survive.

The end of the first century BCE and the early first century CE was a time marked by a strong interest on the part of intellectuals and the educated elite in the composition of literary works dealing with a range of agricultural matters. This interest in part reflects the fact that in Roman society landed wealth determined social standing and was at the core of its political organization. On an ideological level, landed wealth was seen as the only respectable form of investment that members of the upper classes, or those who aspired to move up the social ladder, should pursue. Literary works dealing with agricultural matters could therefore have an important ideological and even political dimension. For instance, Varro's agricultural treatise and the care of the villa promoted in it have been seen as an allegory for the upkeep of the state, considering the inextricable link that existed between the land and the state (Green 2012). Landowning, use of the land, and property rights in antiquity have consequently also occupied an important place in investigations on the ancient economy (e.g. see Erdkamp, Verboven, and Zuiderhoek 2015).

The vast majority of these ancient agricultural works is now lost to us (White 1970, pp. 18–41 for works on agriculture), but we have in some cases the titles and the names of the authors (e.g. Plin., *HN* 19.177: Sabinus Tiro's *Cepurica* = "Garden Stuff"), showing an interesting array of writers, including the medical author Celsus, who wrote also on agriculture. Pliny the Elder's encyclopedic work *Natural History*, particularly Books 14–15 and 17–19 (on viticulture, oleiculture, fruit trees, farm management, etc.), is also a rich source of information on agricultural practices in general and on agriculture in Italy, as are, to an extent, Vergil's *Georgics* (but see Doody 2007). Some information on management choices, such as the use of tenants and the practice of selling grapes on the vine, can be found in the letters of Pliny the Younger about his estate near Tifernum Tiberinum in central Italy (e.g. *Ep.* 8.2; 9.15; 9.20; de Neeve 1992).

The Archaeological Evidence

The reconstruction of ancient settlement patterns and site hierarchy is centered on field survey data. Field surveys in Italy have revealed the different settlements patterns and how they changed over time, the symbiotic relationship between farms, villas, and rural villages and towns, and the extent to which more marginal areas were brought under cultivation. The famous South Etruria Survey, which ran from the 1950s to the 1970s and investigated the area north of Rome, became a milestone in Mediterranean archaeology and revealed how intensively this region was settled (results partially synthesized in Potter 1979). Some areas of Italy, characterized by fertile agricultural land such as the *ager Veientanus* or the *ager Campanus,* had dense concentrations of farms and villas; other areas, like ancient Lucania, less so. In some areas, such as the region of Caere in the late Republic and early empire, farms appeared in areas at higher elevations, which had not been occupied in the earlier period and were not settled and cultivated again, not even in the medieval era and later periods (Maffei 1990). Regional differences were present also in the rate of urbanization, which have a bearing on the development of the rural areas and the type of cultivation chosen, since a nearby urban market creates for the farmer opportunities to sell certain products and acquire others, reducing the need for a strict self-sufficient model.

Excavation projects have investigated actual agricultural production units, often focusing on the large villa estates of the wealthy but in some cases also on medium-sized villas and farms, bringing information on what was cultivated, the agricultural processing facilities, storage areas, and allowing some estimates of the size of the agricultural estates. The Villa Regina at Boscoreale, near Pompeii, is a good example of a medium-sized villa producing wine for the market but also engaging in the cultivation of other crops. The portion of land belonging to this farm that was investigated archaeologically revealed the root cavities of a vineyard but also, interspersed in between the vines, of olive and almond trees (Jashemski and Meyer 2002, pp. 24–25). The building, in addition to wine pressing facilities, also had a threshing floor, evidence that cereals were grown too.

The most famous example of a wealthy agricultural estate linked to the market economy (production and export of wine to Gaul), with working farm and residential villa at its center, is the site of Settefinestre, near the ancient colony of Cosa in south Etruria. Built in the mid/late first century BCE and probably owned by the senatorial family of the Sestii, this villa is the only rural villa of Roman Italy that has been *completely* excavated according to the modern principles of stratigraphic investigation (Carandini 1985). It also embodies the type of agricultural establishment described in the works of Columella and other writers: viticulture was the cash crop, but not in a monoculture context; rather, it was part of a "portfolio" of crops, some grown for internal needs, some for the market. At Settefinestre, olive oil was also produced, as attested by the olive rotary crusher and the oil press, cereals were grown (the estate had a proper granary, dated to a later phase than the main villa), and probably some fruits and vegetables too, at least for the use of its occupiers. As for farm animals, this villa certainly had a sizable piggery, with stalls for the animals neatly arranged around a courtyard, which has been dated to the second century CE.

Settefinestre has been interpreted as an example of late Republican agricultural success of wealthy members of Rome's political elite, built on the export of wine, the ready availability of slaves as manpower (so some scholars talk of a "villa system based on slave labor" to indicate a specific type of land management in cash crop agriculture), and the appropriation of land from small farmers (Carandini 1985; Terrenato 2001 for a critique of the traditional view which saw the origin and development of the villa as a linear process, from small farm to the large villas of the first century BCE). When overseas demand for Italic wine declined in the Imperial period, since provinces such as Gallia Narbonensis had become wine producers, villa estates like Settefinestre would have lost their profitability and slowly "declined," with Italy facing an agricultural crisis. This scenario, for some time taken to be indicative of trends valid for most of the peninsula, is now recognized to have been in existence only in certain parts of Italy. Attestations of crude repairs and burials within once luxurious rural villas, starting in the late second century CE, but more frequent for the third to fifth century period, were interpreted as attestations of this agricultural crisis, with villa estates occupied by squatters. However, these modifications seem to pertain more to religious changes due to the spread of Christianity, which modified sensibilities in the treatment of the dead, than to the actual abandonment of land cultivation (Marzano 2007, pp. 199–222).

In addition, scholars such as Rosenstein (2008) have cast doubts on the economic profitability of viticulture in the Republican era too, focusing attention to the level of demand and the size of "market share" that each producer was likely to have. The extent to which the "villa system" was widespread in Italy itself has been reassessed in the last 10 years of so, showing that it characterized only certain areas: Tyrrhenian Italy, particular coastal areas, the *suburbium* of Rome, part of Campania, and areas of former colonization (Witcher 2006b). In many parts of the peninsula, peasant agriculture continued to exist alongside the larger market-oriented estates of the rich. Launaro (2011) has convincingly shown, on the basis of field survey data, that with only a few exceptions the relationship between large villa estates and farms was not mutually exclusive. Indeed, peasant farmers do not automatically mean total self-sufficiency, a reality completely disconnected from the urban market, and the pursuit of identical agricultural strategies everywhere. Location with respect to urban areas, type of land, and family size are only some of the variables at play. It has been noted how certain assumptions in scholarship about the primitivism, vulnerability, and level of productivity of peasant farming need to be put in the right context. Even apparent economically "irrational" choices (e.g. high input in manual labor) can, in fact, lead to resilience (Witcher 2016, pp. 474–478; Frayn 1979 on subsistence farming).

Much information on the trade of certain agricultural produce, largely oil and wine, has come from pottery studies (e.g. see Panella 1981; Peña 2007, pp. 47–56 on use of amphorae and 299–306 on the amphora evidence from Monte Testaccio attesting large-scale import of olive oil to Rome. For introductions to Roman pottery studies and trade: Peacock 1982; Peacock and Williams 1986; Peña 2007). At least in the case of fluvial and transmarine transport, wine, oil, and fruit (preserved in honey-based syrup, brine, or vinegar) were packed in terracotta amphorae, and these containers survive well in the archaeological record. Amphorae have been well studied to develop typological classifications, chronologies, and identify (e.g. by petrographic analysis of the fired clay) the area where they were manufactured and hence the area from where their content originated. It is not possible here to do justice to the wealth of information on trade patterns and place of production revealed by amphora studies on Imperial Italy. These studies have traced both the inter-regional movement of goods and long-distance trade, even outside the proper boundaries of the empire. For example, many first-century CE Dressel 2-4 wine amphorae from Campania were recovered in excavations at the Red Sea ports of Berenike, Myos Hormos, and in faraway India (Tomber 2012). These ports sustained a two-way flow of goods: from India came luxury goods such as pepper and pearls, whereas Italic wine, tableware, and certain textiles were exported there from the Mediterranean (Tomber 2008; Sidebotham 2011).

The growth in population size up to c.150 CE, not only of the capital Rome but also of other urban centers (de Ligt 2012), meant that in some cases Italian agricultural production previously exported was instead directed to regional markets. This is certainly the case for the Tiber Valley corridor leading up to Umbria and its local wine production, which archaeological and literary sources show was largely destined for Rome. The Tiber offered a relatively easy means of transport for this product, and the small, flat-bottomed amphorae (the so-called Spello or Forlimpopoli type) used to commercialize the wine from this area were suitable for being transported on river barges.

The advancement in a number of scientific techniques used in the archaeological sciences (e.g. use of isotope analysis to reveal manuring practices, genetic studies to identify cultivars) and the fact that environmental studies have become a standard component of archaeological projects is also accumulating a considerable body of information on agriculture, sometimes bringing to our attention the cultivation of crops that tend to be forgotten in the mainstream discussion, where the Mediterranean "triad" (cereals, grape, and olives) dominate. One such example is the study of pollen extracted from cores from lakes Nemi and Albano, southeast of Rome, which have revealed the cultivation of hemp in that area in the Roman period; hemp was used for the manufacture of textiles, ropes, and nets. The peak in such cultivation occurred in the first century CE, a time soon after the rise of cultivated trees such as chestnut, walnut, and olive (Mercuri, Accorsi, and Banditi Mazzanti 2002).

The Crops of Italy and Animal Husbandry

In the initial sections of his *De re rustica*, Varro referred to the peninsular Italy of his time as a "fully cultivated" land, emphasizing the market-oriented mixed farming of Roman Italy, with its well-developed arboriculture, viticulture, and horticulture. This late first-century BCE view undoubtedly applied even more to peninsular Italy in the first 150 years of the Imperial era, when a number of new fruit varieties and vegetables common in the West today were either introduced to Italy for the first time (e.g. the peach; Rea 2016 for the discovery of a large first-century CE peach farm just outside Rome) or developed by careful selection and grafting (Thurmond 2006, p. 165). Pliny the Elder (*HN* 15.49–15.56), for instance, lists more than 30 apple and 41 pear varieties. Roman Italy also immediately evokes the cultivation of the vine – largely for wine production, but also for "table grape" to be consumed either fresh or preserved – the olive, and cereals.

Agriculture in the ancient classical world was never characterizes by a one-crop, plantation style of cultivation; even in the case of the large estates producing cash crops, we always find a degree of polyculture. One or two crops may have dominated the production of an estate, but cash crop agriculture always mingled with self-sufficiency and the diversification strategies that are so crucial in the Mediterranean region in order to minimize crop failure due to weather and crop disease. Thus, in an olive orchard trees would be spaced more widely than in modern practices, because cereals were grown in between the rows of trees. For instance, when Cato (*Agr.* 136) mentions wheat from Venafrum and Casinum, regions otherwise renowned for the quality olive oil, he was in all likelihood referring to wheat cultivated in between olive trees. Legumes too, whether for human consumption or animal fodder, could be grown interspersed with fruit cultivation. Legumes cultivated in the Roman world in general and in Roman Italy were broad bean, chickpea, lentil, pea, black-eyed pea, grass pea, lupin, and vetch (but not, as sometime asserted, cowpea or *Vigna unguiculata;* see Heinrich and Wilkins 2013–2014).

While the boom in the export of Italian wine had considerably diminished in the Imperial period, wine production remained for several regions of Italy an important part of agriculture. The Falernian wine, produced on the slopes of Mount Falernum at the border between

Latium and Campania, or the Caecuban wine, produced between Tarracina and Fundi in coastal Latium, retained their popularity and reputation as high-quality wines throughout the Imperial age (see classification of wines in Pliny, *HN* 14.55). The Falernian commanded a high price in Diocletian's Price Edict (*Ed.* 2.7) of 301 CE and, as in modern times, food adulteration was not unknown of in ancient Rome. The second-century CE physician Galen remarked that all the "Falernian" drunk in Rome could not have possibly been genuine (*On Antidotes* 14.77). Alongside high-quality wines, ordinary wines were produced too, as the market for this product was large, especially in urban centers. Although it is impossible to quantify this production, many of the small and medium farms growing vines were probably making ordinary wines (the Villa Regina mentioned above may have been such an example). An idea of the possible differences in price between a low-quality table wine and better ones in the first century CE comes from a graffito from a tavern of Pompeii. The graffito, no longer extant, read: "You can drink here for one *as*. You will drink better if you give two; if you give four, you will drink Falernian wine" (*CIL* 4.1679).

Large estates could also focus on producing table wines rather than high-quality wines; this may have been the case of the above-mentioned Tiber Valley wine production packed in the Spello amphorae, which have been posited to have contained common wines, similar to the ones produced in the region in modern times. While in the Imperial period Rome imported large quantities of common wine from Gaul and the Iberian Peninsula, it attracted also regional imports in these low-quality productions since the capital was a huge market for wine (De Sena 2005; Marzano 2013 for attempts at quantifying how much of the wine needs of Rome and Ostia was satisfied by regional imports).

Cereals grown in Roman Italy included bread wheat, durum wheat, einkorn wheat, emmer wheat, millet, rye, and barley. The major wheat producing areas of Italy were Apulia in the south, the rich alluvial Po Valley in the north, and, outside peninsular Italy, the islands of Sardinia and Sicily. Since its annexation as a province in 241 BCE, Sicily had provided, via taxation in kind, wheat for Rome, and the island continued to be an important producer of wheat in the Imperial period. Sicilian wheat was destined for the *annona* system, state-sponsored monthly distributions of wheat, which had been in place in Rome since the Republican era and which had paramount importance in maintaining social order in the capital (Erdkamp 2005, pp. 209–244 on the *annona*, Sicilian wheat, and taxation in kind). In the mid-second century CE, the Greek intellectual Aelius Aristides could still praise the *annona* by saying that Sicily, together with Egypt and North Africa, fed Rome (*Orationes* 12). Although the archaeological record for Roman Imperial Sicily is somewhat patchy due to the focus of earlier investigations on the Greek period, recent discoveries confirm the continuation of cereal cultivation in Sicily in late antiquity. Excavations of a Roman villa at Gerace in central Sicily have revealed a fourth-century granary 50 m long and, from a fifth-century phase of the villa, a huge amount of carbonized cereals, legumes, and other seeds (barley seeds, bread wheat, as well as lentils, broad beans, and grapes; Wilson 2018). While in some areas of the Roman world (e.g., Egypt), higher demand and the "globalizing" forces of the Imperial era caused cereal cultivation to move from hulled to naked cereals such as durum wheat (which are more cost efficient to process and transport), current available archaeobotanical data for Italy indicate that there many different types of cereals continued to be cultivated. Such a scenario is probably partly due to the geographic and climatic diversity of the Italian peninsula (e.g. rye and bread wheat predominate in the north of the peninsula, hard wheat in the south), to specific economic conditions (exemption from agricultural taxes), and to strategic decisions taken by the farmers when assessing the pros and cons of growing hulled versus naked cereals (Heinrich 2017). The former are much better suited to long-term storage and would be preferred in the case of self-sufficiency; the latter, requiring less labor to process and being lighter to transport, are a better choice when surplus production is aimed at the urban market, where the transformation of wheat into flour, and then into bread, took place.

Animal husbandry focused on cattle, pigs, horses, mules, and sheep/goats; livestock was reared for meat, wool, and traction (Pasquinucci in Forni and Marcone 2002). Different, larger breeds were developed in the Roman era, and the integration of animal husbandry into arable farming was important in terms of agricultural productivity, being the source of manure (see the section on technological innovation). Domestic fowl was kept largely for eggs, but particularly in areas close to urban centers a range of other animals were raised on rural estates: geese, duck, quail, thrushes, peacocks, pheasant, wild boar, venison, and also fish. Initially, some of these products were expensive delicacies, but with time they became more affordable. In Diocletian's Price Edict, venison and pork were similarly priced, and goose and duck were comparable in price to the cheapest meats (Kron 2015, p. 165).

Agricultural Tools and Technological Innovation

There were a number of technological innovations affecting the agriculture of Imperial Italy and the rest of the Roman world. Those with the most important effects on agricultural productivity, and the fruit of many centuries of experiential learning, concern seed selection, crop rotation with suppression of bare fallow, rotation of legumes, manuring practices, and irrigation and drainage (Kron 2012a, pp. 157–158). The integration of livestock into arable farming, a system known as convertible husbandry or ley farming, was a very important advance. In this land management system, arable land was continuously cultivated by rotating crops of cereals and leguminous fodder crops (which have nitrogen-fixing properties); the land would then be left for several years as pasture of long fallow or meadow to reconstitute its fertility (Kron 2012b). Convertible farming is well described in the works of the Latin agronomists, on which Kron based his analysis, and is possibly also attested archaeologically. The Roman Peasant Project, which has investigated a number of very small rural sites in southern Tuscany with the aim of shedding light on the life of lower-class rural dwellers, has collected archaeobotanical and other archaeological evidence (pasture and cereal pollen; presence of field drains, fodder crops) pointing toward the practice of convertible agriculture even at these small rural holdings for the period from the early first century BCE to the early first century CE (Bowes et al. 2017). If this interpretation is correct, this evidence would go toward supporting Kron's optimistic view of the agricultural productivity of peasant farmers (Kron 2008).

In the case of animal husbandry, zooarchaeological evidence has shown that several breeds of cattle, horse, pigs, and sheep were developed which were larger and had more meat (or finer wool) than breeds present in the earlier and later chronological periods (MacKinnon 2004; 2010). To these developments in animal husbandry, and so to the availability of more animal proteins in the human diet, has been linked the increase, on average, in the height of individuals and a general improvement in the standards of living across the territory of the empire (Kron 2005; Jongman 2007).

While agricultural tools and implements have varied very little throughout the centuries (a Roman wine dresser knife or a hoe are not very different from the tools used until recently in Italy; on tools, see Chapter 20 of this volume and White 1975), technological innovation occurred in the case of machinery for the processing of agricultural produce. While there are considerable regional variations across the empire in the typology of oil and wine presses and the evolution was not always a linear one (Curtis 2001, p. 384), the mid-first century CE saw the wide adoption of the so-called lever-and-screw press, which according to Pliny (*NH* 18.317) was invented about one hundred years before his own time, i.e. in the mid-first century BCE. This type of press used a screw rather than a windlass attached to a counter-weight to lower the press beam, the element that exercised pressure on the stacked frails containing olive pulp or treaded grape. From a technical point of view, the use of the screw to lower the free end of the beam offers a greater mechanical advantage than using an anchored windlass, and thus such a press could exercise more extracting force (Curtis 2001, p. 391).

Another innovation in press technology, dated by Pliny (*HN* 18.317) to about 50 CE, is the direct screw press. This press type discarded the beam of earlier presses and placed the screw into a wooden frame; it resembled a letter press (White 1975, pp. 231–232 for description and an illustration). The great advantage offered by this type was that it was considerably smaller than earlier presses (which featured a long beam acting as lever) and also portable. It is the press type that seems to have become rather common in late antiquity, but it is difficult to identify archaeologically as it was made entirely of wood, a material which rarely survives archaeologically.

As far as grain cultivation is concerned, technological innovation can be seen in the case of harvesting: Pliny the Elder briefly refers to a mechanical reaper (*vallus*; *HN* 18.296) in use on the large estates of Gaul, a piece of equipment depicted on four reliefs discovered in the northern provinces (at Reims, Arlon, Montauban-Buzenol, and Trier). It is generally believed that the *vallus* may have been in use also on some of the estates of northern Italy. Also, Palladius (7.2.2–7.2.4) describes a mechanical harvester in his treatise, which he calls the *carpentum* and which was slightly different from the *vallus* (see detailed discussion in White 1967, pp. 157–173).

The water mill is an important technical innovation, which found practical applications from the late first century BCE/early first century CE onward (Wilson 2000). Vitruvius, in his treatise on architecture (*Arch.* 10.5.1–10.5.2), describes the mechanism of a geared water mill, but for many years it was believed that the knowledge of this technology had remained theoretical and that water mills had spread only from late antiquity onward (Greene 2000). In fact, archaeological evidence has shown that by the first century CE the water mill was in use alongside the "more traditional" grain mills powered by animals or humans (Wikander 1984; Wilson 2014), such as the hour-glass mill, typical of urban bakeries, several examples of which can be seen at Pompeii and Ostia. While few water mills have been identified in Italy, undoubtedly the result of bias in the archaeological record, the trend evident from other areas of the empire such as Gaul indicates that several large villas estates had water mills. The introduction of such an innovation on large estates, i.e. on properties whose owners had capital at their disposal to invest in technological innovations, allowed for the more rational use of labor (Marzano 2015). Studies have also highlighted that whether a landlord was an absentee or resident owner determined the level of interest in technological innovations and the willingness to invest in them (Lewitt 2008).

Proper drainage of the land and irrigation are two basic but important elements that can considerably affect agricultural production and determine type of cultivations. Roman engineering skills are well known; many of the large-scale drainage projects carried out in Italy in the Republican period (e.g. in the Pontine Marshes and the Po Valley) occurred in the context of military expansion and colonization. Indeed, the drainage of the Pontine Marshes by laying in the soil thousands of amphorae could not have been possible without the large mobilization of manpower provided by the army. In the Imperial period such infrastructure was maintained and improved when necessary, often funded by Imperial generosity. It is only in the later empire that, with the breaking down of the sociopolitical system and the changes to the administrative structure introduced by Diocletian, maintenance of essential infrastructure, including clearing of drainage ditches and canals, started to be neglected. Recent geoarchaeological and palaeoenvironmental studies carried out at Paestum and Velia in southern Italy suggest that the geomorphological changes in the landscape observed for the third–fourth centuries CE (formation of coastal lagoons, progressive silting of these, floods, and ground-level aggradation) were not due to climatic deterioration, but rather to soil erosion due to reduced maintenance of farmland and deforestation of slopes (Amato et al. 2012).

Irrigation structures for orchards and vegetable gardens are attested in Italy, for instance, in the *suburbium* of Rome, where growing vegetable and fruit trees made sense considering the needs of the capital (Thomas and Wilson 1994). At times, evidence for irrigation infrastructure points to irrigated meadows and hence to animal husbandry, including horse breeding (Quilici Gigli 1989). The use of force pumps in wells to provide water for irrigation is attested archaeologically for the Imperial period, and iconographic and textual evidence attest the use of water lifting devices like Archimedes' screw for irrigation.

Landownership and Its Transformations

The Imperial period saw the concentration of land in the hands of fewer landlords, with the creation of very large estates (*latifundia*) and further decrease in the number of small and medium-sized landholdings, thus continuing a phenomenon of the Republican period (see Chapter 20 in this volume). An oft-quoted remark to support this view is Pliny the Elder's exclamation that *latifundia* had ruined Italy (*HN* 18.35). However, generally speaking, landownership was very fragmented in Italy, and while there were rich landlords (the wealthiest of all being the emperor) who owned a lot of land, this was not in the form of one contiguous estate, but of several properties geographically scattered. Documentary evidence such as the second-century CE alimentary table from Veleia support this. This inscription records a scheme introduced in Italy by the emperor Trajan (98–117 CE), the *alimenta Italiae*, to support financially a number of boys and girls in Italian towns. It was financed via the interest local proprietors paid on government loans taken against their properties. The Veleia inscription lists the names of the participating landowners, the size of their estates, value, and which other properties they bordered, thus offering a map of local landownership and showing how the holdings of the same owners were interspersed with estates by other landlords (Criniti 1991).

In the first two centuries of the Imperial era, the emperor, largely via testamentary bequests and confiscations, progressively became the owner of a large amount of land (Maiuro 2012). Imperial ownership of agricultural villa estates may impact in a number of ways on those properties. Once-lavish residential quarters could be converted to utilitarian use if the emperor never visited the estate. The opposite was true for properties that the emperor visited regularly. The villa where young Marcus Aurelius retreated in the country, taking part in the vintage and reading Cato's many century-old agricultural treatise (Fronto, *Ep.* 4.6), had a *cella vinaria* and press room only superficially replicating the usual building techniques and finishes of hundreds of such utilitarian structures known from Roman villas. Excavations at Villa Magna (Anagni) have revealed that the herring-bone pattern floor, normally made with bricks, was in fact made by using small tiles of precious marble (Fentress and Maiuro 2011). This was "farming" in a setting fit for an emperor. Imperial ownership could also impact the actual management and agricultural production. It has been suggested that the development of high-quality wines and the reputation acquired by some wines were linked to production on imperially owned estates (Maiuro 2012, pp. 219–220).

Ownership of Italian estates by elite members of provincial origin increased in the Imperial period, particularly in the areas closer to Rome, but also in the very south of the peninsula (e.g. the extremely wealthy Herodes Atticus of Attic origin owned estates outside Rome and also in southern Italy). The desire of upper-class families, particularly if engaged in successful political careers in Rome, to invest in Italian properties became a legal obligation with Trajan, when senators were required to invest at least 1/3 of their wealth in Italian land; this requirement was reduced to 1/4 by Marcus Aurelius (Pliny, *Ep.* 6.19.4; *SHA Marc.* 11.8). When in 286 CE the capital was moved from Rome to Milan, and later to Ravenna (in 402 CE), the presence of the Imperial court in the northern regions had an impact on the countryside too, on the one end stimulating agricultural production further, and on the other promoting the construction of well-appointed country residences to be used as leisure retreats. With the growth of Christianity, in this period the Church became a great proprietor, effectively replacing the emperor in part of the Italian peninsula with respect to amount of land owned (De Francesco 2004; for an overview of the early Christian West, Humphries 2008; see also Vera 1999 on a new type of aggregation of rural estates, the *massa fundorum*; Francovich and Hodges 2003 for an overview of changes in settlement patterns and societal organization in the period 400–1000 CE).

With the reforms of Diocletian (284–305 CE), Italy was provincialized and lost the fiscal and military privileges it previously had, most notably the exemption from direct taxation. Reforms of the late Imperial tax system imposed greater fiscal responsibilities on landowners including the duty to collect taxes on tenants who did not own any land. Following these fiscal reforms, a new managerial form for large agricultural properties, featuring a specific legal status for dependent tenants, emerged: the colonate. The *coloni* (tenants) came to be restricted in a number of ways, including their mobility and ability to alienate property; in effect, the obligations these tenants had toward their landlords were based on the land where they were registered (Lo Cascio 1997; Grey 2012). A law of 393 CE preserved in the *Codex of Justinian* (11.52.1) defines registered *coloni* as "slaves of the land" and the late-antique colonate has in the past been seen as the origin of medieval serfdom (Rosafio 2002; Wickham 2005, ch. 5, with Banaji 2011; on slavery in late antiquity, rejecting the idea of a transition to serfdom: Harper 2011).

Important Debates and Avenues for Future Investigations

An important scholarly debate that has unfolded in recent years concerns attempts at calculating how much Italian land could produce and what levels of population it could sustain (i.e. the carrying capacity the land; Lo Cascio and Malanima 2005; Hin 2013). This debate has not started with a focus on agriculture per se, but was rather concerned with ancient demography and the still current discussion between the proposers of a high population count for the Imperial era and those in favor of a low count (on the demographic debate, see Chapter 20 in this volume). Recently, the question of modeling the carrying capacity of Roman Italy has been tackled by using Geographic Information Systems (GIS). Goodchild and Witcher (2009; see also Goodchild 2013) used as a case study the *ager Veientanus* in south Etruria, integrating the known settlement patterns with figures for crop yields (both ancient and modern) in order to arrive at an estimate of potential agricultural production and the population size that could be supported by it. According to these authors, the fact that newly founded farms were not located on marginal land, but on good, fertile land, may indicate the subdivision of larger properties and the move on the part of wealthy landlords to the use of tenancy. The aim would have been to guarantee a steady income rather than necessarily striving to maximize agricultural production.

Strictly linked to this topic have been the various studies proposing a more positive appraisal for the productivity of Roman agriculture which have reacted to the somewhat pessimistic views of peasant farming productivity typical of scholarship inspired by Beloch and Brunt (Kron 2008; 2017). Kron, who represents one of the most optimistic views on ancient agricultural yield among ancient historians, argues for high levels of Roman agricultural productivity in both market-oriented intensive mixed farming and in animal husbandry. He observes that Roman agriculture had productivity levels comparable to those of the seventeenth-century Low Countries and mid-nineteenth century England. Estimated cereal yields in Roman Italy were ten- to fifteen-fold; such yields are higher than those of the medieval and early modern period, and compare to yields achieved in Italy in the 1970s (Kron 2012b). Likewise, Columella's estimate of 31.5 to 42 hl/ha as the normal yield for a typical vineyard is comparable to the production of French vineyards in the 1950s, when regular and large-scale use of fertilizers started (Tchernia 1986, pp. 359–360; Kron 2012b, pp. 159–160).

Two other topics at the center of important scholarly debates have a bearing on agriculture: what impact the so-called Antonine Plague of c.166–180 CE had on the population of Italy, and consequently, whether an eventual sharp drop in population levels affected overall agricultural production; and possible climate change. The Antonine Plague was a pandemic probably of smallpox, brought back by troops returning from military campaigns in the East. According to Cassius Dio (72.14.3–72.14.4), an eruption of the disease some years later caused 2,000 dead per day in Rome. Its impact on the population of Italy is debated (Lo Cascio 2012), but it is likely that the epidemic affected above all the population of urban centers and less so the rural areas.

Evidence for possible climate change in the Roman era is not easy to evaluate and some scientific studies appear to reach contradictory conclusions, but the amount and quality of data used is constantly improving. Although it is difficult to draw conclusions about climate specific to one circumscribed region, it seems that the period from c. 200 BCE up to c. 200 CE was characterized, particularly in the western part of the Roman Empire, by a warmer, wetter, and more stable climate than the preceding centuries, which favored agricultural production; archaeological evidence for Roman viticulture in Britain supports the idea of a mild climate in the western regions of the empire in this period. This favorable period is referred to in the literature as the Roman Climate Optimum (Harper 2017, pp. 39–54). The period from 200 to 400 CE, marked by political, economic, and military crises, was also less stable climatically, with gradual cooling, variable precipitation, but with an overall tendency to a drier climate, and some major volcanic eruptions in the years from c. 235 to 285 CE, which potentially caused episodes of rapid climate change. As has been noted:

> Such rapid short-term changes would have had a great capacity to disrupt food production during the most difficult decades that the Roman Empire had faced so far; the political, military, and monetary crisis peaked between c. 250 and 290. (McCormick et al. 2012, p. 186)

When available, archaeobotanical evidence from late antiquity has been used to suggest a sharp lowering of the standards of living. For instance, it has been argued that there was a general state of regression in the late Roman Empire, with widespread famine, on the basis of charred archaeobotanical taxa including grass peas, acorns, and small horse bean seeds from a mid-fifth century CE hut excavated c. 50 km north of Rome (La Fontanaccia, Allumiere; Sadori and Susanna 2005). However, considering the type of dwelling, it is unclear whether the inhabitants of a "small hut" of the early empire would have eaten much better than their fifth-century counterparts (thus also Witcher 2016, p. 471).

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FURTHER READING

White 1970 and 1975 remain standard points of reference on agricultural implements and practices, although centered on textual evidence and predating the availability of much archaeological data. An important work on Roman agriculture is, in Italian, Forni and Marcone 2002. Spurr 1986 uses an ethnographically informed approach to discuss ancient textual evidence on arable cultivation, often confirming that practices reported in the agronomists have ethnographic parallels. A proper synthesis of all the archaeological evidence has not yet been attempted. Witcher 2006a and 2011 offer important methodological considerations on field surveys and stress the importance of focusing on new research issues. Well-preserved archaeobotanical evidence is particularly abundant from sites in the Vesuvian regions, such as Pompeii. Jashemski and Meyer 2002 presents much of these rich data, while Borgongino 2006 gathers additional information on unpublished botanical material from earlier investigations in Pompeii and surroundings. Morley 1996 investigates the effects a large metropolis such as Rome had on the agricultural production of its countryside. While much of Rome's *suburbium* produced fresh vegetables, fruit, and other fresh foods, and in the Imperial period the capital imported huge amounts of wine and olive oil from the provinces, wine and oil continued to be produced in the hinterland of Rome too. De Sena 2005 and Marzano 2013 use archaeological evidence for oil and wine processing facilities to offer rough estimates of the potential production in wine and oil from Rome's hinterland. Some of the papers in Carlsen, Ørsted, and Skydsgaard 1994 (e.g. by Quilici on the important role of centuriation for agriculture in central Italy) focus on specific Italian topics. De Neeve 1984 remains standard reading on the development of farm tenancy in the Republic and early empire, whereas papers in Lo Cascio 1997 investigate tenancy in the Imperial period and late antiquity. Several of the papers in Lo Cascio 2000 deal with periodic markets and marketing of agricultural produce in Roman Imperial Italy.

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CHAPTER TWENTY-TWO

Agriculture in Roman Gaul*

Alain Ferdière

What "possible" (Fiches 1994) picture can we have of the Gallo-Roman countryside and the agropastoral activities in these provinces? Textual, epigraphic, iconographic, and especially archaeological data offer some answers (Ferdière 1988, 2006; Bender 1997).

For the provinces of Gaul and the Germanies, from the second century BCE to the end of the fifth century CE, there seem to be two contrasting trends, divided along geographical lines, north and south. In the south, especially in *Gallia Narbonensis* – the first area conquered by Rome – a Mediterranean agrarian system prevails, but in the north – the majority of the Gallic territory – there is a more "continental" system. Nevertheless, it is very difficult to determine the precise economic balance between agriculture and animal husbandry from one region to another, from one period to another, because there is insufficient evidence to quantify production (Leveau 1995b, 2003a; Durand and Leveau 2004, for Late Antiquity). More generally, there is the question of how specialized farms became in a system which was clearly oriented toward a market economy: polyculture/mixed economy (including integrated grazing practices), monoculture, exclusive, or only preferential specializations? While it is doubtless true that the economy shifted to speculative monoculture, agricultural versatility seems to have largely been the rule, at least in southern Gaul (Leveau 2003a,b). Thus, in the High Empire, for example, the viticulture of *Gallia Narbonnensis* turned to mass production, favoring quantity over quality, presumably tending toward exclusive specialization. The same applied to the settled areas of the large cereal plains of northwest Gaul and elsewhere, where there was a marked specialization in animal husbandry or for meat destined for urban supply (especially beef: see Groot et al. 2009), or for wool (sheep). One might also find specializations in forest or sea products.

The fertility of Gaul appears clearly in the texts of Caesar (*BG*) and Strabo (*Geogr.*, 4.1.2), which mention products from Transalpine (Narbonnese) Gaul identical to those from Italy, and from Celtic Gaul (the Three Gauls and the Germanies) for wheat in abundance, together with millet and acorns, and for all species of cattle. All croplands, except for some wooded or marshy areas, were exploited by a particularly dense population. In contrast, Caesar notes that

*Translated from French by Timothy Howe.

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

Map 22.01 Source : Maps by David Hollander.

Map 22.02 Source: Maps by David Hollander.

the Germans (beyond the Rhine) were little occupied by agriculture, preferring local production of milk, cheese, and meat, via collective ownership; and Pliny (*HN* 37.203) compares the fertility of Gaul with that (then famous) of Spain.

The objective of the Roman conquest of the regions seems to have been, above all, to open up new territories to agriculture, beginning in Transalpine Gaul – future *Narbonnensis* – at the end of the second century BCE, then in "Long-Haired" Gaul (up to the Rhine) by Caesar in the middle of the first century BCE. First of all, for Roman and Italian settlers in Transalpine Gaul, subjugation of the countryside was the goal, as evidenced by the early foundation of a number of colonies in this territory, as well as the confiscations and aggressive exploitation of the lands and resources of the province, as noted by Cicero (*Font.* 5.12, 6.13, 7.26; *Quinct.* 3.12–3.13, 4.14–4.16, 29.90 (pastures)). Subsequently, as with the rest of the Gallic provinces, all of the *civitates* contributed to the functioning of the Empire and its armies by paying taxes, imposed on all at least from the reign of Tiberius forward. With this taxation, the products of agriculture formally entered into a market economy, which, perhaps, would become more self-sufficient in Late Antiquity.

The first observation to be made here is that there was a great continuity between earlier Gallic periods and the Gallo-Roman, both in terms of the density of settlement in towns and countryside and the development of agropastoral activities and related practices and techniques. All of the Gallic provinces were in fact concerned with two essentially different types of agriculture (broadly speaking), linked to climatic conditions: on the one hand, in the southeast (*Narbonnensis*), which is of the Mediterranean type, we see predominantly polyculture on small plots, sometimes requiring irrigation; on the other, for all the rest of the Gallic territories (and the Roman Germanies), which are of the temperate, continental, and/or Atlantic type with heavier soils and humid climates, we see, *inter alia*, extensive cereal farming. Therefore, these two rural Gauls must be studied separately, both in terms of the geological conditions of the cultivated soils but also with respect to climatic conditions, within the palaeoclimatic context of the time, which saw significant changes between the last part of the La Tène Period and Late Antiquity (Magny 1995; Ervynck et al. 1999). Thus, from the beginning of the Empire, investors and landowners/operators of land devoted to agropastoral activities were essentially, or almost exclusively, native to Gaul, often from the great Gallic aristocratic families, who now controlled the *ordo* (senate) of the cities across all the Gauls. The contribution of Romanization and Rome, especially from the second half of the first century CE, was mainly in the systematization of agricultural technique, in the development of new land, and in the improvement of yields (Ouzoulias 2014). At least from the beginning of the Second Iron Age (500–50 BCE), especially with the introduction of iron, agropastoral techniques and associated tools have been fully mastered, and so Roman innovation in agriculture after the conquest of the Three Gauls was almost nonexistent.

Infrastructure: Structuring the rural landscape, Settlement, Forms of Rural Building, and Field System

Almost everywhere, and often even before Caesar's conquest, the density of rural settlement was very high, with a typical farm plot of about 50 ha. The units that make up this land use are in scattered settlements, in the form of farms and *villae* of various types and dimensions (Wightman 1975), generally operating within an estate system, such as the "small" estate near Bordeaux of the poet Ausonius (*De hered.)* of 1050 *iugera* (260 ha), in Late Antiquity.

Most common was the *villa*, as found in Narbonne (Collective 1993-1996), Aquitaine (Berry: Gandini 2008), or Belgic Gaul (Picardy: Agache 1978). But at the same time, there were smaller farms with ditched enclosures almost everywhere, most of them built of perishable materials (earth and wood). By Late Antiquity there were various transformations in the forms of rural settlement (Van Ossel 1992): land groupings, "Germanic" type villages, especially in *Germania Secunda* (Lenz 2005); the relocation of settlement mainly to high and fortified villages (Schneider 2007); and the creation of cave shelters (Gagnière and Granier 1963; Raynaud 2001). However, it is often difficult to determine precisely the functions of the various service buildings on such farms (Demarez 1987; Leveau 2007; Trément 2017).

As for the physical divisions of the land itself (Chouquer 1996-1997), only those techniques that left archaeological traces are identifiable: especially ditches, but also banks, walls, or even hedges. Many of the field systems found were more or less regular, with small fields of often less than a hectare, such as the "Celtic fields" in the Netherlands (Brongers 1976), or in the Haye forest in Lorraine (Georges-Leroy et al. 2014). Elsewhere, in the Mediterranean regions, for example, there were terraces (Harfouche 2007). It is also possible to identify some boundary systems for these fields, such as the boundary stones of the alpine pastures of the Allobroges (Rémy 2011), or those marked by vessels or sherds in Île-de-France and Picardie (Pissot et al. 2013). But another system, typically Roman, was centuriation, especially linked with colonial foundations (*centuriae* of 200 *iugera*, or about 50 ha). For Narbonnese Gaul, inscriptions found nowhere else in Gaul, such as the first century CE marble texts from Orange (Piganiol 1962) (Figure 22.1), concern cadastral maps that are now well located on the land, especially for the Tricastin region (Favory 2013), and centuriated networks were known elsewhere in *Gallia Narbonnensis* (Chouquer 1996–1997). And although they were not true centuriations, vast territories in other regions were subdivided by regular parcels into which the local network of rural settlements is inserted: the Sénart Plateau (Seine-et-Marne) by drainage ditches – or Mer-Beaugency, in Petite Beauce (Robert 1996a and b).

Figure 22.1 Fragments of the Cadastre d'Orange. Source: Courtesy of Le Musée d'Art et d'Histoire d'Orange.

Agrarian Techniques and Tools

Tillage practices were essentially varied (Ferdière 1991; Fries 1995): rotation of crops, fallow, companion planting, etc. The relationship between polyculture and monoculture, and between agriculture, in the strictest sense, and animal husbandry was variable. Tools remained relatively unchanged from the Second Iron Age (Raepsaet 1995; Ferdière 2009), with only a few new forms appearing in the Roman period. We can see this, for example, among the collections of bronze miniatures in some burials from the Cologne region (Kiernan 2009). Techniques for harnessing (Raepsaet 2002; Raepsaet and Rommelaere 1995; David 2015) and for making carts (Molin 1984), for the use of animal labor in field work, are particularly well documented in Gaul: a yoke for the horns was preferred to one for the withers, and there were also types of harness collar for just one horse or mule (French "jouguet"), to allow for the full exploitation of animal traction (David 2011).

Land Improvement and Soil Amendment

A combination of techniques were deployed to improve soil fertility and yield:

- Management of water was a prime necessity: irrigation was only necessary for the arid regions (Beltrán Lloris 2014) and therefore mainly present only in Narbonnese Gaul, primarily for small crops (gardens, vegetable gardens, etc.). Everywhere else, there was an excess of water, and its management was necessary: drainage was important, and ditches of different sizes were created at the edges of the plots according to the volume of water to be drained. Such canal networks were found even in very wet areas, such as marshes like the closed depressions of Provence and the Rhone Valley in Narbonnese Gaul (Leveau 2012), for the purpose of development: for example, the Orange B centuriation (Berger and Jung 1996), Limagnes d'Auvergne (marshes of Sarliève: Trément et al. 2005), the Antwerp polders in Flanders (Bellens and Clerbaut 2013), and the Marne-la-Vallée region of the Brie plateau (Desrayaud 2008).
- Fertilization consisted of spreading the excrement of animals and humans, often mixed with the used bedding of livestock (this practice is primarily attested by the scatters of small pottery sherds from mixed domestic waste found in archaeological surveys: Poirier and Nuninger 2012). A scene from the rustic calendar of Saint-Romain-en-Gal shows the transport of dung on a screen, and large pits for the manufacture of manure have been found on certain Gallo-Roman farms (Poitevin 2017). Such fertilizing schemes required the presence of livestock on the farm, and thus suggest a mixed agrarian economy.
- Green manuring is also attested in Gaul by the ancient agronomists. This process returned organic material to the soil after harvest, by plowing and harrowing the non-useful parts of cultivated plants, especially those from leguminous plants, such as stems and leaves; prairies were also turned over by plowing in order to fertilize the soil, as at an estate near Autun in the Late Empire (Sidonius Apollinaire, *Epist.,* 8.8.1). The agronomists suggest that the practice of crop rotation was also used.
- The less calcium-rich soils of Gaul required emending with lime and the practice of liming (lime: calcined limestone) or marling (marl, calcareous clay), attested in Gaul, under the name of *marga*, and the practice of lime or chalk (*creta*) emendation, known at Poitou and Burgundy (Pliny *HN* 17.42, 43 & 47), is also mentioned by Varro (*RR* 1.7.8).

- Finally, we should mention the addition of imported soils of different composition, attested by archaeology in northern Gaul (present-day Netherlands) and also mentioned by Pliny (*HN* 17. 42 & 47) for Ubiens (Cologne region).

Plowing Techniques

Beginning in protohistoric times, plowing was carried out by means of a pulled instrument, the ard (*aratrum*), which was mainly made of wood (Figure 22.2). From the early Gallic period, this implement was equipped with an iron plowshare (*vomer*), which was at first a simple socket, and then in Roman times becoming a heavier metal piece with flap sleeve or bar (Mignot and Raepsaet 1998; Ferdière 2001; Marbach 2004a,b). Heavy and relatively sophisticated plows, possibly equipped with a coulter, drawn by at least one pair of oxen, are attested on the heavy and silty soil of the northern part of Gaul. In order to improve the performance of the plough and in particular to turn the earth, before the invention of the mouldboard heavy plough, various technical expedients were implemented: multiple plowings over a season, cross-plowing, inclination of the ard, addition of wooden "ears" to remove the earth split by the ploughshare, or adding an iron (or wood reinforced with iron) coulter, and possibly also adding a wheel or at least a skate to prevent the ard from penetrating too deep into the earth. This last development is attested for the *Alpes Penninae* (a mountainous region to the northwest of the Alps) by Pliny (*HN* 18.172-173). Called a *plaumoratum*, it was used to recultivate land left fallow. At the end of the third century, we also see mention of "the Gallic fields plowed by the barbarian oxen" – of the *Laeti* or *Foederati* – (*Hist Aug.*, *Probus*, 15. 3-6).

Figure 22.2 Scene of plowing and sowing. Roman mosaic from Saint Romain-en-Gal, 1st half of 3rd century CE, Musée d'archéologie. nationale, Saint-Germain-en-Laye, France. Source: Courtesy of Musée d'Archéologie Nationale

Sowing

Before sowing, the earth was first harrowed, as mentioned by the agronomists, using a simple bundle of thorns that trailed on the ground. However, in time more elaborate traction harrows with a wooden frame were used (in Flanders: Deforce and Annaert 2005). After the land had been harrowed, it was then time to sow the seeds, either in autumn or, as the agronomists attest, in spring, although Pliny (*HN* 18.183) was surprised to learn that the *Treviri* had done this. The archaeological study of seeds (carpology) shows the widespread use of autumn sowing. The practice of "méture" (mixture of two cereal species sown together) has thus practically disappeared (Matterne 2001, p. 184ff; Lepetz et al. 2002, pp. 96-99). Sowing was usually accomplished by broadcast; however, it is possible that seeding in "pockets" (a small batch of seeds placed in a preliminary hole) and/or in line (in a furrow prepared for this purpose) were practiced (Ferdière 1997). After sowing, the seeds would be covered with soil by a final harrowing.

Harvesting

The traditional tool of the harvest remained the hand sickle, made of iron, as the iconography shows, and not the scythe, which was at this time reserved solely for haymaking. The stem of the plant was cut at the base, the half-stem, or just under the ear, depending on the region and the type of straw desired (for bedding, extra fodder for livestock, stubble for roofs, etc.). The evidence from seeds, especially for the north of France, shows that the high cut was preferred there, at least for wheat, though not for rye whose straw was most desirable (Matterne 2001, p. 127; Lepetz et al. 2002, pp. 100-101).

The people of Gaul deployed a unique harvesting instrument, called the *vallus* (Ferdière 1997; Raepsaet and Lambeau 2000; Nys, Bonato and Limbrée 2010), which is well documented by two texts and – for the Center-East of Gaul – by five iconographic representations (*Remi* and *Treviri*), the first mentioned in the second half of the first century CE (Pliny *HN* 18.296, for the *latifundia*, the great estates of Gaul) and the other at the beginning of the fifth century (Palladius, *Agr. de Agr.,* 6.2. 2-4, for the "plains and flat countries" of Gaul). The *vallus* (Figure 22.3) was a wooden box mounted on wheels, with a series of wooden teeth at the front, a shaft for the mule, and a sort of large comb on the wheel, which was used for the rapid harvest of large cereal areas in the plains of these northeast and central-eastern regions of Gaul. Spelt, whose ear is easily detached from the stem, was undoubtedly harvested with this technique. On-line seeding allowed the straw not to be totally degraded by the *vallus*: the latter could no doubt be recovered on a second pass, perhaps with the great scythe, also peculiar to Gaul, and whose qualities Pliny (*HN* 18.261) praises. It should also be noted that a hand comb was used in Gaul for the harvest of millet (Pliny *HN* 18.297). We also have sheaf binders made of deer antler.

Treatments after Harvest

Cereals were sometimes stored as they were, whole and unprocessed as ears, as shown by some discoveries of carbonized remains. But often cereals underwent various treatments before being stored. The first was threshing: here the grain was separated from the remains of the stem and other elements of the ear (the chaff). Only the so-called naked cereal species can be stripped of their casings in this way. The hulled grains required a second threshing, or

Figure 22.3 Vallus relief, Buzenol, Belgium. Photograph by Villaegalloromaines / Flickr.

even other treatments. The threshing floor, made of stone covered with clay, was, according to the agronomists, carefully prepared. Such areas have, however, rarely been found in the excavations of the agrarian parts of *villae* or farms (e.g. the *villa* of Touffréville, Calvados: Derreumaux, Matterne, and Malrain 2003). The traditional articulated threshing flail does not seem to be attested at the time, and only the flails made from softwoods are mentioned in the ancient texts. Mainly, threshing then consisted of turning on a prepared area various animals (horses, oxen, etc.), which, by their trampling, separated the grain from the chaff; the animals may, moreover, have been yoked to rollers of stone (generally of conical form) in order to facilitate this work, or to types of carriages without wheels (*tribula*) – basically wooden platforms trimmed with sharp stones, loaded with stone blocks or even a driver. But there is no clear evidence of these in the Gallic provinces.

The result of the threshing was then removed with a shovel (wooden, represented, for example, in the miniatures from the region of Cologne; see above) to be sorted by winnowing: we have for Eastern Gaul (Rhineland) a winnowing scene, as well as representations of winnowing in the miniature tools already mentioned.

Storage and Preservation

The Gallo-Roman techniques of storage and preservation of cereals differed somewhat from those of previous periods, the use of the buried silo being practically abandoned and reappearing only in the High Middle Ages. According to intended use, grain was stored in chests, *dolia*, for daily consumption, in granaries for longer-term food reserves and seed, and in large public granaries (*horrea*) for sale and export (to both towns and armies). Grain was more readily stored in loose grain form than in sheaves (Matterne 2001, pp. 184–200). It (like legumes) was stored in well-ventilated or open-air granaries (Ferdière 2015; 2019). Often, these were small wooden platform granaries, of a few square meters, elevated on posts, like those of the earlier periods, or even larger masonry buildings, capable of receiving much greater quantities than their walls would ordinarily support, and thus made from stone supported by solid buttresses or internal pillars and cross-walls to accommodate the considerable weight of large quantities of grain. There are many examples of granaries with cross-walls adjoining *villae*; standardized barns with polyvalent functions also survive (Ferdière, Gandini, and Nouvel 2017), as well as urban and military *horrea*.

Mills and Milling

We turn now to the transformation of grain into flour and food. For hulled grain species, it was necessary, before grinding, to get rid of the husk, either by double threshing or by soaking, and even, according to the texts, by roasting. Certain heating structures, known from northern Gaul especially, were probably not intended for roasting but rather for drying the grain and/or malting, to aid in the manufacture of beer, as seems likely given the presence of germinated grains found by some seed studies, particularly those from the Somme (wheat, spelt, and barley) (Van Ossel and Huitorel 2017).

For milling, there were flour mills of various types: domestic mills and *molla asinaria*, animal (donkey or mule)-powered mills (especially in towns). Water mills were commonly used – especially in the countryside – and were clearly introduced in Gaul by Romanization. The mill constitutes an important technical innovation, although the first textual references are from Late Antiquity (Ausonius, *Mosella*, 362; Fortunatus, *Carmina*). We now know of many examples of such mills throughout Gaul, in Narbonnese Gaul (Longepierre 2012), but also in the Three Gauls (Jaccottey and Rollier 2016), for example, at the large peri-urban *villa* of Avenches "En Chaplix" in Switzerland (Castella 1994), the oldest ones dating from the beginning of the first century CE. And there is near Arles, on the edge of the "vallée des Baux," an imposing flour mill, the mills of Barbegal, consisting of two parallel series of eight mills using an artificial waterfall fed by an aqueduct; this true "industrial" flour mill, first thought to be a late installation, is now dated to the beginning of the second century CE (Leveau 1995a) and is thought to have been supported by a local estate and to have supplied the nearby town of Arles with flour. The flour obtained in these different types of mills was then screened before being used: Pliny (*HN* 18.108) tells us that the Gauls made sieves for this purpose, from horsehair of very high quality.

Rural Production: Agriculture

Very diverse plant species were cultivated throughout the Gaul (Figure 22.4), with a cereal crop dominant everywhere, and new species introduced or at least favored by the time of conquest (Marinval and Ruas 1991; Leveau 1995b; Lepetz et al. 2002, for the North; Marinval 2004, for the Transalpine region before the Caesarian conquest; Bouby 2014, for the basin of the Rhone; Bouchette 2015, for Limousin).

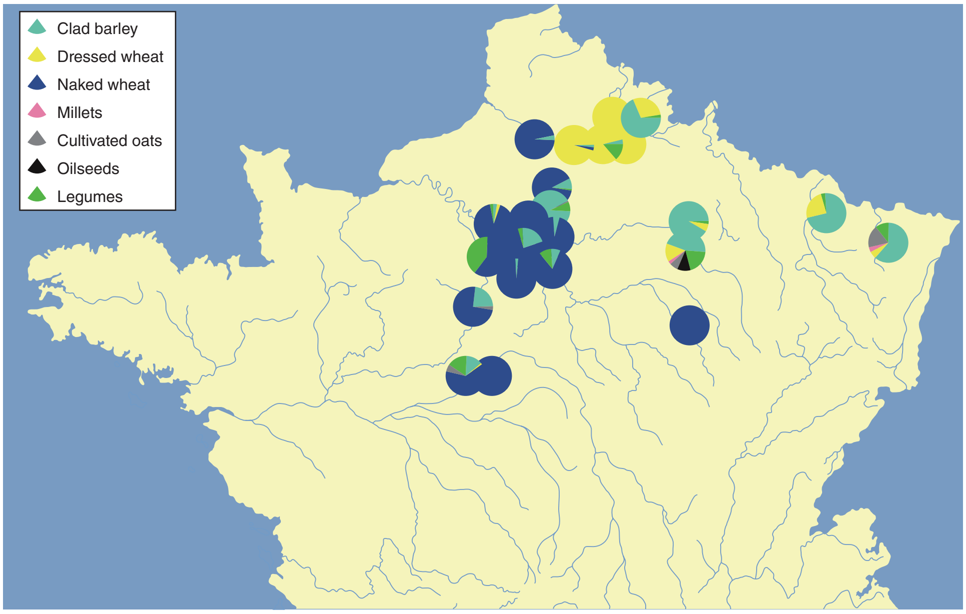

Figure 22.4 Relative levels of crop production during the first century CE. Source: Adapted from J. Wiethold, B. Pradat, F. Toulemonde, et V. Zech-Matterne.

- *Cereals* therefore remained the basis of food and agriculture: the various species have been recognized by seed analysis, and practically all were of exogenous origin. Cereal farming expanded significantly in the Second Iron Age, though the Roman period marked the establishment of the great cereal trade: palynology shows an increase in cereals and associated weeds (*messicoles* in French), as well as a marked decline in forestation in northern Gaul (Defgnée and Munaut 1996). Although the Latin texts offer information about species, it is often difficult to interpret exactly what cereals were grown in what parts of ancient Gaul, and so the data from seed analysis (carpology) promises greater precision. For grains (Collective 2010), the Gauls grew emmer and spelt – both hulled – (Marinval 1989) and einkorn and wheat. These bread grains, were preferred to emmer (which only survived in the extreme north of France), whereas in the northeast or less clement regions of Switzerland, spelt remained alongside hulled barley, and in the South, in the Rhone basin, for example, we see wheat (naked wheat) grown alongside hulled barley (Matterne 2001, p. 82, 184ff.; Lepetz and Matterne 2003; Marinval 2004; Zech-Matterne, Wiethold and Pradat 2014; Bouby 2014, pp. 191-198). As for barley, only the hulled variety was well attested for the Roman period, and its cultivation seems to have been particularly common in the northern city of the Batavians (Netherlands), probably in connection with horse breeding (Voosen and Groot 2008); the barley of the Cavares (Rhone Valley) was attested in Marseille (Liou and Morel 1977). Rye was well established, at least in northern France, although Pliny considered it a bit like a weed, and it seems to have been primarily reserved for the feeding of horses (Matterne 2001, p. 184ff.; Lepetz et al. 2000, p. 100; Lepetz and Matterne 2003, p. 34). Millet (*panicum*) and Italian millet were only anecdotally attested in these regions, with the first species well represented only in northern Gaul (Matterne 2001, p. 184ff.; Lepetz et al. 2002, p. 80), though in southern Gaul it was known much earlier but then disappeared after the Roman conquest

(Marinval 1992; Bouby 2014, p. 193). Millet was also known in Gaul by Pliny, Polybius, Caesar (for the region of Marseille), and Strabo (*Geogr.,* 4.1. 2 and 2.1 for Aquitaine). Oats, also considered to be a weed by the Romans (so Pliny), may have been cultivated during Gallo-Roman times, especially in southern Gaul, but perhaps only for the feeding of cattle. In Late Antiquity, there were no notable changes in the types of cereal cultivation, but spelt increased significantly in northern Gaul with legumes and oilseeds (see below), as well as the cultivation of rye and oats, probably more as fodder for the growing number of animals (see below).

Gallic cereals, which were reserved primarily for local food, were exported to Rome and Italy, or to the army (Reddé 2011), and the Gallo-Roman *civitates* were assessed for payments and taxes in kind (see the *Theodosian Code*), for the supply of armies, especially those stationed on the Rhine frontier. Pliny (*HN* 18.66) informs us of the export of soft wheat to Rome, and Strabo mentions exports from Gaul to Spain. Moreover, shippers of wheat destined for the Roman *annona* are known from inscriptions in the Saône-Rhône region. Later, a fourth-century text (Claudian, *In Eutropium*, 1.404–1.409) mentions wheat from the *Senones* (Sens) and the *Lingones* (Langres) exported to the City, and exports were still known in the fifth century by Sidonius Apollinaris.

Finally, cereal farming certainly supplied Gaul with the native beer (*cervesia* or *birra*, from respectively wheat or barley), which is very poorly documented by archaeology (Laubenheimer, Ouzoulias, and Van Ossel 2003), though better by the ancient texts (Pliny, *HN* 14.149, 18.68, 22.164; *Edict on Prices*, 2.12). One can find Gallo-Roman breweries or malting plants in Germany.

- *Vegetables* and *legumes,* sometime grown for crop rotation, play an important role in food and agriculture in Roman Gaul: in particular, peas, lentils, fava beans, beach pea, vetch, and lupin, some of these for fodder, were grown separately in gardens and orchards near urban areas (Matterne 2001, p. 184ff., pp. 199–200). The same applied to *oilseeds*, such as flax and hemp, which had other uses, such as textiles and cordage. In the north of France, beach pea and vetch (and hemp) did not develop significantly until the Roman period (Matterne 2001, p. 82, 184ff.; Lepetz et al. 2002, p. 82), a period marked by an uptick in the development and exploitation of vegetables. While Mediterranean species were sometimes acclimatized to the north, such as chard or gourd calabash in Longueil-Sainte-Marie, Oise (Marinval, Maréchal, and Labadie 2002), only the Gallic sesame (*vela*) and probably the carrot (*pastinaca*) and the parsnip of Roman Germany were known to Pliny (*HN* 19.89 & 90, 22.158).
- *Viticulture* is one of the best-known agricultural activities in Roman Gaul, since it took a considerable hold after the conquest. Indeed, viticulture is attested in Transalpine Gaul well before the conquest, from the sixth–fifth centuries BCE, originally introduced by the Greek colonies such as Marseille and present in its cultivated form probably at the end of the fifth century BCE (Marinval 1997; Py and Buxô i Capdevila 2001; Bouby and Marinval 2001; cf. Terral and Bouby 2012; Bouby 2014, p. 146ff.). First produced for local needs only, after less than a century from the conquest of the Three Gauls, vines were cultivated for wine production almost everywhere. From the second half of the first century CE, wine was produced in almost all of Gaul (Brun and Laubenheimer 2001; Brun 2005; Poux, Brun, and Hervé-Monteil 2011), in Burgundy (Garcia and Chevrier 2010), the Bordeaux area and Aquitaine (Berthault 2000), the Loire Valley (Hervé-Monteil et al. 2011), Berry (Dumasy et al. 2011), Touraine (Ferdière 2007), the Clermont-Ferrand basin near the Arvernes (Vallat and Cabanis 2009) or the valley of the Rhine and the Moselle, particularly in Late Antiquity (Brun and Gilles 2001; Schnitzler 2011), and of course first in Narbonne,

where numerous wine-producing vineyards have been studied (Brun and Laubenheimer 2001; Bouby 2014, pp. 209-219).

Roman texts praise the vineyards of Gaul, especially those of Narbonne (cf. Brun 2001), but also of the Three Gauls (Columella, *RR*, 3.2.19; 3.28; 3.7.1; 3.9.1; 3.3.7), as was probably the case with the *Bituriges Cubi* (Berry) from the first century CE and in Late Antiquity for the *Treviri* and the Moselle Valley (Ausonius, *Mosella*, 153-162; Fortunatus, *Carm.,* 3.12, 7.4, 10.9), Alsace (Gregory of Tours, *HF*, 9.38), Touraine and Anjou (Gregory of Tours, *HF*, 7.22; 8.32), the Bordeaux area and Aquitaine (Ausonius, *Epist.,* 27. 90–98, *Hered.,* 12.22, *Ordo*, 128-132, 138-139; Paulin de Pella, *Euch.,* 194-197; Fortunat, *Carm.,* 1.20; Salvien, *de Gub.,* 7.8), Auvergne (Sidoine, *Carm.,* 17.16-17), Armorique (Gregory of Tours, *HF*, 8.32; 9.24), Burgundy (*Panegyrics*, 6.4-8), and Paris (Julien, *Misopogon*, 6, 340c–7, 342a). The production of Gallic wines developed to such an extent that Pliny compared it, at the end of the first century CE, to that of another major wine producing province, Spain (*HN* 37. 203); and he also informs us of some peculiarities of the vineyards of Narbonne, which were planted obliquely to the wind, or in scallops, or cultivated between trees (*HN* 14.13-14.14; 17.21 & 203).

Several iconographic data inform us about viticulture, mainly for vintage and transport in barrels. For its part, archaeology has unearthed winemaker's or picking knives, plantations of vines (vineyards) in pits or small trenches, especially in *Narbonensis* (Boissinot 2001), as well as cellars and wine-presses in rural settlements, such as the vast Molard wine-growing estate in Donzère with its large cellars (Odiot 1996). Finally, we can see workshops producing wine amphoras, for example, in Loupian (Hérault) (Pellecuer 2007), but also in the Three Gauls, first imitating those from Italy or Spain, but soon replaced around the middle of the first century CE with typically Gallic amphorae, with flat bottoms. However, around the second half of the first century CE, wine producers adopted a new container for the transport of wine and winemaking, the barrel, which replaced the *dolium* in winemaking and the amphora in transport; it seems that this wooden barrel was a Celtic invention from the north of the Alps (Marlière 2002).

Gallic viticulture developed so rapidly that the emperor Domitian (late first century CE) issued a protectionist decree in favor of Italy, though this was never enforced (Suetonius, *Dom.*, 7.2), and was repealed two centuries later by Probus (*Hist Aug., Probus*, 18.8). Thus, we can see that Gallic viticulture expanded greatly between the end of the first and beginning of the third centuries CE, and a real decline was only noticeable in Late Antiquity in some regions which had experienced early and massive development, such as the Rhone Valley (Leveau 2003a, p. 347; Favory, Fiches, and Raynaud 1998, pp. 108-110).

- *Olive oil* production occupies a lesser place in Gaul: although part of the traditional culture of the Mediterranean regions (Brun 2005), the olive tree cannot be grown farther north than Valence, in the Rhone Valley. There was a steady development of olives in the Roman period, better attested in Provence (Brun 1986) than in Languedoc (Leveau 2003b et al. 1991), though it probably did not go beyond the satisfaction of local needs, since most of Gaul's demand was satisfied by Spanish and later African imports. However, at the end of the first century CE, Pliny (*HN* 37.203) compared the production of Gallic oil with that of Spain, which was famous for its oil, and earlier Strabo (*Geogr.,* 4.1.2) praised the olive and oil production of Marseille.
- *Other cultivated plants:* Various types of fodder were grown for the feeding of animals (see Aguilera et al. 2015), and cereals (see above) were preferred for their dual purpose as fodder and human food: oats, barley, and rye were grown widely after the fourth century when bitter vetch production declined (Matterne 2001, p. 184ff.). But the recurring

presence of large haymaking scythes (Marbach 2012) shows that hay was an agricultural product in its own right, and certain hay meadows were maintained for this purpose. Indeed, the hay scythe was specific to Gallic *latifundia* (see above), as was shown by Pliny (*HN* 28.261); the natural historian also praised the quality of Gallic grinding stones (*passernices*) made from fine sandstone. These were used to sharpen scythes and sickles. Small scythe anvils were also found on which harvesters could straighten their blades (*HN* 36.165). Combining cereals and animal husbandry in this way was a characteristic of Gallic mixed farming, as one can see at Jouars-Pontchartrain (Yvelines), with leftover legumes mixed with hay residue for feeding livestock (Matterne 2001, p. 131), or the stable of Dourges (North) (Derreumaux 2005). This maintenance of hay meadows, or even pasture, is also indicated by the presence of another unique tool, the thistle cutter.

Industrial crops mainly concerned the production of *textile fibers* of plant origin (Wild 1970, pp. 13–18; Roche-Bernard and Ferdière 1993, pp. 41–54): these were hemp, little attested in Gaul, and linen, the main textile fiber of the region together with wool. Linen was well attested in Gaul and had its own special tax (Pliny, *HN* 19.7–8 & 13, and 9 for Germany). Pliny reports that it was produced throughout Gaul, from the *Cadurces* (Quercy, with the mattresses), the *Ruteni* (Rouergue), the *Caleti* (Pays de Caux), and the *Morini* (Pas-de-Calais). Epigraphy documents the importance of *linarii* or *lintarii* in Lyon, Narbonne, and Nîmes, and Imperial workshops for flax are mentioned in Vienne (Isère) in the Late Empire by the *Notitia Dignitatum* (*Occ.*, 11.62). Although flax is little attested by carpology or palynology, it makes a notable appearance in the northern half of Gaul not as a textile fiber but rather as a seed for food or oils (Lepetz et al. 2002, p. 80). Hemp and nettle were also cultivated for their oil in Gâtinais, for example (Matterne 2001, p. 104; Joly et al. 2008). Other plants were used as dyes such pastel, buckthorn, cranberry or bilberry (Pliny, *HN* 16.77, in Gaul), dyer's rocket, broom, nettle tree and madder (Firmin 1989; Roche-Bernard and Ferdière 1993:105–110; see Pliny, *HN* 22.2, for plant dyes in Gaul).

The *osier* was widely used for basketry, and is well attested in Gaul (Blanc and Gury 1989; Barbier et al. 1999): the red osier (willow tree) is mentioned by Pliny (*HN* 16.177)). Other plants, used as condiments, aromatics, or medicinally, were only grown in the north of Gaul after the Roman conquest and its concomitant changes in tastes and eating habits (Lepetz et al. 2002, p. 82). Some of these were introduced from elsewhere, such as black mustard, dill, celery, coriander, fennel, and savory (Matterne 2001). Pliny (*HN* 12.98) mentions cinnamon from Rhineland and, for example, Narbonne thyme (*HN* 21.57).

- *Arboriculture* and *fruit production* – with viticulture (see above) – were also developed under the Romans (Ruas 1996; Matterne 2001, pp. 199-200): walnut and plum in northern Gaul (Matterne 2001, p. 184ff.; Lepetz *et al* 2002, p. 81; Zech-Matterne 2010), pomegranate and fig trees in the South; other tree species were probably acclimatised in the northern half of Gaul, such as mulberry, peach, walnut, and fig trees. The literary texts mention the Gallic peaches (Pliny, *HN* 15.39, Columella, *de Ag.*, 10.411), the curious seedless apples (*spadonia*) of the Belgians, and the Lusitanian cherries, which grew from Belgium to the shores of the Rhine (Pliny, *HN* 15.51 & 103). Orchards have been found in Champagne near Reims (Koehler 2003), and fruit trees were found in vegetable gardens in Longueil-Sainte-Marie (Oise) (Marinval, Maréchal, and Labadie 2002). These vegetable gardens and orchards were not simply ornamental but practical as well, even though they adorned the most luxurious *villae* (Farrar 1996; Bertholet and Reber 2010), such as that of Richebourg (Yvelines: Barat and Morize 1999). Hitherto unknown species were thus introduced into the Gallic *villae*, planted in horticultural pots (Desbat 1997), such as boxwood, of which a Gallic species was grown, trained into a pyramidal shape (Pliny, *HN* 16.70–71), and known at Longueil (see above).

- Finally, the exploitation of *wood* and *forest* was part of the rural and estate economy, as we see from the estate of Ausonius near Bordeaux (*de Herediolo*, above), whose woods accounted for more than half of the area. But almost every place in Gaul during the Roman period was marked by an increase in deforestation, although Late Antiquity did see a phase of reforestation (Chabal 1997; Bernard 1998). Walnut (above) and chestnut were widely favored (Matterne 2001, p. 184ff.), especially the latter in Limousin (Miras et al. 2013).

  The exploitation of timber, for construction (including naval) or as fuel, which was necessary in large quantities for certain crafts, was certainly the subject of elaborate management strategies, if not forestry *stricto sensu* (Nenninger 2001; Bernard 2003). One can find in the Mâconnais a *saltuarius*, manager of an Imperial estate or perhaps forest (Dondin-Payre and Chew 2010). And if the production of charcoal for the smelting of iron is poorly attested, that of pitch (distilled resin), to coat *dolia* and barrels (caulking) or to caulk boats, is well documented in the south of the Massif Central (Causses) (Mauné and Trintignac 2011), and also in the Landes (Vignaud 2007); furthermore, Pliny (*HN* 15.75) mentions Gallic birch bitumen.

Rural Productions: Animal Husbandry

Before Caesar's conquest, the Romans viewed the Gauls as heavy consumers of meat (Strabo, *Geogr.,* 4.4.3), so it is not surprising that conquest brought little change to livestock production (Luff 1982; Arbogast, Méniel, and Yvinec 1987; Pigière 2009). Animals were used as beasts of burden (cattle, possibly horses, and mules) in the field and to meet the food needs of the population.

In particular, a pastoral economy existed in the middle and high mountains; in the alpine regions, where transhumance was practiced with the Crau plateau, and the Pyrenees (Galop 1998; Leveau 2006, 2009; Réchin 2006; Jourdain- Annequin and Duclos 2006; Jospin and Favrie 2008; Segard 2009), and also in the Vosges (Pétry 1979) and the Jura (Gauthier 2004). In Late Antiquity, there is evidence of a marked increase in pastoral activities and livestock production (Jaillette 2003), but it is unclear if these were changes in the methods of breeding or toward less stabling on the farms themselves, or of some other factors – an animal plague (epizootic) is mentioned as affecting northern Gaul in the Late Empire (Endelechius, *De mort.*). Whatever the case, in Late Antiquity we can certainly find more shepherd caves in use in the southeast quarter of France (above) and perhaps also the reoccupation of some sites in the heights (above) in these same regions.

Stabling structures (stables, barns, sheepfolds, piggeries and henhouses) are rarely uncovered by archaeology (Ferdière 2017). Strabo (*Geogr.,* 4.4.3), a contemporary of the emperor Augustus, tells us that a great many animals were raised in Gaul, especially pigs (for cured meats) and sheep (for wool). The profitability of animal production in Gaul was in fact a literary topos, among the authors of the Imperial period as was the general fertility of Gaul, (Varro, *RR*; Pomponius Mela, *Geogr.,* 3.17; Sidonius Apollinaris, *Carm.,* 5, 45), though there are rare references to breeders (or shepherds? *pecuarius*) on the Rhine (Tacitus, *Ann.,* 13.54-13.55; cf. Jaillette 2003).

Figure 22.5 Cheese presses, Musée national d'histoire et d'art Luxembourg. Source: Le Musée d'Art et d'Histoire d'Orange.

Apart from equids, the main species were raised mainly for food (beef, pork, lamb, and goat) or traction/burden and milk. For meat food, pigs were most common, but were less desired than beef in northern regions, or sheep in the south (King 1999), and there was much variation in regional preferences during the five centuries under discussion. During the Roman period, it seems that there was increasing efficiency in the feeding of animals, particularly with regard to the quality of fodder (above), which may have contributed to changes in species preference. The practice of castration also became much more systematic, for more docility and an increase in weight. Over time, there seems to have been a marked increase in the size of animals at the withers, which only declined at the beginning of the High Middle Ages (Audoin-Rouzeau 1995; Peters 1998).

Milk – from the cow, sheep, and goat – was mainly produced for cheese: the ceramic cheese strainers are a clue (Figure 22.5), and certain Gallic cheeses were famous on Roman tables, such as those from Gévaudan, Mont Lozère, and the regions of Nîmes (Pliny, *HN* 11.240 and 241) or Toulouse (Mart. *Epigr.,* 11.32.18). Skins and leather, on the other hand, were secondary products, crafted from the salvaged remains of animals raised primarily for their meat, milk or wool (see Leguilloux 2004; Deschler-Erb 2012, pp. 127-137).

It is possible that Gallo-Roman estates specialized in animal husbandry (beef, sheep, horses, etc.) – especially in regions with high textile activity – and this was clearly the case in the most northern parts of Gaul (Lauwerier 1988; Kooistra 1996; De Clercq 2010).

- *Cattle,* bred for field work and heavy transport, and meat and milk, were the dominant species in northern Gaul, with the Gallo-Roman oxen being of much stronger stature than previous breeds (Lepetz 1996a, p. 86; Forest and Rodet-Belarbi 2002; Nuviala 2016). By the first century CE, these Gallo-Roman breeds were replacing local cattle in places like Bassée in the Senons (Horard-Herbin, Méniel, and Séguier 2000; Duval, Lepetz, and Horard-Herbin 2012), and yet, small oxen continued to be raised alongside the new more productive and meatier animals. Rather than new "species" from the outside, there was undoubtedly a progressive improvement of the domestic breeds by crossing and selective breeding (zootechnics) (Lepetz 1996a, p. 95, for the north and the Île-de-France; Bowman et al. 2009, for the trade in cattle in Friesland). Draft oxen tended to be shod (*bousandales*: Brouquier-Reddé 1991). Sidonius Apollinaris (*Epist.,* 2.2.14) described herds of cattle equipped with bells (*greges tinnibulatos*) in the pasture (*depasta buceta*) at his estate of *Avitiacus* in Auvergne, and there is evidence for an outbreak affecting cattle in the third quarter of the fourth century, in the town of *Ambrussum*-Villetelle (Hérault) (Porcier 2012), perhaps the same as the plague mentioned in the literary record (above). With respect to urban meat production, there was a special process: cattle arrived on foot from the countryside, were slaughtered, carved up, and sold by specialized artisans, before being distributed by local butchers.

One can see cowsheds for cattle in the alpine village of Brig-Glis (Guélat, Paccolat and Rentzel 1998), at Meylan (Isère) (Jospin and Favrie 2008, pp. 129–131), or on the rural settlements of Saint-Brice-la-Forêt (Val-d'Oise) (Broes et al. 2012) and Bouxières-sous-Froidmont (Meurthe-et-Moselle), not to mention all the byre houses in the extreme north of Gaul (Heeren 2014 and above).

- *Pigs*, derived from the indigenous boar, also increased in size during the Roman period. The Gauls and then the Gallo-Romans were heavy consumers of pork. The pigs of Gaul were, according to Strabo (*Geogr.,* 4.4.3), particularly vigorous and raised mainly outdoors. Cured meats – especially ham – produced in Gaul were famous at Roman tables (Strabo, *loc. cit.*): from Cerdagne (Pyrenées) or the *Menapii* to the North (Martial, *Epig.,* 13.54; *Edict on Prices* 2.11), from the *Sequani* in Franche-Comté (Strabo, *Geogr.,* 4.3.2) or from Comtat (Varro, *RR*, 2.4.10); this demand has been well studied for the *civitas* of Trier (Méniel 2014). Pork – like other meats – was preserved by drying, salting, or smoking (Leguilloux 2006): installations for smoking meat are known, for example, in Mathay (Doubs) or Augst (Switzerland) (Deschler-Erb 2012), and are more and more numerous in the farms and *villae* in Late Antiquity (Van Ossel 1992, pp. 137–151).
- *Sheep* and *goats* are not easily distinguishable through archaeozoological studies and so are treated together here. The breeding of both species increased significantly with the arrival of the Romans in the provinces north of the Alps (Peters 1998). Sheep were well represented almost everywhere and raised for meat, especially in southern Gaul, and like the cattle discussed above, increased in size over time. Strabo (*Geogr.,* 4.4.3), at the beginning of the Roman period, attests to Romans farming sheep in the north of Transalpine-*Narbonensis* (perhaps the French Alps?), describing their practice of covering their animals with a jacket of skin in order to obtain a finer wool. These references to wool, or cloth and clothing made from this fiber, are clear indications of sheep breeding: *gynaecia* of the *Noticia Dignitatum* (*Occ.,* 11.54-11.59, 72-77; 12.13-12.14, 19, 26-27, 29: spinning "factories" at Tournai, Trier, Reims, Metz, Autun, Lyon, and Arles), the quality of the wool of Pezenas (Pliny, *NH*, 8.191) or of the Atrebates (Orosius, *Hist.*, 7.32.18), Gallic jackets (*Hist. Aug., Caracalla*, 9.7; *the two Gallieni*, 6.6; *the divine Claudius*, 17.6; *Probus*, 4.5; *Carus, Carinus and Numerienus*, 20.6), and the importance of textile and clothing production in Gaul (Martial, *Epig., Edict on Prices*: multiple citations), particularly in Belgian Gaul, in the *civitates* of the *Treviri* (Trier), and the *Ambiani* of Picardy (Agache 1978; Drinkwater 1982; González Villaescusa 2010). Gallo-Roman sheepfolds have been found in Narbonnese Gaul, on the Crau plateau, in use from the second century CE (Badan, Brun, and Congès 1995), corresponding to

large-scale sheep farming, perhaps transhumant here in winter after leaving their alpine pastures (or freer seasonal movements?), as suggested by the literary sources (Strabo, *Geogr.,* 4.1.7; Pliny, *HN* 21.57; cf. Leveau and Segard 2004); other sheepfolds are known, for example, in Vaunage (Languedoc: Raynaud in Collective 1993–1996, pp. 1–10). As with other animals, there was a marked increase in sheep farming in Late Antiquity, in *Narbonensis*, in the region of Annecy, and in the Île-de-France (Columeau 2002; Olive 2003; Leblay, Lepetz, and Yvinec 1997, p. 53).

Goats were certainly much less common, though mentioned in Gaul by Arrian (second century CE: *Cyn.,* 34.2) and Varro (*RR*, 2.3.9) who observed that Gallic goats were kept apart to avoid infection. But it is known that goat's milk was used for cheese, and goat hair was used for coarse weaving.

- For *horses*, the abandonment of hippophagia means that we are badly informed by archaeozoology about their breeding (Arbogast et al. 2002), although the horse was certainly an important animal in Roman Gaul: the privileged place of the gaulish goddess Epona, protector of horses and riders, confirms this. Pliny (*HN* 3.23, 37.203) describes the training of horses and importance of raising them in Gaul, and Gallic mares were mentioned in the *Historia Augusta* (*Divine Claudius*, 9.5–9.6). Some regions may even have practiced specialized horse breeding, such as the Lower Rhine (Voosen and Groot 2008; Groot 2016), and we see a revival of this breeding at the end of Antiquity: the appearance of rye and oats, as fodder, in northern Gaul (see above), could thus accompany this later expansion (Matterne 2001, p. 184 ff.).

  The horse was used for riding or for pulling vehicles to transport men as well as goods, and so the Gallo-Roman horse has a height and girth at the withers much larger than its Gallic predecessors. Its importance to farm work can be inferred from an ironwork device peculiar to the Roman period, the hipposandal (Figure 22.6), which protected the horse's feet on difficult routes (Lawson 1978); but nailed horseshoes are also attested (de La Rocque de Sévérac 1980). And in terms of physical remains, apart from post stations, the identification in the archaeological record of horse stables is problematic.

Figure 22.6 Iron horse-sandal. Source: © RMN-Grand Palais / Art Resource, NY.

The donkey seems to appear in Gaul only with the advent of the Romans (see, e.g. Lepetz 1996a, p. 95; Lepetz et al. 2002, p. 87), when it was crossed with the horse to produce mules and hinnies. Like mules, donkeys were used for heavy transport, as is attested in the iconography. Claudian, in the fourth century (*Idylls*, 8 (51)), mentions the mules of the Rhone Valley, and the hermaphrodite mares of the *Treviri* (Pliny, *HN* 11.262) are probably mules or hinnies. Despite the economic importance of these beasts of burden for land transport, mule breeding remains largely undocumented for Gaul (Lepetz 1996a, pp. 52–56; Peters 1998).

- *Other domestic animals*: Dogs had various uses, domesticated rabbits were present in *Gallia Narbonnensis*, and of course bees were common throughout the region for their honey and wax (Collective 2019).

  As for backyard poultry (chickens, geese, pigeons, etc.), these were rarely present in the Gallic period, though the chicken became more and more popular from the first to the fifth century CE (Lepetz 1996a, p. 126ff.; Lepetz et al. 2002, p. 89), when they took a relatively important place in the Gallo-Roman food supply (Leblay, Lepetz, and Yvinec 1997, p. 54). Domestic geese also became common, and in the first century CE, we hear of geese being exported by road to Rome from the city of the *Morini* (North Sea coast) (Pliny, *HN* 10.53).

Other Rural Activities?

Some activities that are strictly speaking not agropastoral existed at the margins of the rural economy.

- These include *hunting* and *fishing*, as well as the exploitation of *seafood*. Hunting, in particular, became more popular among the elites of Late Antiquity (Trinquier and Vendries 2009, pp. 141–159): wild boar, deer, thrushes, and ducks (Ausonius, *Epist.,* 14.16–14.32; 18.7–18.16; cf. Arrian, *Cyn.)*.

  Fishing at sea or on rivers was widely practiced, as is shown by the remains of fish identified in food waste (in Lattes in Languedoc: Sternberg 1995; for the Aquitaine coasts: Ephrem 2015). Pliny (*HN* 9.29) mentions dolphins trained for fishing in the pond of Lattes (Hérault). In general, it is clear that certain rural establishments, such as *villae*, were located down by the sea in order to exploit various coastal marine resources, not simply because of the amenable locations and milder climate (for the Mediterranean coastline: Lafon 2010; the *villa* of Mané-Vechen, Morbihan: Provost 2007): the coastlines of the Mediterranean and the Armorican peninsula were especially developed developed and exploited (Delestre and Marchési 2010; Carpentier and Leveau 2013).

  The consumption of fish seems to have played an important part in the diet of Gallo-Roman coastal populations, especially in northern France (Oueslati 2013). Fish salting facilities have been found mainly in *Armorica* (Douarnenez Bay: Sanquer and Galliou 1972; Leroy 2003), but were also known further south along the Atlantic coast, for example, in Guétary (Ephrem 2010). And batteries of fish smokers are postulated for Guérande and its surroundings (Loire-Atlantique: Sélèque 2012). The coasts of Roman Gaul do not appear to have been large producers of *garum* and other fish sauces, although Pliny (*HN* 31.95) mentions the bass *garum* produced in Fréjus. There were also breeding ponds for freshwater fish, such as those in Molesme (Côte-d'Or: Petit 2005) and Mageroy (Belgium: Zeippen and Hallebardier 2006). The shellfish and especially the oysters of the Gallic coasts were prized, as the innumerable shells collected on Gallo-Roman sites far inland attest: these were wild oysters mainly, and not produced from oyster cultivation (Pliny, *HN* 32.62 for the Médoc; Ausonius, *Epist.,* 5, 1–2, 9, 18–19 and 25–40 for Bordeaux and Marseille, Narbonne, and other Gallic coasts). Shell analysis (conchyliology) has made significant progress on this problem (Schneider and Lepetz 2007; Bardot-Cambot 2013; Bardot-Cambot and Forest 2013). The production of purple (dyeing, from murex) is attested in Toulon and Narbonne (*Noticia Dignitatum, Occ.,* 11.72–11.77).

Finally, we should also mention salt production – rock or sea salt – which was indispensable for life (Hocquet 1994; Hocquet and Sarrazin 2006).

- *Handcrafts* and the production of *raw materials* – like trade and transport – were not distinguished from the other productive activities of the countryside by the Romans (Polfer 1999; Ferdière 2003): raw materials for the iron industry (from Berry: Dumasy, Dieudonné-Glad, and Laüt 2010, or Maine: Sarreste 2011) and stone for building or for example for millstones (from Eifel: Mangartz 2012). For the production of manufactured objects, artisanal centers were often rural and probably dependent of the estates, as for pottery and, in particular, the production of wine amphorae (Mauné 2007) or architectural terracotta (Ferdière 2012) and textiles (Ferdière 1984). Rural manufacturing seems to have developed extensively in the Later Empire (Polfer 1999; Van Ossel 1992).

Conclusion: Integrated Agriculture

In the end, because of the absence of data, some of our initial questions remain – at least in part – unanswered. The overall picture, however, at least for northern Gaul, is that of an obvious agricultural intensification, with, on the one hand, the exploitation of new land by wise management of the environment, and on the other hand, a systematization of practices leading in particular to better yields (Trément 2010; Ouzoulias 2014).

In short, a Gaul, which was above all agricultural, responding to the first expectation of conquest and Romanization and despite the development of urbanization.

FURTHER READING

Agriculture in Roman Gaul is poorly documented by Greek or Latin texts: there is only brief and vague information from Caesar (*BG*), with the majority of data deriving from Pliny the Elder and the Latin agronomists; for Late Antiquity, we have only the *Price Edict*, Ausonius, and so on. Consequently, there have not been many studies of the subject, and very few in English: in addition to Ferdière (1988 and 2006), see Wightman (1985) for agriculture in northern Gaul, and Kooistra (1996) for the region now located in the modern Netherlands; for rural life, in general, see Wightman (1975), White (1967, 1970a,b, 1975, 1977) and Bowman and Wilson (2013). For the Celtic field system, see Brongers (1976), Lauwerier (1988), and Groot (2016). On the Romanization of Gaul and its countryside, see Wood and Queiroga (1992) as well as Woolf (1998). For *villae,* see Smith (1997), Roymans and Derks (2011) (for northern Gaul), and Roymans, Derks, and Hidding (2015) for the Hoogeloon *villa*, in particular. Carlsen (1994) and Lewit (2005) are useful for understanding the world of farms and *villae* in the Late Empire. See Altekamp and Schäfer (2014) for Roman land use and the impact of Rome on settlement and Erdkamp, Verboven, and Zuiderhoek (2015) for the general exploitation of land in the Roman Empire.

For animal husbandry, see Luff (1982) and with archaeozoology, Van Zeist (1970). Ucko and Dimbleby (1969) provide a useful discussion of the domestication of plants and animals, as does Whittaker (1988) for animal husbandry and pastoralism. For animals in the Roman *villa*, see Percival

(1976) and Frazer (1998); for the northern provinces, see Habermehl (2013). For granaries and the corn supply for the city of Rome, see Rickman (1971, 1980) and Erdkamp (2005, grain market for the Roman Empire as well as for Rome); for global economic aspects, see Rostovtzeff (1926). Williams and Peacock (2011) deal with milling in the Roman world. Stevens (1966) and Christie (2004) analyze food plants of the Later Empire, and Farrar (1996) examines the gardens of the Western Empire. For textiles, see also Drinkwater (1982) and Wild (1970).

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CHAPTER TWENTY-THREE

Agriculture in Roman Iberia

Benedict Lowe

According to the Greek geographer Strabo writing in the early first century CE, the Iberian Peninsula is divided into two parts (3.1.2): the greater part of the Peninsula is inhospitable and ill-suited to agriculture, consisting of mountains, forests, and infertile plains. By way of contrast, the South – modern Andalucía – is fertile, in particular, the region of ancient Turdetania. Turdetania was blessed with an abundance of natural resources both agricultural and mineral (3.2.3–3.2.4). Although couched in moralizing terms, Strabo's portrayal reflects the geographical diversity of the Iberian Peninsula.

The Iberian Peninsula covers an area 580 000 km² extending from Punta de Tarifa (Cádiz) overlooking the coast of Morocco in the south to Estaca de Bares (Galicia) on the Bay of Biscay in the north. Its position spanning the junction of the Mediterranean and Atlantic together with the sheer size of the Peninsula and the wide variety of its landscape ensures considerable ecological and environmental diversity. Broadly speaking, the Peninsula can be divided into three geoclimatic zones. The Mediterranean coast extends for 1660 km and consists of a narrow coastal plain isolated from the interior by a string of mountains extending from the Baetic Cordillera – that includes the highest point of the Peninsula in the Sierra Nevada – to the Sistema Ibérico in the northeast. The encircling mountains are cut by river valleys – the Ebro, Guadalquivir, Tagus, and Duero – that penetrate the interior, though only one – the Ebro – enters the Mediterranean. Together with the valley of the río Guadalquivir, the coast enjoys a warm Mediterranean climate with short, mild winters and long, dry summers. Unlike the rest of the Mediterranean coast, the South-East is semi-arid with scarce precipitation. In contrast to the fertility of the coastal areas, the interior of the Peninsula is dominated by a high tableland – the Meseta – that extends from the Sierra Morena to the Cantabrian Mountains, roughly the kingdom of Castile. Ranging in height from 600 to 800 m above sea level, the Meseta is rugged and sparsely populated. The climate is harsh with wide seasonal variations: cold winters and long, hot summers. The extremes of temperature, lack of rainfall, and rocky, infertile soils limit the agricultural potential and encourage the raising of livestock; however, cereal cultivation and viticulture did take place.

The wide regional variations in climate and environment render it impossible to discuss the agriculture of the Peninsula in general terms. Studies are further hampered by the paucity of

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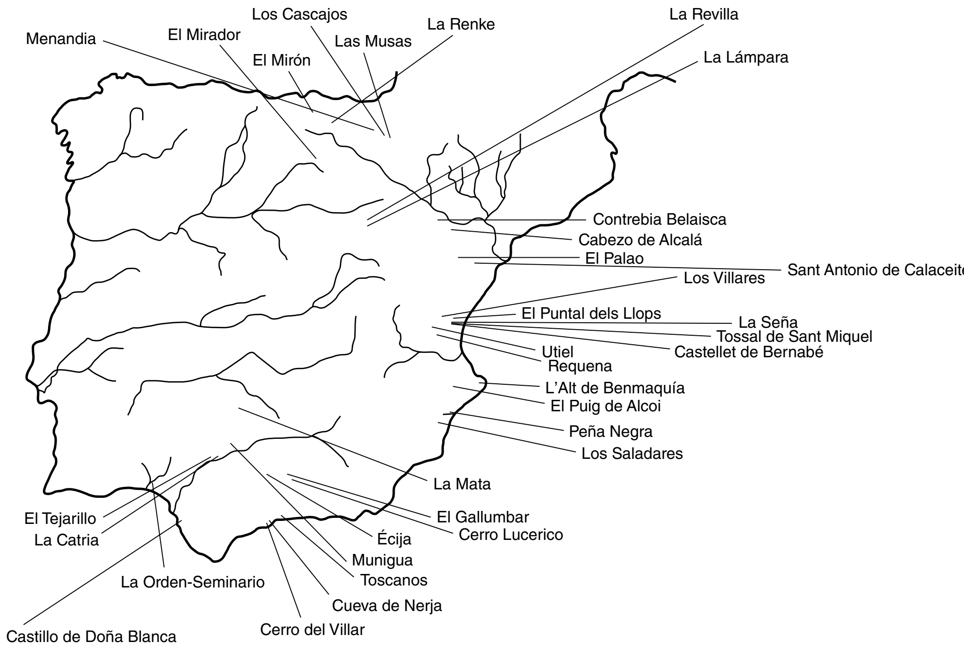

Figure 23.1 Sites in Iberia referred to in the text. Source: Illustration by Benedict Lowe.

archaeozoological data: it is only comparatively recently that excavations began to provide a systematic record of floral and faunal material, and even now there are wide variations in the regional and chronological distribution of the data available. The majority of available data comes from the North-East, including coastal Cataluña and the Empordà, Bajo Aragón, and to a lesser extent Valencia and the East Coast.

Development of Agriculture and Animal Husbandry During the Neolithic

The earliest evidence of agriculture in the Iberian Peninsula dates to the sixth millennium BCE. The Neolithic period saw not only the continued exploitation of existing subsistence resources – hunting, fishing, and gathering – but also the development of new farming techniques. In the Early Neolithic, wheat and barley were cultivated: einkorn (*Triticum monococcum*), emmer (*Triticum dicoccum*), common wheat (*Triticum aestivum*), naked barley (*Hordeum vulgare* var. *nudum*), and hulled barley (*Hordeum vulgare* var. *polystichum*). Cereals formed a staple component of the diet, providing not only a high yield but also an important source of carbohydrates, proteins, energy, and fiber. Common wheat was the most numerous with the increased cultivation of hulled barley during the Bronze Age. Other cereals – common millet (*Panicum miliaceum*), foxtail millet (*Setaria italica*), and oats (*Avena sativa*) – only appear later in the Bronze Age and Iberian periods, respectively (Alonso Martínez 2000, p. 31). Evidence of agriculture has been found at both preexisting cave sites, as well as at open-air settlements lacking previous habitation. The earliest evidence comes from the cave of Can Sadurní (Begues, Barcelona) (5470–5300 BCE): hulled wheat predominates, together with both emmer wheat and einkorn, as well as common wheat and lesser quantities of barley (Antolín et al. 2013, p. 21). One of the most significant open-air sites was discovered at La Draga. The site was a pile-dwelling village in the lake of Banyoles that was destroyed by fire c. 4720 BCE, preserving large quantities of charred plant remains. Pollen analysis suggests the disappearance of deciduous oak forests began c. 5650–5450 BCE as the forests were cleared to allow cultivation of domesticated crops. The most common was hulled barley, as well as naked wheat, emmer wheat, einkorn, and opium poppy (*Papaver somniferum*) (Antolín et al. 2014, pp. 248–249; Revelles et al. 2014, p. 301). The cultivation of cereals was complemented by the consumption of legumes, including the introduction of new legumes such as broad beans (*Vicia faba*), lentils (*Lens culinaris*), and peas (*Pisum sativum*). Although a direct correlation is impossible, the presence of significant numbers of vegetables may indicate the practice of crop rotation with legumes replenishing the nitrogen content of the soil stripped by cereal cultivation.

It is only later that evidence for agriculture begins to appear in the Meseta: cereal cultivation is attested at the cave of La Vaquera (Torreiglesias, Segovia) between 5480 and 5320 BCE (Gibaja Bao et al. 2012, p. 35; Rojo Guerra et al. 2011, p. 111). Einkorn predominates in Early Neolithic levels dating to the last third of the sixth millennium BCE at La Lámpara and La Revilla del Campo in the Ambrona valley (Miño de Medinaceli) in the northern Meseta (Stika 2005, p. 193; (Rojo Guerra et al. 2006, p. 80). Carbonized emmer wheat (*Triticum dicoccum*) dated to 5230–4920 BCE has been found in the cave of El Mirador (Ibeas de Juarros) in the Sierra de Atapuerca. In addition to emmer wheat, the inhabitants also exploited free-threshing wheat as well as legumes (peas and beans), bromes, alfalfa, and clover (Martín 2009, pp. 78–79). The earliest evidence of agriculture from Cantabria comes from the cave of El Mirón in the valley of the río Asón. Several taxa have been found in Neolithic levels dating between 4600 and 3600 cal BCE: the earliest is a charred grain of emmer wheat. Einkorn and free-threshing wheats have also been found (Peña-Chocarro et al. 2005, p. 582).

The origin of animal domestication within the Peninsula is the subject of considerable debate, ranging from the role of indigenous hunter-gatherer communities to the impact of external influences bringing new techniques of farming and animal husbandry. The earliest domesticated animals are found in the Early Neolithic settlement sites of the Ambrona valley in the middle of the sixth millennium BCE: a macro-ungulate bone from pit 9 at La Lámpara dating to 5837–5665 cal. BCE and ovicaprids from La Revilla del Campo dating between 5466 and 5261 cal BCE (Rojo Guerra et al. 2006, p. 84). The wide variations in geomorphology and climate meant that there were regional variations in the domestication of animals: while animal husbandry became widespread over much of the Peninsula by the middle of the sixth millennium BCE, the earliest evidence of domestication only reached the northwest c. 4500 BCE. Ovicaprids are the most numerous domesticated species, although hunting continues to be important at a small number of Early Neolithic sites, with rabbit, wild boar, and red deer featuring prominently. The incidence of species that had previously been an important component in the diet of hunter-gatherers such as rabbits and wild boar show a sharp decrease in the Early Neolithic, while by the Middle Neolithic cattle and pigs are increasingly important at the expense of ovicaprids – although at some sites there is an increase in the number of goats perhaps to provide milk (Pérez Ripoll 1999, p. 98). While ovicaprids are the most numerous species in Early Neolithic levels at Caserna de Sant Pau (Barcelona) (44.9% of the faunal remains), significant numbers of pigs (*Sus* sp.) (30.4%) and cattle (*Bos taurus*) (20.4%) were also present – although the excavators were unable to distinguish between domesticated and wild pigs from the osteological evidence (Albizuri Canadell et al. 1993, pp. 80–81). At La Draga, ovicaprids are most numerous with 40.5% of the faunal remains followed by *Bos taurus* (30.7%) and *Sus domesticus* (21.8%). Although domesticated species predominate, accounting for 93.2% of the assemblage, this was supplemented by hunting with wild boar, aurochs, roe deer, red deer and ibex also being found (Altuna et al. 2009, pp. 152–253). Similar ratios occur at La Renke (Santurde, Álava) and Los Cascajos (Los Arcos, Navarra), although cattle predominate at both accounting for 63.7% and 82.4% of the faunal remains respectively (Altuna et al. 2009, pp. 147–148; et al. 2001, p. 76). Not only did cattle provide meat and milk but at La Draga it appears that they were used as transport and draft animals with finds of yokes and signs of bone deformation caused by the application of pressure; however, the limited number of examples suggests that the use of animals was unspecialized (Bosch Lloret et al. 2008, p. 329). At Mendandia (Sáseta, Treviño) it has been suggested that the inhabitants were systematically managing wild animals (*Bos primigenius*) for domestication by culling animals between the ages of four and eight weeks (Altuna et al. 2009, p. 149; Alday Ruiz et al. 2012, p. 238). The relative frequency of ovicaprids compared with bovines may reflect a specialized use of rock-shelters, caves and open-air sites with ovicaprids more numerous at the former, while cattle and other domestic species are dominant on open-air sites (Altuna et al. 2009, pp. 155–156).

New Species: The Impact of Colonial Contacts

The arrival of Phoenician and Greek colonists together with access to the trade networks of the wider Mediterranean had profound implications for agriculture: stimulating technological developments, opening up of new areas for farming, and the cultivation of new taxa. The locations of the colonies were ideal for the development of intensive agriculture: the situation of the Greek colony at Empúries on the Gulf of Rosas allowed access to the fertile alluvial soils of the Baix Empordà. Fueled by the demand for cereals offered by the colonists, the indigenous population engaged increasingly in the cultivation of cereal crops. Cultivation was organized through a hierarchy of sites devoted to the gathering and transfer of cereals. Once gathered, cereals require storage to prevent spoilage, infestation by pests, or germination. According to Varro (*Rust.* 1.57.2), the most common technique used by the Iberians was to store grain in silos that were sealed to provide an anaerobic environment and protect against moisture. Some were of considerable scale: for example, 180 silos have been excavated at Turó de la Font de la Canya (Avinyonet del Penedès). The volume of cereal cultivation increased during the third and fourth centuries BCE with the largest grain silos at Font de la Canya dating to this period (López Reyes et al. 2013, p. 34; Asensio i Vilaró et al. 2006, pp. 693–694; Colominas et al. 2011, pp. 61–62). Surplus production was concentrated in larger centers, for example, at Mas Castellar (Pontós), where between 2500 and 3000 silos have been discovered. The site was transformed in the third century BCE to engage in the large-scale cultivation of cereals gathered from smaller sites in the area, for example, at Olivet d'en Requesens (Creixell) and La Qüestio d'en Solà (Ermedás). The storage capacity of the grain silos increased from 540 l before 400 BCE to an average of 3348 l between 300 and 175 BCE – a capacity of 283.2 tons of cereal (Bouso García et al. 2000, pp. 119–120). According to Varro (*Rust.* 1.57.3), the inhabitants of Hispania Citerior also used aboveground granaries to store grain. Columella recommends the use of aboveground storage in wet climates, which ensured ventilation and protected the crops from spoilage (Varro *Rust.* 1.57.1; Columella *Rust.* 1.6.12-14; Pliny *HN* 2.18.302). Three such granaries have been discovered at La Moleta del Remei (Alcanar, Montsià) that were in use successively from the end of the fifth century BCE to the end of the fourth or beginning of the third century BCE (Gracia Alonso 1995, pp. 92–94).

A similar intensification of cereal cultivation seems to have occurred in the hinterland of the Phoenician colonies in the south. The colony of Cerro del Villar lies at the mouth of the río

Guadalhorce. The site was settled by the Phoenicians at the end of the eighth century BCE and abandoned c. 570–560 BCE. Floral analysis revealed a predominance of cereals: barley is most common followed by lesser quantities of common wheat and emmer wheat. As well as cereals, legumes have also been found, principally peas and lentils, although they are more numerous in the earlier levels with cereal cultivation dominating in the later phases of occupation (Aubet Semmler et al. 1999, pp. 308–312). The valley of the río Guadalhorce was well suited for intensive irrigation agriculture worked by the inhabitants of a scatter of small rural settlements in the hinterland of the colony. Several such smaller settlements have been identified: Loma del Aeropuerto, Cártama, Cerro de las Torres, Campamento Benítez, and Los Remedios (Aubet Semmler et al. 1999, pp. 54–56). Produce was then brought to the colony for processing: finds of stone querns and the large number of weeds indicate that threshing took place within the colony (Aubet Semmler et al. 1999, p. 312). The expansion of agriculture led to the increasing use of cattle for traction. The majority of the cattle bones from trench 3/4 are adults (39 out of 44), suggesting their use for milk or traction. The predominance of barley in the floral record may be related to the prominence of cattle: although barley is used for human consumption – particularly as beer or porridge – it was mainly used as feed for cattle. The poor state of preservation makes the identification of the bones difficult, but the colonists appear to have raised a mixed livestock with ovicaprids, cattle, and pigs (Aubet Semmler et al. 1999, pp. 315–318). The large number of pig bones is particularly striking: compared to cattle – and to a lesser extent sheep and goats – pigs compete far less for access to available resources. The high percentage of cattle bones at Toscanos may suggest a similar intensive exploitation of the valley of río Vélez. Similarly, the cattle found at Castillo de Doña Blanca may have been used as draft animals (Roselló Izquierdo et al. 1994, p. 45). The increased presence of cattle at Cerro del Villar coincides with a decrease in the number of sheep and goats, while pigs are scarce in all phases of the site – all of whom are detrimental to intensive agriculture. The colonists supplemented their diet with hunting: faunal evidence from Cerro de la Tortuga indicates that deer, wild boar, and wild cats were still to be found in the woods surrounding the valley of the Guadalhorce (Aubet Semmler et al. 1999, p. 43).

The Phoenicians appear to have been responsible for the introduction of the chicken (*Gallus gallus domesticus*) to the Peninsula, with the earliest examples being found in the Phoenician colonies from the eighth century BCE: the earliest evidence comes from Castillo de Doña Blanca and Toscanos (Hernández Carrasquilla 1992, p. 50; Roselló Izquierdo et al. 1994, p. 85). The coracoid bone of a domestic chicken has been found at Cerro del Villar in a context dated to the beginning of the sixth century BCE (Aubet Semmler et al. 1999, p. 319). It is only from the fourth century BCE that chickens begin to be found more widely.

As well as the intensification of cereal cultivation, colonial contact also prompted the introduction – or cultivation – of new species, principally grapes (*Vitis vinifera*) and olives (*Olea europaea*) (Buxó Capdevila 2008, pp. 147–148). While wild grapes (*Vitis vinifera* var. *sylvestris*) were consumed by Prehistoric peoples as early as the Paleolithic, the earliest evidence for their cultivation comes from plantings dating to the ninth century BCE at the site of La Orden-Seminario in Huelva; however, cultivation at that time appears only to have been of limited scale, expanding during the Orientalizing period from the ninth to the sixth centuries BCE (Vera-Rodríguez et al. 2013, p. 104; Echevarría Sánchez et al. 2015, pp. 65–66). Environmental analysis from the Phoenician enclave of Castillo de Doña Blanca (Cádiz) reveals a change in agricultural activities at the end of the sixth century BCE: while barley, wheat, and canary grass continue to predominate in Phases I–III (675–550 BCE), there is a dramatic increase in the importance of vine cultivation, rising from 6.25% of the sample in Phase III to 32.8% in Phase IV (550–500 BCE) (Roselló Izquierdo et al. 1994, pp. 25–27).

Over the ensuing century, the consumption of grapes extended along the East Coast, penetrating the interior via the Ebro Valley by the end of the seventh or beginning of the sixth century BCE. A letter dating to the end of the sixth century BCE discovered in the Neapolis of Empúries records the delivery of a cargo of wine from Saiganthe – modern Sagunto – purchased from an Iberian merchant, Besped (Sanmartí Grego et al. 1987, pp. 120–122). The only evidence for the production of wine, however, comes from Segeda I (Poyo de Mara), where a large two-story house extending over 90 m^2 on the eastern slope of the settlement (Area 2) contained a wine press dating to the final phase before its abandonment in 153 BCE. Chemical analysis of the plastered basin in space 5 revealed tartrate deposits from the fermentation of wine. The room also contained the charred remains of *Vitis vinifera* and grape leaves (Burillo Mozota 2010, p. 144; Burillo Mozota et al. 2005).

The growing importance of viticulture and its commercialization are reflected in the production of the first amphora forms – sack-shaped Vuillemont R1 – devoted to the exchange of wine that were found throughout the Phoenician colonies from 675/650 BCE. The site of L'Alt de Benimaquía (Dènia) lies on a rocky spur to the east of the outcrop of Montgó and consists of a fortified enclosure dating between 625 and 550 BCE. A substantial winery was discovered to the south of the city wall consisting of four rooms containing basins and pressing floors (rooms 1, 2, 4, and 5) as well as storage areas (rooms 6, 8, and 14). Quantities of amphorae together with 7000 grape seeds were found against the southern wall of room 2 as well as barley and free-threshing wheat (Gómez Bellard et al. 1993, pp. 21–22, 382–388; 1994, p. 16; 1995, p. 258). The scale of the installations together with the volume of imported and locally produced Vuillemont R1 amphorae go beyond domestic requirements and would have necessitated a significant local cultivation of vines.

To date, the seventh century BCE context of L'Alt de Benimaquía is unique, and it is not until the end of the fifth century BCE that wine and oil presses begin to be found in indigenous sites along the East Coast, in particular in Edetania at La Seña, Tossal de Sant Miquel, Castellet de Bernabé, and La Monrovana (Peña-Cervantes 2010, p. 155). Particularly striking is the abundance of evidence of viticulture that has been found in the vicinity of Utiel-Requena – ancient Kelin – where at least ten wine presses have been discovered as well as a wine cellar. Vine cultivation may have begun as early as the middle of the seventh century BCE; however, it is only in the sixth century that we get the first evidence for the production of wine. Three wine presses, an olive oil press, and a cellar have been found at Rambla de la Alcantarilla. The laborers may have resided in the neighboring Casa de la Alcantarilla, while smaller dependent farms were situated at Solana de Cantos 1 and 2, Rincón de Herreros, and Solana de las Carbonerillas (Quixal Santos et al. 2016, pp. 26–38). A similar pattern of occupation appears to have existed immediately to the east with the principal settlement Los Morenos and smaller sites at Casa Berzosilla and Solana de las Pilillas, where four wine presses have been discovered (Martínez Valle 2014, pp. 54–56; Quixal Santos et al. 2016, p. 38; Pérez Jordà et al. 2013, pp. 153–154). Evidence of viticulture from elsewhere in the Peninsula is sparse, although a small winery has been found within a wealthy house of the sixth–fifth centuries BCE at La Mata (Campanario) in Badajoz (Duque Espino 2010, p. 199).

Once pressing is completed, the grape juice is allowed to ferment for a period of 30 days (Cato *Agr.* 26) during which time the yeast converts sugars – principally fructose and glucose – into ethanol and carbon dioxide. The temperature was regulated to prevent spoilage. This was achieved by burying the vessels containing the mixture, and Cato recommends wiping the containers twice a day to keep them cool. According to the Elder Pliny, placing the containers under a northeast- or east-facing window allowed the circulation of cool air (*HN* 14.27.133–14.27.135). Possible wine cellars have been identified at several sites in Bajo Aragón and the Ebro valley (Burillo Mozota 2010, pp. 141–143): in 1903, two wine cellars were excavated on the edge of the settlement at San Antonio de Calaceite. Benches around the walls and in the center of the rooms may have supported amphorae (Moret et al. 2006, p. 157). Similar cellars have been found elsewhere, for example, at Cabezo de Alcalá (Azaila), Contrebia Belaisca (Botorrita) and El Palao (Alcañiz), where several possible wine cellars have been identified together with remains of presses and a possible oilery (zone 5) (Benavente Serrano et al. 2016, pp. 236–239).

The intensification of agriculture was linked to the consolidation of the Iberian city-states (Grau Mira 2014): control of the exploitation of agricultural resources and their exchange provided an important resource underlying the creation of the nascent Iberian culture with the transition toward a class-based society and the growth of regional polities. Hierarchies of settlements were geared toward optimizing the exploitation of the landscape with larger fortified settlements exercising control over smaller rural villages or farms. Despite the paucity of faunal evidence and the wide regional variations that exist therein, two distinct models of animal husbandry seem to have existed, with the herding of cattle predominating in the south, while the raising of sheep and goats was more significant along the east coast: for example, at Los Villares (Caudete de las Fuentes), ovicaprids predominate in all periods of the site, especially sheep (*Ovis aries*) – although in later phases (principally phase IV dating from the fifth to the third centuries BCE), there was a growing use of pigs as a source of meat (Martínez Valle 1991, pp. 257–258; 1987–1988, p. 193). Similarly, ovicaprids predominate at El Puig de Alcoi as well as a growing use of pigs from the fourth century BCE together with an increasing use of animals for secondary functions: milk and wool as well as breeding and ritual use (Pérez Jordà et al. 2013, pp. 202–203, 208–209, 219–220). By way of contrast, at Castellet de Bernabé (Liria), goats predominate, and the animals were killed for meat, being slaughtered at their optimal weight between 18 and 26 months of age (Martínez Valle 1987–1988, pp. 195–197; Iborra Eres 2004, p. 152). Analysis of stable carbon ($^{12}C/^{13}C$) and nitrogen ($^{14}N/^{15}N$) isotopes from the bone collagen of 14 infant burials reveals a diet of pig, sheep, deer, and goats (Salazar-García et al. 2010, p. 319). The picture is complicated by regional variations as sites adapted their husbandry to best meet the potential of their immediate environment: the predominance of ovicaprids at Los Villares and El Puig is in contrast to the predominance of cattle at Peña Negra (Crevillent) and Los Saladares (Orihuela) (Martínez Valle 1987–1988, p. 188) – perhaps due to the suitability of the coastal plains for the herding of cattle. The dominance of goats at El Puntal dels Llops (Olocau) reflects the rearing of animals best suited for the mountainous location on the southeast slopes of the Sierra Calderona (Iborra Eres 2000, p. 85; 2004, p. 188; Bonet Rosado et al. 1981, p. 178). While domesticated animals predominate throughout – in particular, ovicaprids – at several sites, for example, at Cormulló de los Moros, Castellet de Bernabé and Puntal dels Llops, the diet of the inhabitants was supplemented by the hunting of red deer (*Cervus elaphus*).

Further north in Cataluña, the same pattern is repeated: for example, at Turó de Ca n'Olivé (Cerdanyola), the inhabitants specialized in the raising of sheep as well as lesser quantities of goats. Pigs and chickens were also exploited for meat and eggs, respectively, while the small numbers of cattle and horses were kept alive until adult (Albizuri Canadell et al. 1999, pp. 42–43). Ovicaprids predominated at the coastal site of Alorda Park (Calafell) (62.3%), with lesser quantities of pigs providing a source of meat (Albizuri Canadell et al. 1992, p. 289). At Turó del Vent in the Vallès Oriental, sheep and goat were the most numerous domesticated animals with cattle becoming increasingly important from the middle of the third century BCE (Oliva Benito 2000, pp. 164–165). At Guàrdies and Mas d'en Gual (El Vendrell), on the other hand, cattle and pigs were the most dominant species in the third century BCE, with an increase in the number of ovicaprids c. 200 BCE (Valenzuela et al. 2010, p. 220).

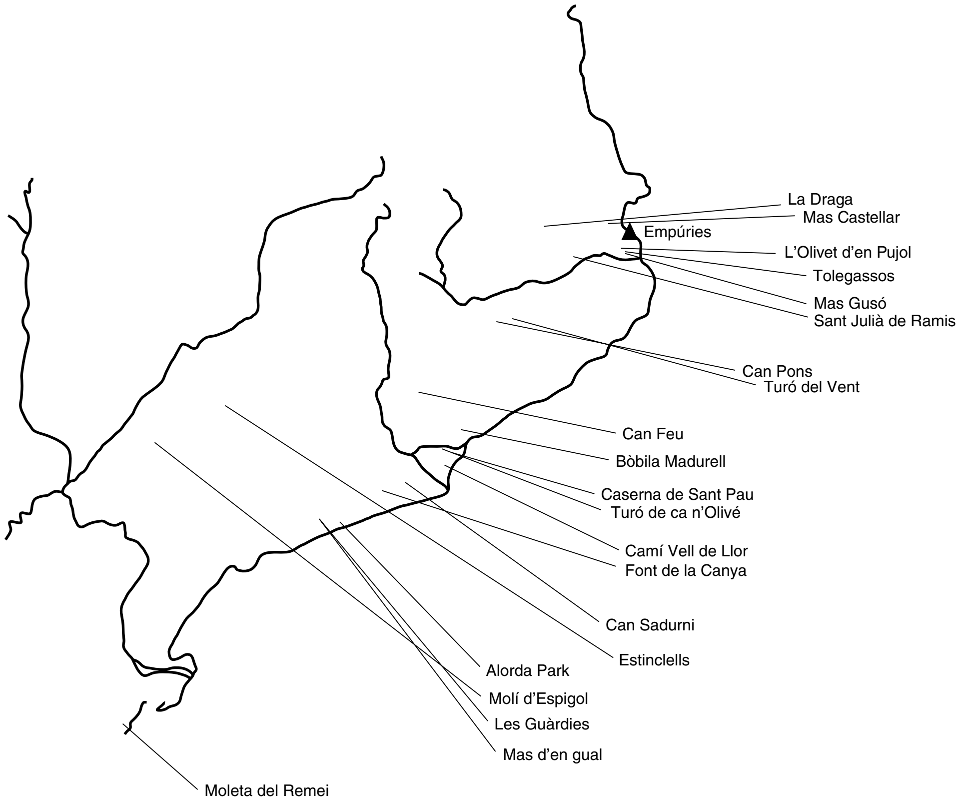

Figure 23.2 Sites in Cataluña referred to in the text. Source: Illustration by Benedict Lowe.

Restructuring of Rural Landscape in Second–First Centuries BCE

The end of the second century BCE onward saw a profound reorganization in the rural landscape of the North-East prompted by a shift from cereal cultivation to viticulture (Olesti i Vilà 1995, p. 165, 192; 1998, p. 247). According to the Elder Pliny, wine from Laietania was notable for its quantity, while that of Lauro or Tarraco was known for its quality (*HN* 14.71). Martial disparagingly refers to Laietanian wine as *faex laietana* (7.53.6); however, he is more positive about that of Tarraco (13.118): *Tarraco, Campano tantum cessura Lyaeo haec genuit tuscis aemula vina cadis.* Earlier farms and silos were abandoned and replaced by new forms of rural occupation with farms built along Italian lines and kilns producing amphorae modeled upon those of Italy. The earliest locally produced wine amphorae appear during the first century BCE, culminating in the large-scale production of Pascual 1 and Dr 2–4 amphorae from the Augustan period onward. This transformation was not merely confined to the adoption of an Italian rural economy based on villas (Revilla Calvo 2004, p. 189): the types of rural occupation were far more diverse, ranging from Italianate villas (for example, at Can Martí (Samalús), Santa Margarida de Montbui (Igualada), Mas Gusó (Bellcaire d'Empordà), and Torre Llauder (Mataró)) to smaller farms (for example, at Camí Vell de Llor (Sant Boi de Llobregat) and Casa del Racó (Sant Julià de Ramis)) – several of which predate the arrival of the Romans. Neither can their appearance be necessarily linked to the arrival of Italian immigrants, as at several sites an Iberian material culture continues to predominate. At Can Feu (Sant Quirze del Vallès), a field of 25 silos dating to the third century BCE was replaced by a villa devoted to the production of wine at the end of the first century BCE (Martínez et al. 1988, pp. 27–30). Two wine cellars containing dolia together with the carbonized remains of *Vitis vinifera* date to the Augustan period, and three kilns producing Pascual 1 and Dr 2–4 amphorae have been discovered 35 m to the south of the villa (Carbonell Solé et al. 1998, pp. 289–290; Martínez et al. 1988, pp. 30–32).[1] Two phases of occupation have been identified at El Bosquet (Sant Pere de Ribes): nine silos dating from the middle of the second century were replaced at the end of the first century BCE with a wine cellar containing four dolia (Bosch Argilagós et al. 1987, pp. 229–230; 1989, pp. 154–156). The granary at La Burguera (Salou) dating from the second century BCE to the second half of the first century BCE was replaced in the reign of Tiberius with a larger winery with five presses and a wine cellar containing approximately one hundred dolia (Bosch Puche et al. 2011, pp. 156–160). A large villa devoted to the production of wine was constructed toward the end of the reign of Augustus at El Morè (Sant Pol del Mar) with the apogee of production taking place during the second century CE. The villa is arranged over four terraces extending over an area of 2132 m^2: the residential area on the first terrace; the second terrace consisted of a metal workshop, an area for the milling of grain, and a winery arranged around a courtyard with the press room and the facilities for processing the must along the eastern side.[2] The third and fourth terraces contained dolia. Quantities of ceramic waste suggest that there was also a kiln producing Pascual 1 and Dr 2-4 amphorae for the shipment of wine (Gurri i Costa et al. 1998, pp. 564–565; Beltrán de Heredia Bercero et al. 2006, pp. 97–99). This intensification of agriculture may in turn have led to the import and breeding of larger and more robust cattle for use as traction (Colominas et al. 2014, pp. 15–16; 2013, pp. 192–194). The larger animals are initially found in newly established Roman farms such as L'Olivet d'en Pujol before becoming more widely distributed during the course of the first century CE. In place of the earlier reliance upon sheep and goats, pigs and cattle become increasing numerous. While sheep and goats were kept for milk and wool, most pigs were killed over the age of five, at which point their value for breeding decreases. Whereas in the Iberian and Republican periods cattle were being reared for traction and meat, from the Early Imperial period, increasing numbers were killed after the age of five after being kept for traction and milk (Colominas et al. 2009, pp. 14–15). Geoffrey Kron (2004, pp. 123–124) has advocated the existence of mixed farming or convertible husbandry whereby cattle were raised to optimize the yield of land under pasture.

During the course of the first century CE, villas began to appear throughout the Peninsula. In 1883, a particularly well-preserved winery and peristyle villa was discovered at Las Musas (Arellano). The main phase of the occupation dates from the middle of the first century CE until the third century when the complex was destroyed by fire. On the north side of the peristyle is the press room containing two presses, with the wine cellar lying on the west side containing at least thirty-four dolia. In the northeast corner was an open area – a *fumarium* – used for the aging of wine and a hearth used to reduce the must to make either *defrutum* or *sapa* (Mezquíriz Irujo 2003, pp. 73–74, 89–91; 2004, pp. 135–138; Sánchez Delgado et al. 1993–1994, pp. 58–59).

The transition to viticulture was far from all-encompassing, however: in September 1993, a small farm was discovered at Can Pons, 300 m to the west of the town of Arbúcies dating

1 A fourth kiln (e-14) produced smaller coarse ware pottery (Martínez et al. 1988, pp. 31–32).

2 Traces of tartrates have been recovered (Beltrán de Heredia Bercero et al. 2006, p. 101).

from the second half of the second century to the first quarter of the first century BCE (Font Valentí et al. 1996, p. 101). The farm consists of a rectangular building, 17 × 10 m in size, arranged around a central room (II). It was constructed out of drystone walls with beaten earth floors and lacking any Italian architectural elements (Font Valentí et al. 1996, p. 95; 2000, p. 255). Finds of loom weights and a possible loom suggest that textile working took place here, as well as wine production with a dolium and a small basin in room IV (Font Valentí et al. 2000, pp. 254–256). One hundred meters to the east, a small wine cellar (Sector II) was discovered containing quantities of *dolia* and *tegulae* together with *Vitis vinifera* (Font Valentí et al. 1996, p. 95).

The winery at L'Olivet d'en Pujol (Viladamat) overlies two silos dating to the second half of the fourth century BCE. At the end of the second century BCE, it was replaced with a storeroom containing 75 dolia (Casas Genover 1989, pp. 21–23, 39–44). Contemporaneous with the wine cellar are the earliest traces of occupation of the neighboring site of Tolegassos. In the middle of the first century AD, the small Augustan villa was remodeled around two courtyards, the larger of which contained at least 141 buried dolia. Although both *Vitis vinifera* and cereals – principally barley – have been found in contexts dating to the final quarter of the second century BCE, cereals predominate. Fragments of more than one hundred hand mills have been found together with the base of a fixed mill (Casas Genover et al. 2003, pp. 255–257).

Wild olives (*Olea europaea* var. *sylvestris*) are found in the Peninsula from the Upper Paleolithic at Cueva de Nerja (Nerja, Málaga). Difficulties in distinguishing wild from cultivated olives means that it is impossible to determine the date at which they were first cultivated (Rodríguez Ariza et al. 2007, pp. 226–227); however, it seems likely that the impetus came with the arrival of Greek and Phoenician colonists (Buxó Capdevila 1997, pp. 275–276). According to Pseudo-Aristotle (*de Mirabilibus Auscultationibus* 135), the Phoenicians traded olive oil and pottery with the indigenous population in return for silver – at which point it would appear that the indigenes had yet to develop oleiculture on any significant scale. In the absence of chemical analysis, it is difficult to distinguish between presses used for grapes or olives. The most significant distinction was the presence of a mill or *trapetum* used in the crushing of the olives. Olive presses have been found at several locations as early as the fifth century BCE: at Saus (Gerona), the earlier focus on cereal cultivation was supplemented by the processing of olives at some point from the middle of the fifth century or beginning of the fourth century BCE when the broken remains of four oil presses were dumped in the abandoned grain silos (Casas Genover 2010, p. 76). A possible olive oil press excavated at Cerro Naranja dates to the second half of the fourth century or beginning of the third century BCE and consists of the base of a possible press and two basins for the storage of liquid (González-Rodríguez 1987, pp. 92–93). At the end of the third century BCE, a fragment of an olive press was reused at Mas Castellar de Pontós (Pons i Brun et al. 2002, pp. 395–396).

Excavations of the walled settlement of Estinclells (Verdú, Urgell) uncovered an oil press (House 15) dating to the end of the third century BCE (Asensio i Vilaró et al. 2010, pp. 60–61). A mill for crushing the olives was found in the adjoining house (16) (Asensio i Vilaró et al. 2010, pp. 65–66). Analysis of residue from the channels of the press and the basin of house 15 revealed the presence of triglyceride esters and fatty acids typical of olive oil.[3] Small olive stones were recovered from the channel of the olive press (Asensio i Vilaró et al. 2010, pp. 69–70).

3 Although there were lower percentages of oleic acid than is normal (50% compared to a norm of between 60 and 80%; Asensio i Vilaró et al. 2010, pp. 69–70).

The first half of the first century CE saw a dramatic increase in the production of olive oil in the Guadalquivir valley. According to Strabo (3.2.6), the region of Turdetania produced not only large quantities of cereal and wine, but also olive oil in large quantities and of the highest quality. Nearly one hundred kilns producing Dr 20 amphorae used for carrying olive oil have been discovered along the banks of the Guadalquivir and Genil. Several of the workshops were of considerable size: three kilns were excavated at El Castillejo (Remesal Rodríguez et al. 1997, p. 168), five kilns have been discovered at El Tejarillo (Ponsich 1974, p. 145; Chic García et al. 2004, pp. 284–285), and the workshop at La Catria extended over 20 ha (Chic García et al. 2004, p. 299). The impetus for this development was the need to supply the city of Rome, with the earliest amphorae reaching Monte Testaccio during the reign of Augustus (Remesal Rodríguez 1998, pp. 193–197).

Although amphora production was concentrated in the vicinities of Sevilla, Córdoba, and Écija, evidence of olive oil production is much more extensive. In the valley of the Guadalquivir, olive oil presses have been discovered at 432 sites (Ponsich 1991, pp. 262–263).[4] In contrast to the evidence for viticulture, few of these sites have been systematically excavated. Several are known from the area of Antequera, the most important being at El Gallumbar, where excavations have uncovered an oilery dating from the second quarter of the first century. To the west of the site lies a *cella olearia* – a layer of olive lees has been identified on the floor of the room from the olives that were stored here prior to pressing. A milling room with the base of a possible *trapetum* and quantities of olive lees and a pressing room have been identified together with basins and dolia for the settling of the olives (Romero Pérez 1990, pp. 500–504; 1997–1998, pp. 118–128; 2013, p. 384). The settings for six presses are visible at Cerro Lucerico (Fuente Tójar) together with a pavement of *opus spicatum* similar to that found at El Gallumbar (Carrillo Díaz-Pinés 1995, pp. 70–74; 1996, pp. 623–624; 2013, pp. 351–355).

Excavations conducted by the German Institute at Munigua (Villanueva del Río y Minas) revealed two oileries: a pavement of *opus spicatum* and the *labrum* of a press in House 1 dating from the end of the first century/second century CE, and an oilery in House 2 dating to the second and third centuries CE (Hanel 1989, pp. 207–221; Teichner 2000, pp. 1344–1346). Excavations in the Algarve have uncovered a large villa at Milreu (Estói) occupied throughout the Imperial period. The villa was engaged in the processing of both grapes and olives, with the construction in the second half of the first century of both a winery containing two or three presses and an oilery containing a further five presses (Teichner 2013, pp. 476–482).

Conclusions

The variety of species suggests that mixed cultivation was the norm through the Iron Age – the presence of both cereals and vegetables may indicate that crop rotation was practiced or that the produce of different fields was stored together. At some sites, the predominance of a single crop may indicate something approaching monoculture, for example, at Molí d'Espigol, where 98.42% of the archaeobotanical remains are *Hordeum vulgare* (Cubero Corpas 1998, p. 39). The suitability of ovicaprids for the Mediterranean environment means that they are most frequently exploited throughout the Peninsula from the Early Neolithic onward. The difficulties in distinguishing between the bones of sheep and goat means that it

4 Although this figure is perhaps an overestimation (Carrillo Díaz-Pinés 1995, p. 82; 2013, p. 372).

is impossible to determine the relative importance of either species; however, in general terms, it appears that sheep predominated in both Iron Age and Iberian sites providing not only meat, but also secondary products such as milk and wool. The arrival of Greek and Phoenician colonists stimulated significant developments in agriculture and animal husbandry: intensive cereal cultivation in the hinterland of Cerro del Villar was accompanied by the raising of cattle for traction. While pigs – as well as sheep and goats – complement cereal cultivation, both the raising of cattle and cereals compete for access to land, requiring a delicate balance to be maintained. The growing importance of pigs as a source of sustenance at the expense of cattle may reflect the increasing pressures applied to land use and food supply. Colonial markets also stimulated the cultivation of grapes and olives: it is only during the seventh century BCE that there is evidence of grape processing at Alt de Benimaquía although the production of Vuillemont R1 amphorae may suggest that processing began earlier. Although cereals offer a widespread and cheap source of calories, they are a relatively inefficient use of land compared to other crops such as wine and olive oil that can be produced in larger quantities from a smaller area as well as providing an important source of calories (Jongman 2007, p. 604): the caloric yield per hectare for wine and olive oil is about five times higher than that of cereals. Viticulture provided a mechanism by which the nascent Iberian elite were able to reinforce their status and control the development of urbanism. Lack of evidence for olive processing makes it impossible to determine the impact upon oleiculture.

The paucity of archaeobotanical samples of sufficient size continues to hamper analysis, in particular, the lack of evidence from elsewhere in the Peninsula to determine whether the East Coast and the hinterland of Cádiz are truly exceptional or if parallel developments were taking place elsewhere. The production of Tiñosa and Carmona amphorae around the Bay of Cádiz indicates that wine and oil continued to be produced for export through the fifth century BCE. Colonial markets stimulated other areas also with the development of cereal cultivation in the Baix Empordà to meet the market offered by the colony at Empúries.

By the end of the first century BCE, Spain was an important source of wine, olive oil, and cereals; however, the relative roles of immigrants and indigenes in this process remains unclear. The arrival of Rome prompted a transformation of the rural landscape that may be associated with the introduction of Italianate villas first in Cataluña and spreading elsewhere during the first century AD. The demands of the annona led to the development of large-scale oleiculture along the valleys of the Guadalquivir and Genil that in turn fueled other areas of the economy, for example, cereal cultivation and fish sauce production.

From the end of the first century CE, the economy of the Peninsula underwent a recession the reasons for which are still not understood. While a significant number of wineries ceased operation at this time, others were expanded such as Tolegassos and Can Sentromà, where a new wine cellar was constructed in the middle of the second century CE containing 24 dolia (Prevosti i Monclús 1981, p. 193; Guitart Durán 1970, p. 116) – perhaps the more diverse economies of villas enabled them to better adapt to changing circumstances (Peña-Cervantes 2010, p. 167).

The abandonment of Monte Testaccio and the cessation of production of Dr 20 amphorae in the third century AD reflects a profound reorganization of the production of olive oil in Baetica: a significant number of oileries ceased operating, and the subsequent production of Dr 23 oil amphorae was smaller in scale, capacity, and distribution. Lack of excavations means that our knowledge of olive oil production during the Late Empire remains unclear. Although large-scale industrial oileries are no longer attested, it remains an important component of the economies of Late Imperial villas. The best excavated is that of El Ruedo (Almedinilla) where the final phase of occupation in the second half of the fifth century CE was remodeled to accommodate the construction of an oilery (Muñíz Jaén et al. 2000, pp. 255–261). While olive oil production continued into the Late Empire and the distribution of Dr 23 – however limited – shows its continued export, the reduced number of installations and their association with villas point to a reorganization of land ownership and agricultural production.

This synthesis – as with much that has gone before – is hampered by the scarcity and geographical bias of archaeobotanical data from the Peninsula. Much earlier work has focused upon statistical analyses in order to quantify the relative frequencies of different taxa and changes in species over time. Closer engagement with other disciplines will help in answering these questions, for example, genetic analysis to distinguish between wild and cultivated olives; analysis of the amino acid content of bone collagen in order to distinguish between the bones of sheep and goats; DNA analysis to determine changes in animal haplogroups in order to understand developments in breeding practices. While the need for larger assemblages of archaeobotanical data from a broader spectrum of sites across the Peninsula is slowly being rectified, the adoption of a holistic approach to the analysis of ancient remains will allow the development of a more nuanced assessment of the importance of agriculture and animal husbandry in the diet and lifestyle of our Iberian forebears and the environment within which they lived.

FURTHER READING

Recent years have seen significant advances in the study of Iberian agriculture; however, much of this material remains accessible only to specialists. Several scholars have published in English, particularly the work of Ferran Antolín and his colleagues on the Neolithic sites in Cataluña. The work of Ramon Buxó Capdevila is recommended, especially his articles Buxó Capdevila 1997 and Buxó Capdevila 2008. On the development of Neolithic agriculture, see Stika 2005.

On animal husbandry, the following are recommended: on the domestication of animals in the Neolithic, see Saña 2013. Lídia Colominas 2009, 2014, 2017 has explored the impact of Rome upon animal husbandry.

For wine production among the Iberian communities of the East Coast, see Pérez et al. 2013a. The study of oleiculture has been the focus on the work of José Remesal Rodríguez and the Centro para el Estudio de la Interdependencia Provincial en la Antigüedad Clásica at the Universitat de Barcelona. The following articles are recommended: Remesal Rodríguez 1998 and Blázquez Martínez 1992.

On the role of agriculture in the growth of Iberian city-states, see Grau Mira 2011, 2014, 2003 and Santos Velasco 1989.

Syntheses are available in Lowe 2009 and Haley 2003, both of which provide extensive bibliographies.

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CHAPTER TWENTY-FOUR

Agriculture in Roman North Africa

Dennis Kehoe

Roman Africa, encompassing Libya, Tunisia, Algeria, and Morocco (the Maghreb), offers an important case study for the complex changes that Roman rule brought to the agricultural economy of the empire's provinces. Roman rule in Africa saw the transformation of the countryside, with the development of a rural economy that supported a burgeoning urban culture. With perhaps more than one million people living in cities of 5000 or more, Africa ranked among regions of the empire behind only Italy and Egypt in its urban population (Wilson 2011, pp. 183–184; Bowman 2011). The largest city, Carthage, had a population on the order of 300 000. Lepcis Magna in Tripolitania perhaps had 90 000 people, while there were numerous much smaller cities. Africa's urban culture produced many members of the empire's elite classes, including equestrians and senators, and eventually the emperor Septimius Severus, originally from Lepcis Magna, who became emperor in 193 and established a dynasty that endured until 235. The elites who emerged in Africa derived their wealth from often vast estates, producing olive oil and grain for urban markets and for export. Africa experienced perhaps its greatest prosperity in late antiquity, when its role as an exporter of olive oil increased. To judge by the striking presence of consumer goods on rural sites in this period, the vast class of small landowners and tenants enjoyed considerable purchasing power, (Dossey 2010, pp. 31–97). Moreover, the Roman government depended on Africa for supplies of wheat and olive oil to support its food distribution program at Rome, the *annona*, under the Principate and in late antiquity.

Africa offers a great deal of evidence for investigating its rural economy, both in terms of agricultural techniques and of the relationships among the most important groups in Africa's agricultural economy, including elite landowners, peasant cultivators, and the Roman state. This evidence includes archaeological remains of villas and farms as well as olive pressing installations, inscriptions recording land tenure arrangements, and even mosaics depicting rural life (see Figure 24.1). These different types of evidence figure in most issues connected with agriculture in Roman Africa, as indicated in the discussion that follows. In addition, rural surveys (Ørsted et al 2000; Stone et al. 2011; de Vos 2013, all cited below) make it possible to trace in some detail the settlement history of a region over a long period of years and to understand better how the agrarian economy was organized and changed over time.

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

Figure 24.1 Mosaic depicting a Roman estate, from Carthage, late fourth to early fifth century CE, Bardo National Museum, Tunis, Tunisia. Source: © Gilles Mermet / Art Resource, NY.

Geographical Considerations

The core region of Roman Africa, including Africa Proconsularis (most of modern-day Tunisia), as well as parts of eastern Algeria and western Libya (Tripolitania), includes a variety of geographical regimes. The region is divided by the Aurès mountains, stretching to the southwest from NE Tunisia (see Figure 24.2). To the north is the Tunisian Tell, a hilly region crossed by the only river in the region that flows throughout the year, the Medjerda (ancient Bagradas), and to the north of the Tell are coastal plains. This area is subject to a Mediterranean climate, receiving an average of at least 400 mm rainfall annually, sufficient to support the cultivation of wheat and other grains without irrigation; some regions, particularly those close to the Mediterranean coast and flanked by mountains, received much more rainfall, as much as 1000 mm per year. To the east of the Tell and the Aurès to the south are arid high steppes that give way to the Sahel, dry plains along the eastern coast of Tunisia; these regions receive somewhat less rainfall, generally in the 200–400 mm annual range, as does Tripolitania, which features narrow coastal plains backed by mountains (Hobson 2015, pp. 29–33; Shaw 1984, pp. 135–142). The arid pre-desert region along the southern frontier receives 100–200 mm in annual rainfall, while areas with less than this are considered desert.

Mediterranean Agriculture

In regions with at least 400 mm of rain, farmers often practiced Mediterranean dry farming, a system of agriculture that was common throughout the Mediterranean world. In a Mediterranean climate, most rain falls in the autumn and winter, while the summer months are very dry. Consequently, farmers plant their fields with grain in the fall and harvest them in the late spring (Sallares 2007, pp. 27–34). In the common two-field system, a field would remain fallow for a year after being harvested. Dry farming involves repeated plowing of the field with a light plow, or ard (Latin *aratrum*), to create a thin layer of soil to capture the moisture from morning dews while also inhibiting evaporation. In this type of agriculture, the labor requirements were seasonal, especially intense during the plowing and at the harvest. It seems generally agreed that the Mediterranean dry farming produced modest yields, on the order of 500 kg of wheat per hectare, which corresponds to the 4:1 yield that the Roman agronomist Columella suggests was common in Italy (*de Re Rust.* 3.3.8). This estimate may be on the low side of typical yields; Paul Erdkamp (2005, pp. 34–54) views ancient yields as considerably higher, up to about the order of 8:1 to 10:1. Since droughts were frequent, there must have been wide variations in yields from one year to the next, and the risk of poor crops resulting from drought was ever present (Horden and Purcell 2000, pp. 175–230; Stone et al. 2011, p. 219).

Polyculture provided an important strategy to make more intensive use of the land and to reduce risk. Polyculture involved cultivating wheat or other grain crops such as barley between tree crops, especially olive trees and other fruit trees, or vines. Another advantage of this strategy was that it allowed the farmer to distribute labor throughout the year, since the harvest for cereal crops came in the late spring, and the olive harvest and vintage in the fall. The dry farming of cereals is more difficult in semi-arid regions (less than 400 mm annual rainfall), and the principal crops of these regions were generally olive trees and other fruit trees, including figs, almonds, and pistachios. But even when arboriculture represented the main form of agriculture, farmers commonly also inter-cultivated wheat or barley, the latter of which is more drought resistant.

Any discussion of agriculture in North Africa must take account of the important role of pastoralism. The raising of livestock, particularly sheep, provided a way to exploit lands that otherwise could not be used for agriculture, such as highland steppes that did not receive enough rainfall to support cereal culture but could still provide pasture. As in other periods of its history, in Roman Africa semi-nomadic groups moved back and forth between upland winter pastures on the frontiers of the empire and summer pastures further north. Such groups also included sedentarized members who raised cereals and other crops. In antiquity, they were well known for their towers, *turres* or *prygoi*, where they stored grain. Pastoral groups had complex relationships with farming communities. On the one hand, they often had disputes with farming communities over the rights to land and water, while on the other they had close economic relationships with farming communities, for which they might provide seasonal labor (see below). One of the challenges that the Roman military faced along the frontier was to control the movements of pastoral groups to protect agricultural settlements and to collect taxes from them (Whittaker 1978; Raven 1993, pp. 13–14; cf. Cherry 1998, pp. 24–74).

Irrigation

Irrigation was required in semi-arid and arid regions to cultivate many crops, but it was also practiced in areas with more abundant rainfall to increase yields and to bring under cultivation lands that might not be suitable for dry farming. The archaeological evidence for irrigation works from the Roman period indicates the Romans' success in adopting traditional techniques developed before Roman rule (Shaw 1984). The key was to take advantage of local topography to channel the water from occasional rainstorms into cultivated fields, using the many wadis (oueds) in the region, that is, streams that flow when there is rainfall but dry up in the summer. Occasional violent storms create flash floods, sweeping not only water but also silt from higher elevations. Flood-zone agriculture involves channeling these sudden streams into cultivated fields, using a system of barriers and conduits (Shaw 1984, pp. 142–147). The violent flow of the water has a tendency to wash away barriers, so that farmers resort to cheap and replaceable materials, such as earth, local stones, and branches. Flood-zone irrigation makes it possible to cultivate grain in areas with little rainfall. But such methods of capturing water have an inherent inefficiency, so that water from a considerable upland area would be required to irrigate a relatively small proportion of cultivated land. Another form of flood-zone irrigation involved the *qanat* system, which was used in Libya and the Middle East, and in other areas of the ancient world. This involved digging tunnels into hillsides to tap underground reservoirs (Wilson 2008).

Terrace agriculture is similar to flood-zone agriculture, except that the cultivated area is confined to the water channels themselves, the wadis, rather than to plains below the hills (Shaw 1984, pp. 147–151; Mattingly 1988–1989). The principle here is to construct a series of barriers within the wadis that slow the flow of water down the hillside. This achieves two purposes, to hold water in the soil to slow its evaporation, and to capture silt that washes down from higher elevations, thus taking advantage of erosion and not preventing it. The individual terraced plots in the wadi beds would be arranged one underneath the other, with the top of one barrier slightly higher than the bottom of the barrier just above it. The principal crops in such terraces are usually trees with grain cultivated between them. The result is an intensively cultivated plot of land, one that, for wheat at any rate, can achieve spectacularly high yields (on a smaller sowing volume in terms of grain to each unit of land), of 100-fold or even more, and in some circumstances, more than a single crop in a year (Shaw 1984, pp. 160–161). The major constraint to this type of farming is that cultivation would be limited to a relatively small area, leaving most land in a given vicinity with insufficient water. In flood-zone and terrace agriculture, the major points of dispute would center over preventing a downstream neighbor from having access to the water flowing through the channels. This is a common problem in all irrigation systems that rely on shared water courses. The issues that might arise are well illustrated in the *lex rivi Hiberiensis*, an inscription from Spain from the time of Hadrian (117–138) that records the resolution of a dispute between two communities over access to irrigation water from a channel of the Ebro River (Beltrán Lloris 2006; Bannon 2017a, 2017b, p. 83). Such disputes also arose in the Fayyum region in Roman Egypt, when the advancing desert reduced the water available in the irrigation channels that brought water from the Nile (Kehoe 2008). We should expect that local communities in Africa would develop their own methods to resolve inevitable disputes.

In communities in which perpetually flowing springs provided water for irrigation, the major issue would be to develop a system of sharing the water among users in such a way as to protect the interests of the members of the community while at the same time protecting the resource for the long term. Communities that develop such mechanisms to share common-pool resources like water or wood avoid the so-called "tragedy of the commons." This is a race to the bottom in which each user has every incentive to consume as much of the resource as possible without providing any investment for its long-term maintenance, since any restraint or investment for the future will mainly benefit other users (Ostrom 1990). An inscription from the municipality of Lamasba in Numidia preserves the details of a regime to share irrigation water from a spring called the *Aqua Claudiana* (*CIL* VIII 18587 = 4440, *ILS* 5793; 218–222 CE). Lamasba is located in a relatively dry region, about 40 km to the northwest of Lambaesis, the home of the third Augustan legion and the center of a number of veteran settlements, and 100 km to the southwest of Cirta, a major colony. The inscription, studied thoroughly by Brent Shaw (1982), commemorates the resolution of a dispute over water rights within the community. The water was allocated on the basis of time for an otherwise unspecified unit, termed simply K, which must be a proxy for an area of land.

Shaw argues convincingly that the unit in question refers most often to olive trees (which are mentioned specifically in connection with several users) but also the other trees commonly cultivated in North Africa. The trees would be planted at standard intervals, and other crops, especially cereals, would be cultivated among them, as common in other irrigation systems. It is likely that the land irrigated in this way represented only part of what the water users owned, and they would have cultivated additional land with dry-farming techniques or used it as pasture. The method that the community at Lamasba used to share water, based on time in proportion to the amount of land that each user owned, was one recognized in Roman law (e.g. Papir. *D.* 8.3.17; Shaw 1984, pp. 167–168; Bannon 2017b).

In the Lamasba regime, as Shaw discusses, it is striking that there is considerable range in the sizes of the holdings that the individual users irrigated, with a relatively small group of larger landowners, some of whom had multiple plots of land. The plot sizes range from about 150 to 4000 K. Based on the assumption that trees were planted 5–6 m apart, these plots would range from about 0.4–0.5 ha to 10–14 ha. Of the 85 property owners recorded in the surviving parts of the inscription (representing about 40% of the total subscribers), 13 had parcels of 1000 K or larger, accounting for 21 090 K, while the top 20 landowners accounted for more than 27 000 K, more than half of the total of 53 000 K recorded in the surviving part of the inscription. There were some 17 landowners with 200 K or fewer. Most people occupied small plots of land that they could work with their own family's labor, while the wealthier people, who included veterans from the military camps in the region of members of their families, had much larger parcels. One cannot assume, however, that the distribution of land in the water-sharing regime represents the overall distribution of land in the community, since the majority of land was not irrigated, and some of the owners of small plots of irrigated land may have had much larger holdings of non-irrigated land.

Investment in Agriculture

Olive oil was one of the principal exports of North Africa from the early imperial through the Byzantine periods, and olive culture has rightly been seen as a major source of wealth for the provincial elite in Roman Africa, as well as for many people outside of the elite (Hitchner 2002). Perhaps the most spectacular example of agricultural wealth generated in arid conditions is the city of Lepcis Magna in Tripolitania. Its territory was on the order of 3000 km^2, one of the largest of any city in the Roman world. At the beginning of the Roman period, it had considerable resources, since Caesar at the end of his campaign in Africa in 46 BCE imposed a yearly fine of three million pounds of olive oil, the annual consumption of perhaps 50 000 people (*B.Afr.* 97.3). Lepcis Magna was also the home to a wealthy elite in the second and third centuries CE, who derived a great deal of their income from the export of olive oil (Mattingly 1988, 1994, pp. 138–159). This elite included the family of the emperor Septimius Severus, as well as the third-century equestrian C. Fulvius Plautianus, who became praetorian prefect as well as the father-in-law of the future emperor Caracalla; Plautianus' interests in olive culture are known primarily from stamps on amphoras, the vessels in which olive oil was transported. The type of estate that a wealthy landowner like Plautianus owned in this region is suggested by an inscription from the Libyan *Limes Tripolitanus* (*CIL* VIII 22774). The inscription celebrates the construction of a new tower or *turris* on a fortified estate. To create such an estate in a seemingly forbidding area, the owners would have to have exercised control over water resources and labor (Shaw 1984, pp. 170–171).

Roman interest in the agricultural potential of North Africa began with the initial conquest of the province in 146 BCE following the third Punic War. Before the war, Rome had occasionally imported substantial amounts of wheat from Carthage. After the third Punic War, the

Roman senate arranged for the translation of the work of the Carthaginian agricultural writer Mago (Pliny, *HN* 18.22); to judge by later references to his work, Mago was concerned with the management of estates belonging to absentee landowners, and his knowledge on this subject was likely of great interest to potential Roman investors in North Africa (Greene and Kehoe 1995). But the real effort to take advantage of North Africa's agricultural potential began with Gaius Gracchus' law, the *lex Rubria* of 123–122 BCE, to found a colony at Carthage. It is likely that the initial centuriation of the northern part of the province, involving the measuring out and mapping of land to allot to colonists, was connected with the creation of the colony. The *lex Rubria* was repealed after the downfall of Gaius Gracchus in 121 CE, but the *lex agraria* of 111 BCE in part was designed to create order out of chaos by regularizing the status of land that had been distributed to colonists, in all likelihood recognizing the validity of sales of land by these colonists to larger landowners. In addition, the law recognized the rights of Punic communities that had kept their own land in return for supporting Rome (Hobson 2015, pp. 39–42). In any case, North Africa remained a focus of Roman interest. The establishment of a colony at Carthage under Caesar and Augustus was certainly a crucial development, but at the same time individual wealthy Romans took advantage of their positions of power by acquiring substantial holdings in Africa, often as gifts of the Roman emperor.

Perhaps the best evidence for the development of estates in Roman North Africa comes from the Bagradas (Medjerda) valley in the Tunisian Tell, where a series of inscriptions from the second century CE document land tenure on estates that had passed from private into imperial ownership. The inscriptions mention a number of formerly private estates that took their names from owners who had been governors of Africa in the Julio-Claudian or Flavian periods, including L. Aelius Lamia, consul in 3 CE and proconsul of Africa in 15–17, P. Quntilius Varus, consul in 13 BCE and proconsul around 7–4 BCE, C. Rubellius Blandus, suffect consul in 18 CE and proconsul in 35–36, and the brothers Cn. Domitius Lucanus and Tullus, who both served as governors of Africa under Vespasian (69–79) and ranked among the wealthiest senators of the Flavian period (Kehoe 2012). In addition, the basic regulation establishing land tenure on imperial estates, the *lex Manciana* (to be discussed below), in all likelihood took its name from T. Curtilius Mancia, suffect consul in 55 CE and legate of upper Germany in 56–58. It is commonly assumed that he served as proconsul of Africa under Nero; his daughter married Cn. Domitius Lucanus, who along with his brother acquired Mancia's property through some skullduggery (Pliny, *Ep.* 8.18).

The evidence for the development of estates provided by these inscriptions has been greatly enhanced by the rural survey in this region carried out by Mariette de Vos and her colleagues (de Vos 2013). The Thugga (modern Dougga) survey has revealed evidence for the dimensions of a number of the private estates. The most important of these is the estate of T. Statilius Taurus, who was one of the emperor Augustus' most important military commanders early in his reign, and proconsul of Africa in 36–34 BCE. A series of boundary stones indicate that he gained ownership of a huge estate, comprising perhaps 3636 ha, in the heart of this region (de Vos 2013, p. 193). This estate in all likelihood passed through the Statilii family to become property of the emperor Nero (his third wife was Statilia Messalina), and so became the *saltus Neronianus* of the Bagradas valley inscriptions. Boundary stones also indicate that another senatorial family, the Passienii, had an estate of about 1000 ha, while a property of c. 250 ha belonged to a M. Licinius Rufus. These estates were created in a region that also included many towns, often with very small territories. In addition to the spectacularly wealthy landowners like Statilius Taurus, there was also a class of landowners wealthy enough to fund substantial civic benefactions in local towns. The best example of this is Thugga, a town with perhaps 5000 residents and a modest territory as characteristic of the region, but one that boasts spectacular archaeological remains today.

As prosperous as the Bagradas valley seems to have been, it was one of many locations in which wealthy landowners were able to acquire substantial estates. In fact, North Africa was notorious for large estates. Although this is an obvious exaggeration, Pliny the Elder reports that six landowners owned half of Africa before the emperor Nero had them executed and took over their land (*HN* 18.35). Much later, Agennius Urbicus, one of the writers whose work is included among the writings of the Roman land surveyors, offers a famous description of gigantic estates in Africa that competed with towns for their workforces (this work is thought to derive from the early second-century writer Frontinus, p. 53 Lachmann, Campbell 2000, p. 42, pp. 35–51):

> Between towns (*res publicae*) and private individuals in Italy such controversies are not easily raised, but they are frequently in the provinces, particularly in Africa, where private owners have estates (*saltus*) no smaller than the territories that towns have; indeed some estates are much larger than the territories of towns. But private owners have on their estates a considerable plebeian population (*non exiguum populum plebeium*) and villages surrounding them like fortifications. In this circumstance, towns customarily raise disputes about the right of their territory, that they be allowed to impose public services (*munera*) in that part of the soil, or draft recruits from a village.

The Danish archaeological survey in the Segermes Valley provides an additional valuable perspective on the process that led to the formation of large estates (Ørsted et al. 2000). The Segermes Valley is situated on the eastern coast of Tunisia, about 80 km from Carthage, and just northeast of Zaghouan, where the source of the monumental aqueduct that brought water into Carthage was located. This region certainly had settlements in the Punic period, and it seems to have been exempted from the initial centuriation of Africa carried out under the Republic, the one probably connected with the infelicitous Gracchan colony at Carthage. The region is also close to Hadrumetum (modern Sousse), originally a Punic city, but under the Principate an administrative center for imperial properties. The principal site in the valley is Segermes, which achieved the status of a *municipium* in the early third century. Outside of this town, the Danish team recorded some 96 habitations of varying kinds (Carlsen 2000). There were a few substantial rural villas, with one in particular, at a site called Ksar Soudane, that had monumental mausoleums, the presence of which is considered the surest sign of an estate at which the owner resided permanently. Some of the other habitations are termed villas, generally meaning a farmhouse with an accompanying farm, and a few, especially from the fourth century, when the fortunes of the area seem to have increased, have amenities like mosaics. There were also some sites termed "agglomerations rurales," which in all likelihood represented the remains of villages. The landowning elite in this region, aside from the owner of the estate at Ksar Soudane, were probably modest in numbers and in their overall resources. We might compare the estate at Ksar Soudane with the third-century *fundus Aufidianus*, an estate just north of the region of the Bagradas valley inscriptions, located near the town of Mateur in northern Tunisia (Peyras 1975, 1983; Carlsen 2000, p. 112). Although any effort to delineate the boundaries of an estate like this is conjectural, the excavator of the *fundus Aufidianus*, J. Peyras, estimates its size as on the order of 1600 ha. Be that as it may, within this area, there is archaeological evidence for at least 15 habitations, of which 12 seem to be Roman farms. Presumably there were additional ones that have not been discovered. Olive presses have been discovered at three of these sites, as well as at the estate's putative central farm, where an inscription commemorating its owner or possessor was discovered (*AE* 1975.883). In this inscription, a wife commemorates her late husband for restoring the estate, in particular, by restoring and enhancing olive orchards and vineyards.

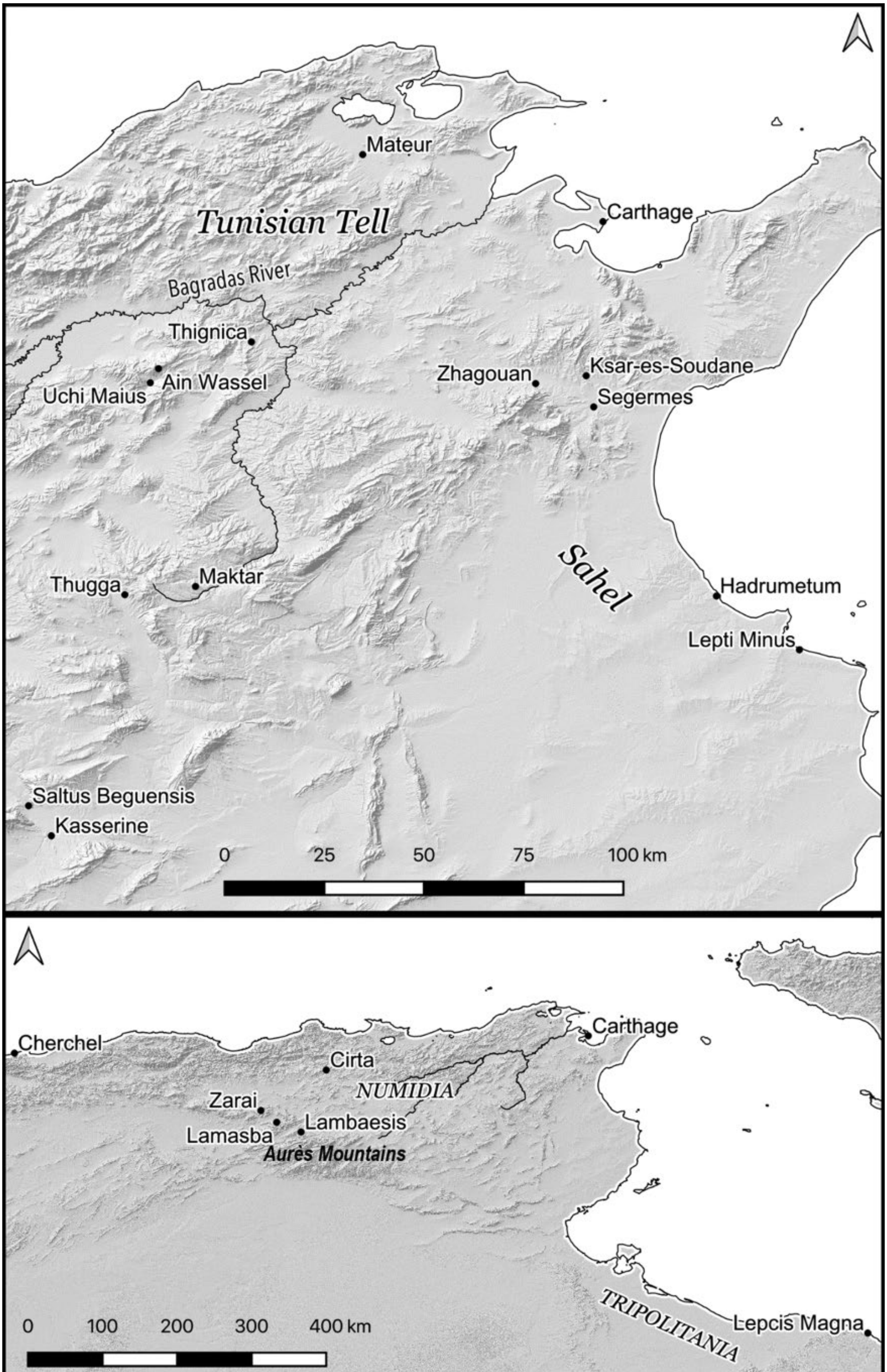

Figure 24.2 Map of Roman North Africa (below) and northern Tunisia (above). Source: Map by David Hollander using QGIS, and map files from the Ancient World Mapping Center. "openwater.shp," "inlandwater.shx," "carte_hillshade.tif", and "awmc_rivers.shp". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm].

This discussion of investment in agriculture by large-scale landowners raises a number of questions, specifically how they profited from their holdings, and how they organized labor on their estates. To address the first issue, olive culture was certainly an important source of wealth in Roman North Africa. Olive culture is more easily traced in the archaeological record because of the surviving evidence for stone olive presses, particularly orthostats and counterweights. The process of olive oil production is well known (Hobson 2015, pp. 64–68; Decker 2010, pp. 121–148). First, the olives would be crushed by a wheel-shaped millstone. The pulp resulting from this process would be placed in sacks or baskets and then stacked and crushed on a press bed. The pressure would come from a wooden cross beam, set in orthostats anchored into a fixed structure such as a wall, and pressure would be increased by raising the beam by means of a windlass anchored with a stone counterweight so as to compress the pulp. The resulting oil would drain into a press bed and then be channeled into some kind of storage container. The pressing operation could be completed several times for the same batch of olives, and the yield of oil is commonly considered to have been about one-fourth or one-fifth of the weight of the olives. The lever press described here was the most common type in North Africa, although there were also screw presses, which used a screw rather than a windlass to increase pressure. The archaeological remains of presses has to be treated with some caution, however, in assessing the agricultural economy of North Africa or of any other region in the Roman Empire. For one, it can be difficult to distinguish between olive presses and wine presses, since both used more or less the same components; the presence of *dolia*, ceramic storage vats dug into the ground, would be strong evidence for wine pressing, but wine could be produced without storing it in such vats. More significantly, the survival of archaeological evidence of presses or pressing installations may lead us to overestimate the role of olive production over other types of crops, especially cereals, which produce little archaeological evidence, mainly milling equipment (Hobson 2015, pp. 68–70), and on occasion storage barns, or *horrea*.

These caveats notwithstanding, it is clear that wealthy landowners, not to mention more modest landowners and even tenants, did invest considerable resources in olive culture. There is a great variety in the ways in which pressing installations were organized. To be sure, the very existence of a press represents a considerable investment, presumably to produce oil for the market, since olive oil can be produced on a small scale without a press (Mattingly 1993, p. 485). The largest presses have been discovered in Tripolitania and in the area around Kasserine, in the High Steppe in central Tunisia (Hobson 2015, pp. 85–91, 95–99). In Tripolitania, Mattingly (1993, p. 490) estimates that the largest presses had a load capacity of 1000 kg of pulped olives per day, much more than the smaller presses from the same areas, which had about one-fourth to one-third of this capacity. In Kasserine, the largest presses had a somewhat smaller capacity than the largest ones in Tripolitania. In Tripolitania, assuming that production extended over several months, the largest presses could have produced about 9000–10 000 kg of oil (the latter figure representing the annual consumption of about 500 people, at 20 liters per person), whereas in Kasserine, the largest presses could produce between 5000 and 10 000 kg of oil over a season. If a harvester could pick 150 kg of olives each day, then six or seven harvesters would be needed to keep a large press working over a protracted pressing season of several months. One point to emphasize is that olive trees produce fruit generally every other year, and although olive trees can continue to produce fruit over decades, their yield was likely to be quite irregular. Thus, the largest pressing installations were intended to handle occasional bumper crops, rather than an average one (Mattingly 1993, pp. 491–493).

Pressing installations near Kasserine indicate an investment in olive production on a considerable scale. In this region, large installations consisted of unadorned buildings housing multiple presses, often about 6 but as many as 12 (Hobson 2015, pp. 89–91). These installations apparently served huge estates, but no central residences have been discovered, and the way in which they were organized remains uncertain. We know of one senatorial estate in this region, the *saltus Beguensis*, which was established in the territory of the Musulamii, a tribal group. The evidence for this estate comes from an inscription recording a senatorial decree from the year 138 CE allowing the owner of the estate, a senator named Lucilius Africanus, to hold a periodic market, or *nundinae*, within his estate. This estate included quite substantial oil installations, one of which measured 31 × 17.5 m and held at least 12 presses, while a second had 8 presses (*CIL* VIII 270, 11451, 23246; Hobson 2015, pp. 87–88). One possibility, to be explored further in the section on agricultural labor, is that the large pressing installations at Kasserine processed the olive harvests of numerous tenants and possibly also small owner-cultivators. It should be noted that other regions, where similar pressing installations have not been discovered, also produced olive oil for export. This seems to be the case for the Sahel region, on the east coast of Tunisia. This region exported olive oil along with fish sauce, or *garum,* and wine through the port at Lepti Minus, among other ports on the east coast of Tunisia. The principal evidence for such exports comes from kiln sites indicating the massive production of Africana I amphoras, in which olive oil was shipped. The rural hinterland of Lepti Minus is not likely to reveal evidence for olive presses, since the kind of stone used to make orthostats in the High Steppe region was not available here; orthostats were probably constructed of wood, a perishable material (Stone et al. 2011, pp. 214–217, 223–250).

From another perspective, the importance of olive oil production to the economy of North Africa is suggested by the effort of the imperial government to capture revenues of oil in kind, presumably to support the distributions of oil in Rome that were instituted by the emperor Septimius Severus in the early third century CE. A group of 32 ostraca from the fourth century that were discovered in Carthage provide valuable information for this effort (Peña 1998). The ostraca in question document aspects of the weighting and storing of oil collected as tax in Africa in the year 373. Although some of this oil was used to meet the expenses of the provincial administration in Carthage, the bulk of it was in all likelihood shipped to Rome to support the state-sponsored distribution of oil in the capital. Much of this oil was carried overland to Carthage from inland locations, some in oilskins made out of leather, and a portion in amphoras. Peña (1998, p. 211) estimates that the total amount of oil processed at the facilities documented in the ostraca at more than 2.5 million pounds (c. 824 000 kg, or 907 000 l), the annual consumption of some 45 000 people. The oil collected in this case was distinct from the supply collected from imperial estates, although both sources served Rome.

Agricultural Labor

If archaeology provides important evidence for the link between investment and olive culture and the emergence of a class of wealthy landowners in Roman Africa, it can offer us only hints about the organization of labor. One of the major issues connected with this concerns whether slave labor was commonly used on large estates in North Africa. One reason for suspecting a significant role of slavery in North Africa's estate economy is a parallel with the expansion of commercial agriculture in Italy in the Late Republic, when wealthy Romans invested in slave-staffed estates to meet the growing demand for wine and other commodities in Rome and in other cities in Italy. The alternative is that estate owners in Africa relied on free labor, including tenants, and even wage labor. Certainly, tenancy was a widespread institution in Africa and elsewhere in the empire, and in the view of many scholars, the most important means of organizng labor on estates (see Lenski 2017; cf. Tedesco 2018). Recently, however, Kyle Harper (2011) has made a strong case for the widespread use of slave labor in agriculture throughout the empire, continuing into late antiquity. The major evidence for the use of slave labor on a large scale in agriculture (as opposed to the use of slaves in domestic and managerial positions) comes from Apuleius' *Apology*, in which the sophist, in making an elaborate defense of his life before the governor of Africa, describes his wife Pudentilla as having more than 400 slaves on her Tripolitanian estates (*Apol.* 93.4–93.5). Earlier in the same speech, Apuleius posits that the two alternatives for exploiting lands were using slaves or exchanging labor with one's neighbors (*Apol.* 17; Lenski 2017). The evidence from Apuleius would seem to suggest that the use of slaves as agricultural laborers was known in at least some parts of Africa, and it seems likely that slaves were used as shepherds. Moreover, the Zarai tariff, a customs regulation from southern Numidia, lists slaves among the various types of property subject to taxation (*CIL* VIII 4508, 18643, 202 CE). Certainly the slaves imported into Africa through this portal could have been destined for domestic purposes, or for sale outside of Africa (Kehoe 1988, pp. 24–27).

To return to tenancy, the apparent decentralized organization of estates discovered as a result of rural surveys point toward its widespread use as a means of exploiting land. In this scenario, tenants would have occupied the individual farms comprising a larger estate, cultivating a variety of crops, including olive trees and cereals; the landowner's profit would involve exacting some portion of the surplus provided by the tenant. In contrast to other provinces in the Roman Empire (other than Egypt), we do have some specific evidence for the conditions under which one group of tenants, those of imperial estates in the Bagradas valley, occupied their land, as a result of the great inscriptions mentioned earlier (Kehoe 1988, 2007, chapter 2; Flach 1978; Kolendo 1991). These inscriptions include responses from imperial procurators to petitions from farmers seeking the right to cultivate uncultivated lands, as well as responses from the emperor Commodus (180–192) to petitions from tenants complaining about abuses that they were suffering. These inscriptions reveal a system of estates belonging to the emperor and administered by the imperial treasury, or Fiscus, and they formed part of a wider network of imperial properties throughout the empire. The system of estates in Africa was large enough to be divided into administrative divisions, including one centered at Carthage, the *tractus Karthaginiensis*, under which the Bagradas valley estates fell, and subdivisions called *regiones*. These divisions were supervised by imperial officials, procurators of equestrian rank, who were assisted by freedman procurators.

The Bagradas valley inscriptions reveal that the imperial administration relied on small-scale farmers, termed *coloni*, to cultivate the bulk of the lands within the estates. The *coloni* were sharecroppers, generally paying one-third of their crops as rent, and in exchange for their rent they had perpetual leaseholds over their land, as long as they continued to cultivate it, and they could use their rights to the land as security in loans and bequeath them to their heirs. The leases of the *coloni* were based on a regulation called the *lex Manciana*, which in all likelihood began as a private lease arrangement, perhaps codifying traditional tenure arrangements that existed when the wealthy Roman landowners formed their estates (de Ligt 1998–1999). As mentioned earlier, there is good reason to link this law with the Mancia who was a senator under Nero. As the private estates on which the *lex Manciana* defined land tenure passed into imperial ownership in the latter part of the first century, this originally private arrangement became a widespread arrangement on imperial estates. The earliest of the Bagradas valley inscriptions (from a site called Henchir Mettich), from the reign of Trajan, established the conditions under which tenants could occupy unused lands, or *subseciva*, associated with the estate on which they had farmsteads. This inscription, apparently an ad hoc response to what must have been one of many such petitions, allowed the *coloni* to occupy unused lands under the terms of the *lex Manciana,* which already defined land tenure within the estate, and also offered special incentives, including a long grace period in which they would not have to pay rent if they planted olive trees and fig trees, and, under some circumstances, vines. The ad hoc program presented in the HM inscription was soon replaced with a more general regulation, the *lex Hadriana de rudibus agris*, "the Hadrianic law concerning unused lands," which codified the incentives of perpetual leaseholds and rent-free seasons for *coloni* who brought unused lands on imperial estates under cultivation.

The Fiscus continued to have an interest in offering these incentives, since one of the inscriptions including the *sermo procuratorum*, the communication from the imperial procurators responsible for implementing the Hadrianic law, comes from the reign of Septimius Severus. Clearly the imperial administration viewed establishing *coloni* as perpetual leaseholders on their lands to be essential in order to obtain revenues from the imperial estates. Set above the *coloni* were short-term lessees, *conductores*, who leased from the Fiscus the right to collect the share rents from the *coloni* and to cultivate certain lands not occupied by this group. The *coloni* were required to assist the *conductores* in this effort by providing a certain number of days of labor each year, generally six, for plowing, weeding, and harvesting, as well as the use of their draft animals.

The Fiscus thus exploited its estates by creating two groups of people with an interest in them. The *coloni* did the bulk of the cultivation, and the Fiscus offered them incentives to invest in the land for the long term. *Coloni* who planted olive trees or vines would also cultivate a variety of other crops, especially wheat and barley, for their subsistence, and the Fiscus would profit by exacting a portion of the crops that they produced. Moreover, establishing the rent of the *coloni* as shares of what they produced afforded the Fiscus some flexibility and the *coloni* additional security, since the rent would be reduced in times of poor harvests without requiring any intervention on the part of imperial procurators. The *conductores* had a somewhat different function, in that their main purpose was to enforce the share contracts of the *coloni* (who would obviously have an incentive to hide their crops or underreport their harvest), and so they relieved the Fiscus of much of the burden of managing the individual estates. The chief function of the imperial procurators was to oversee the contracts of the *conductores*. The *conductores* did not sublease to the *coloni*, but instead filled a role more like tax collectors. This system of exploiting estates created a certain degree of tension between the *coloni* and the *conductores*. The Fiscus relied on these two groups for two different purposes, the *coloni* to invest in the long-term productivity of the land and to produce the crops on which the Fiscus depended for its revenues, and the *conductores* to enforce the contractual obligations of the *coloni*. When conflicts inevitably arose, as they did under the emperor Commodus, the imperial administration consistently sided with the *coloni* to preserve their traditional cultivation rights. Thus, when *coloni* from an estate called the *saltus Burunitanus* complained about abuses that they had suffered at the hands of one *conductor*, a certain Allius Maximus, who apparently bribed the procurator administering the estate to allow him to increase the share rent of the *coloni* and to exact additional labor from him, the emperor in his response ordered the procurators to restore the existing rights of the *coloni*, who erected their petition and the emperor's response on a stele on a location within their estate (see Box 24.1). The imperial administration responded in a similar fashion to complaints from tenants on imperial estates in Asia Minor when they saw their own tenure rights threated by neighboring towns, which sought to impose liturgical obligations on them (Hauken 1998; Kehoe 2007, pp. 79–89).

It does not seem likely that the imperial administration applied the *lex Manciana* or the *lex Hadriana* to private estates, at least in the early empire, since this would represent an unparalleled intervention in private contractual relationships. Even so, it is clear that tenure based on the *lex Manciana* became widespread in North Africa, as it is documented in a number of locations, and even survived into the Vandal period in the fifth century, when Roman authority in North Africa collapsed. The survival of the land tenure based on the *lex Manciana* is indicated in the Albertini Tablets (493–496 CE; Weßel 2003), which record deeds of sale of cultivation rights, termed *culturae Mancianae*, on parcels of land within a larger estate, the

Box 24.1 Inscription from an imperial estate called the *Saltus Burunitanus* (Souk-el-Khmis, Tunisia, in the Bagradas [modern Medjerda] valley, *CIL* VIII 10570, 114464), 182 CE

II

[… collusion], which he has practiced without restraint not only with Allius Maximus our adversary, but with almost all lessees contrary to justice and to the detriment of your accounts, that he has not only failed to take notice despite our insistence and entreaties and petitioning your divine subscription, but he has also indulged in the devices of the same most influential Allius Maximus in this final outrage, that having sent soldiers onto the same Burunitan estate he has ordered some of us to be arrested and harassed, some to be bound in chains, and some, even Roman citizens, to be beaten with rods and clubs, apparently for this single merit of ours, that we had had recourse to an [unrestrained] letter as we were proceeding to implore your majesty in an [injury] so serious with respect to the measure of our [mediocrity] and one so manifest. By the evidence of this injury [to us], Caesar, it is possible to estimate [directly], what …

III

[This matter] has compelled us most wretched people [once] again to supplicate to [your] divine providence, and for this reason we ask, most sacred emperor, that you aid us. As it has been denied in the chapter of the law of Hadrian, which is written above, let the right also be denied to procurators, let alone a lessee, to increase the agricultural shares or the furnishing of labor or draft animals against the interests of the tenants, and, as the letters of the procurators read, which are in your archive of the Carthaginian district, we should owe no more than two days of plowing labor each year, two days of weeding labor, and two days of harvesting labor; and that matter should be without any controversy, since it has both been inscribed in bronze and has been provided by all our neighbors in every direction in the agreement perpetual up to this day, and also has thus been confirmed in the letters of your procurators, which we have written above. Please come to our aid, and since, as poor rustic people tolerating a livelihood gained from the work of our own hands, we are unfairly matched with a lessee most influential among your procurators because of his lavish gifts, to whom he is known through the changes of succession by the circumstances of his lease, take pity on us and deign to instruct by your rescript that we not furnish more than we are obliged to in accordance with the law of Hadrian and the letters of your procurators, that is two days of labor three times, so that by the benefit of your majesty we rustics, your servants and sons of your estates, should no longer be disturbed by the lessees of fiscal farmland.

IV

[The Emperor] Caesar Marcus Aurelius Commodus Antoninus Augustus Sarmaticus Germanicus Maximus to Lurius Lucullus and on behalf of others. The procurators in the contemplation of my discipline and practice – (added by the *coloni*) 'not more than two days of labor three times' – will take care that nothing be exacted from you by way of injury in violation of the perpetual agreement. And in a second hand: I have signed it. I have approved it.

A copy of the letter of the procurator of equestrian rank: Tussanius Aristo and Chrysanthus send greetings to Andronicus. In accordance with the sacred subscription of our lord the most sacred emperor, which Lurius Lucullus [received] after it was given in answer to his petition, …

–

[… and] by another hand: We hope that you live very happily. Farewell.

Presented on the 12 September at Carthage. Happily completed and dedicated on the 15 May in the consulship of Aurelianus and Cornelianus, under the care of Gaius Iulius Pelops son of Salaputus, magister.

Source: Originally published in D. P. Kehoe, *The Economics of Agriculture on Roman Imperial Estates in North Africa*, Hypomnemata 89 (Göttingen: Vandenhoeck & Ruprecht, 1988).

fundus Tuletianos. This estate was located far south of the Bagradas valley, in the pre-desert region of Africa. The rights being exchanged involved the cultivation of trees and other crops irrigated by occasional rainfall flowing through wadi beds (Mattingly 1988–1989).

The type of land tenure that was maintained on the imperial estates in the Bagradas valley gave the *coloni* incentives to invest in the long-term cultivation of the land, and so represented a way for the imperial administration to assure itself, to the extent possible, of stable long-term revenues from its estates. We do not have any direct information about the tenure arrangements on purely private land, but several considerations point toward the existence of broadly similar tenure arrangements there. First, in view of the vast extent of imperial properties in North Africa and their close proximity to private land, there would be considerable competition between private landowners and the Fiscus for the services of *coloni* capable of investing their own resources in the land. Thus, private landowners would have been compelled to offer their own tenants similar terms as imperial *coloni*. At the same time, private landowners would have benefited from allowing their tenants to take the responsibility for planting and maintaining olive trees and other fruit trees. The labor with olive trees is very seasonal; except for occasional plowing around them to loosen the soil to preserve moisture, the bulk of the labor would come at the harvest. Landowners who maintained their own workforce, either slaves or wage laborers, as was practiced on some large estates in Egypt in the third century and later, would face the problem of using it efficiently. Thus, it seems plausible that landowners would prefer to exploit their estates much as the Fiscus did, by delegating the task of cultivation to tenants, and profiting from their rents. Indeed, Mattingly and Hitchner (1995, p. 195) see tenancy arrangements like the *lex Manciana* as playing an essential role in fostering olive culture. Moreover, in late antiquity, the system of employing *conductores* on private estates was widespread in Africa; their function was likely to have been similar to that of their counterparts on imperial estates, in that they enforced the obligations of permanent tenants who cultivated their land more or less independently.

The archaeological evidence assembled in the Thugga Survey is consistent with this picture of decentralized estates in which polyculture involving the production of olive oil as a cash crop was the basic form of production. The Thugga Survey explores a region that has a variegated terrain, ranging from 400 to 960 m above sea level, with steep hillsides and rolling plains (de Vos 2013). It receives an average of 400–500 mm of rainfall annually. Thus, it is suited for the cultivation of grain without irrigation, but terraces could be created on hillsides to capture water and support arboriculture. The region includes many urban settlements, not just Thugga, but also Uchi Maius, Thignica, and other towns that fell under the administration of Carthage but became independent municipalities under Septimius Severus. A survey of 371 km^2 produced 274 farms, with 323 presses, as well as 11 towns of various types, with a further 48 presses. The presses are widely dispersed among the farms: 72 have no press at all, while a further 82 have one. Twenty-four farms have double presses (built together in the same location), while five have triple presses with an additional installation of each type in a town location. Forty-three farms have two single presses, and another seventeen have three single presses (de Vos 2013, pp. 152–156). The evidence of presses indicates the production of oil on a substantial scale for commercial markets, but this region does not have the pressing installations comparable to the large ones near Kasserine (the presses in the Thugga Survey are generally much smaller). Certainly one can interpret the evidence differently, but the archaeological remains of the presses seems compatible with a picture of small and semi-independent farmsteads, with parcels occupied by *coloni* on imperial estates interspersed among privately held land. Farms with individual presses could certainly have served more than one small-scale cultivator, whether a tenant or a small landowner. Some of the occupants of estates were likely to have been emphyteutic possessors, at least in late antiquity. Emphyteusis was a form of land tenure in which the possessor exercised rights like those of an owner, subject to a requirement to pay an annual rent. This represented a way for large institutions, such as the state or the Church, to gain revenues from their land. The emperor Constantine in the early fourth century intervened in a dispute between *coloni*, apparently with the rights under the *lex Manciana* described above, and emphyteutic possessors over water rights (*Cod. Iust.* 11.63.1, 319 CE; Weßel 2003, pp. 111–113).

Agriculture in North Africa, as in other regions of the Mediterranean, required a great deal of seasonal labor, particularly at harvest time. Such laborers were commonly recruited by contractors, *mancipes*, who entered into arrangements with estate owners to harvest, grain, olives, and many other crops. A fourth-century inscription from the town of Maktar in Numidia commemorates such a contractor; in his own description, he managed to accumulate wealth by leading gangs of harvesters, *turmae messorum*; eventually, he was able to acquire a villa of his own and become a member of his town's council (*CIL* VIII 11824, *ILS* 7457). As Brent Shaw (2013, pp. 3–92) emphasizes, the Maktar harvester was one of many organizers of a massive movement of itinerant laborers that the Mediterranean world experienced every year. In Africa, the harvest employed tens of thousands of itinerant laborers, who traveled from south to north following the times at which the grain crops would ripen. Other laborers, hired on a smaller scale for short-term work, might be recruited at local markets, like the vineyard laborers in the Gospel of Matthew (20:1–16). In the fourth century in North Africa, such laborers were called *circumcelliones*. They were apparently recruited from people of modest resources, and tended to speak Punic rather than Latin. Such workers played a prominent role in the religious conflicts between Donatists and Catholics, and the term originally coined to denote seasonal laborers was applied to often violent supporters of the Donatist cause (Shaw 2011, pp. 630–674). Another source of seasonal labor was seminomadic tribal groups, who, as documented in later periods, came to the high plains and the Tell at the harvest time from the winter pastures further south to exchange harvest labor for food and pasture lands (Shaw 2013, p. 32).

Conclusion

This survey has necessarily been selective in the details it has emphasized, but its point is to show the complex ways in which people in Roman Africa developed agricultural techniques to adapt to the region's variegated natural environment. At the same time, Roman landowners and small-scale cultivators created land-tenure systems that made it possible for Roman Africa to produce wealth from agriculture that supported a local urban culture while also generating revenues on which the Roman Empire depended.

FURTHER READING

The most recent major study of Roman North Africa's agricultural economy is Hobson (2015). Hobson is critical of approaches such as the one that I follow in applying economic theory to Roman Africa's agrarian economy and offers instead a perspective incorporating postcolonial literature. Whatever one's theoretical perspective might be, Hobson's work provides an invaluable survey of the evidence for agrarian change in light of North Africa's geography, with a particularly strong focus on ceramic evidence. From a different perspective, Ørsted et al. (2000), de Vos (2013), and Stone et al. (2011) show the important contribution that rural survey can make to understanding Roman agriculture. Leveau (1984) is an important archaeological study of the relationship between Roman and native systems of occupation in the region around Caesarea (modern Cherchell, Algeria). On irrigation and continuity with pre-Roman agrarian regimes, the work of Shaw (1982, 1984) is indispensable. Shaw (2011, 2013) also addresses the social aspects of rural labor. In addition, Fentress (2006) offers an important study of the changes in native structures of property brought about by Roman occupation and urbanization. For olive culture, the archaeological studies of Mattingly (e.g. 1988) and Hitchner (2002) are invaluable. Kehoe (1988, 2007 chapter 2) studies in detail the inscriptions from the imperial estates in the Medjerda valley, as do Flach (1978), Kolendo (1991), and Hoffmann-Salz (2011), the last in a larger study on the economic impact of Roman rule in Spain, Africa, and Syria. González Bordas and France (2017) provide a new text and an important discussion of a recently discovered inscription connected with the Medjerda valley imperial estates. From a very different perspective, Schubert (2008) argues that the regulations connected with these estates encouraged sedentarized farming by North African tribes.

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CHAPTER TWENTY-FIVE

Agriculture in Roman Egypt

Brendan Haug

Introduction: Preparing the Soil

Sometime in late March or early April of CE 278, Ulpius Aurelius, Egypt's *dioikêtês* (chief of finances) composed a circular for distribution to the *stratêgoi* (governors) of the Arsinoite nome (administrative district) and the several nomes of the Heptanomia – in total a 600 km stretch of the Nile Valley from the apex of the Delta to the city of Thebes in the south. Among the original recipients of the document was one Aurelius Harpocration, *stratêgos* of the Oxyrhynchite nome, whose capital city of Oxyrhynchus lay to the west of the Nile some 280 km south of Alexandria. On the 6th of Pharmouthi (1 April) having appended his own introductory remarks, Harpocration forwarded copies of the letter to his subordinates, the *dekaprôtoi*, a group of ten men selected from the Oxyrhynchus' city council and tasked with local administration and tax collection in the nome. It was they who would carry out the *dioikêtês*' instructions.

The subject of this official communiqué, published as *P.Oxy.* 12.1409, was irrigation. Although the country was still in the depths of the dry season – the Nile at low ebb and the first appearance of the annual flood at least two months distant – the *dioikêtês* writes that a critical period of the year had been reached, a time of preparation for the coming inundation:

> Ulpius Aurelius to the *stratêgoi* and *dekaprôtoi* of the Heptanomia and the Arsinoite nome, greetings. Since the time for the building up of the dykes and the cleansing of the canals is at hand, I thought it necessary to announce to you by means of this letter that all the farmers and […] should at this time build them up with all zeal on the [lands?] belonging to them, both for the public benefit of all and the personal benefit of each. For I am convinced that everyone is aware of the benefit that comes from these tasks (ll. 7–12).

Nome officials were commanded both to encourage all to begin the yearly labors and to select overseers from local magistrates or private persons. These overseers would, in turn, compel everyone to perform their appointed tasks personally. Overseers were not permitted

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to accept cash payouts in place of physical labor for only sweat and toil would ensure that critical works were completed.

> So that the dykes are raised to the established height and width and the breaches are blocked up, in order that they may be able to withstand the blessedly impending flood of the most sacred Nile, and so that the canals are cleansed up to the so-called standards and the accustomed dimensions, in order that they may easily bear the coming onrush of water for the irrigation of the fields, this being for the common good (ll. 12–19).

The letter ends with a warning to any persons who attempt to exact bribes or shirk their responsibilities (ll. 20–22): both their life and property are at stake for "endangering measures intended for the safety of all of Egypt."

***

A traditional reading of this papyrus would begin with the assertion that Roman Egypt's governing institutions were designed solely to maximize and extract agricultural surplus (Monson 2012, p. 275). The country was, after all, the granary of Rome – more natural resource than proper province – and the lives of tens of thousands of grain-dole recipients in the city depended upon a constant supply of Egyptian cereals. Behind Ulpius Aurelius' rhetorical invocations of the "safety" of Egypt and the "common good" lay his true goal of filling Roman bellies through the oppressive taxation of the Egyptian peasantry. To this end his local agents would disperse throughout the countryside to enforce a hated dyke- and canal-repair *corvée*, subjecting Egyptian bodies to the lash in order to ensure proper irrigation, a bountiful harvest, and a substantial surplus destined for hungry Romans in the imperial capital (Rostovtzeff 1929).

A more optimistic appraisal informed by later comparative evidence (Mikhail 2010; *id.* 2011) views the state–society relationship in this papyrus from the ground up and emphasizes the agency of the Egyptians themselves. Indeed, despite its authoritative tone and dire concluding threat, Ulpius Aurelius' own words betray that Alexandria had no direct hand in managing the flow of water through the canals and basins of Egypt's countryside. Lacking an irrigation and agricultural bureaucracy capable of governing water resources centrally, the *dioikêtês* instead relied upon the spontaneous initiative of an Egyptian peasantry whose own prosperity was dependent upon the communal self-regulation of local irrigation works. The state nonetheless retained a significant financial stake in Egyptian agriculture and accordingly empowered its local representatives to encourage, coordinate, and materially support the traditional irrigation practices of rural communities. Ulpius Aurelius may speak of compulsion (*anangkasontas*), but on balance his representatives were more likely to serve as *de facto* "community organizers" than agents of authoritarian oppression (Haug 2012).

The truth – an Egyptian agriculture neither enslaved nor largely indifferent to Roman governance – lies somewhere between these two extremes. It has become clear, for instance, that levels of taxation during the Roman period were low to moderate and that Egypt's centrality to the *annona* (Rome's grain supply) has been overstated (Rathbone 2007a, p. 717). Further, Rome's agricultural administration is now understood to have relied less upon despotism than upon the coordination of traditional irrigation practices at the local level. As a result, the classic depiction of the province as exceptional – as the emperor's private property, wrung for maximum gain via ossified and dirigiste Ptolemaic institutions – has been discredited. The richness of the documentary record nonetheless continues to complicate the picture by revealing considerable regional and temporal diversity. Attempts to summarize the characteristics of a distinctly Roman Egyptian agriculture are thus often frustrated by the appearance of contrary evidence from other places and times.

Although the wealth of the papyrological evidence precludes discussion of every topic debated in contemporary scholarship, this chapter introduces a selection of critical issues: the environment, the strengths and weaknesses of our evidence, population and the size of the cultivated area, land tenure and taxation, crops and diet, the management of Egypt's natural resources, and changes to Egyptian agriculture toward the end of the period covered here. Although the debate on several of these subjects is far from settled, this chapter will guide readers toward the most essential contributions.

Environment and Landscape

Environmentally, Egypt is the most "un-Mediterranean" of the Mediterranean countries. As in the rest of North Africa, a Mediterranean climate with sporadic and unpredictable winter rains (c. 20–100 mm/yr) prevails along its coastline. But while these narrow coastal strips quickly give way to desert in neighboring Libya, Tunisia, and Algeria, the River Nile provides Egypt with an ample water supply in the otherwise hyperarid Sahara. Although it empties into the Mediterranean, the Nile is in fact a tropical river, and its flow owes little or nothing to Mediterranean climate patterns. It is instead governed by the southerly climate systems of the Indian Ocean and East Africa and is strongly affected by cycles of the El Niño-Southern Oscillation (Abtew, Melesse, and Dessalegne 2009).

In antiquity, the Nile's yearly cycle of flood, recession, and low ebb structured the Egyptian agricultural calendar. From February to May, the river is at its lowest level, ancient Egypt's dry harvest season. During this period, the White Nile, the Nile's longest tributary, contributes the majority of the river's scanty flow from sources in central Africa as far south as the Nyungwe Forest in Rwanda, some 2700 km from Egypt's southern border (Dumont 2009, p. 2). In flood, however (c. June to September, the irrigation season), close to 95% of the Nile's waters are delivered by a secondary tributary, the Blue Nile, and derive from monsoon rains in the highlands of Ethiopia (Wohl 2011, p. 78). This monsoon runoff also carries with it the silt that fertilized Egypt's fields each year.

Following the convergence of the Blue and White Niles at Khartoum in the Sudan, the flood travels north through the main stem of the Nile for c. 1400 km, arriving at Aswan on Egypt's southern frontier in early June. Today the flood terminates in the Lake Nasser reservoir behind the Aswan High Dam, the cornerstone of contemporary Egypt's perennial irrigation system since its completion in 1970 (Collins 2002, pp. 177–194). Prior to the construction of the High Dam and its predecessor the Low Dam in 1902, the inundation traversed Aswan unimpeded and reached the Delta some 800 km to the north by July, transforming the floodplain into a vast lake dotted by cities and villages built on high rocky outcroppings (Hdt. *Hist.* 2.97). From October to January, the flood receded, and Egyptians sowed their crops on fields that had been cleansed, irrigated, and fertilized by the Nile's bounty.

Since this annual inundation was the primary source of water for agricultural irrigation in the Nile Valley, its height was a harbinger of surplus or scarcity. Weak floods or those that arrived later than usual resulted in food shortages due to insufficient irrigation or a truncated growing season. High floods similarly reduced the annual harvest by leaving much of the countryside waterlogged and uncultivable until late in the year (cf. Plin. *HN* 5.10.57–58). The latter were also far more dangerous than low floods since the fearsome onrush of a

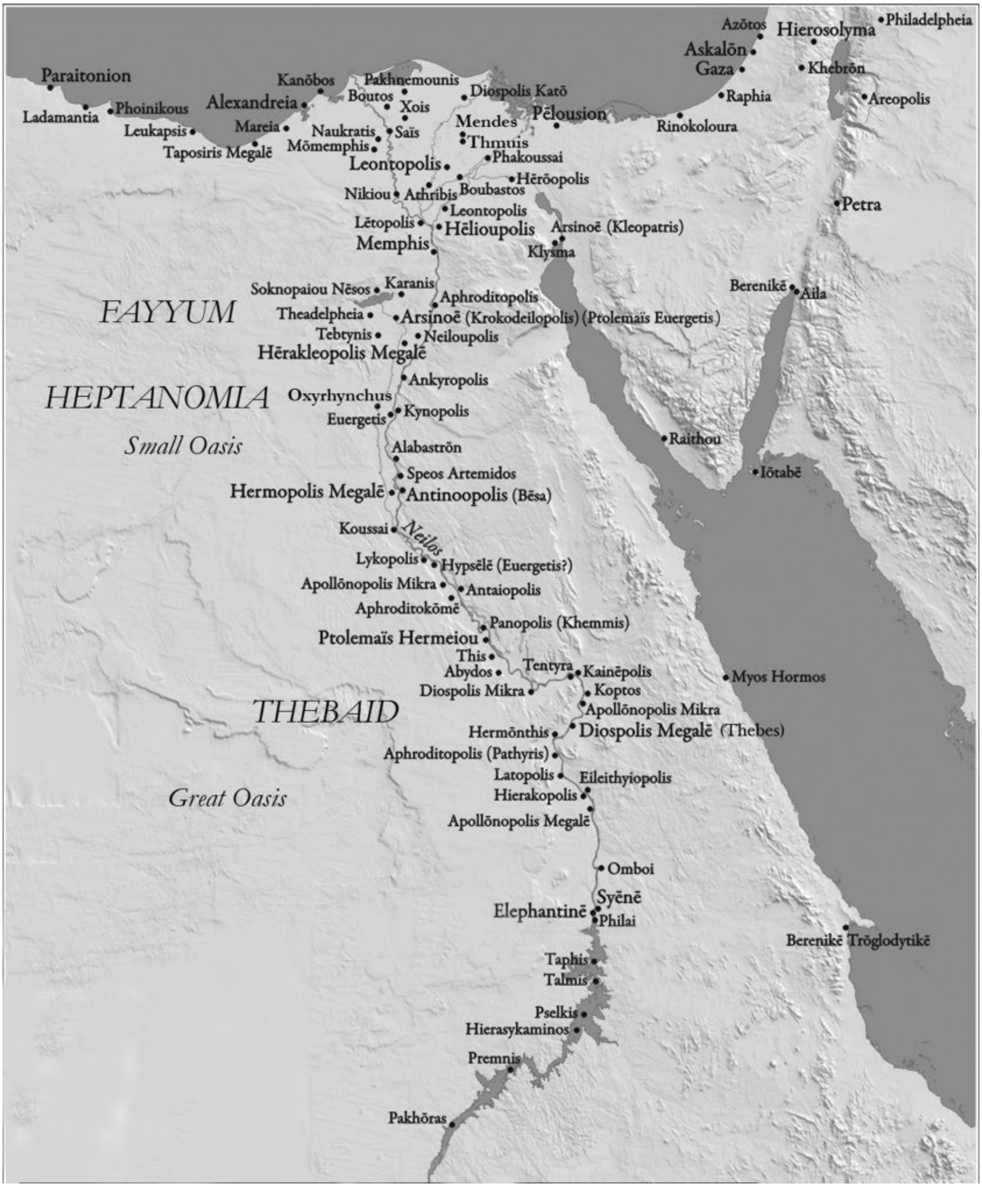

Figure 25.1 Egypt in the Roman Period. Source: Courtesy of Dr. Ian Mladjov.

high Nile drowned humans and animals alike, destroyed irrigation infrastructure, and spoiled stored foodstuffs (Willcocks 1889, pp. 300–301; Wilkinson 2014, p. 8).

These risks aside, the flood was adequate more often than not. While no long-term sequence of recorded flood levels has survived from the Ptolemaic, Roman, or Byzantine periods, records from the seventh to fourteenth centuries CE suggest that the waters arrived on time and in sufficient strength to irrigate the majority of the countryside in roughly three out of every four years (Said 1993, pp. 96–97). Although this method of irrigation permitted only one annual crop, bountiful harvests in good years and an arid climate conducive to food storage enabled the population to endure short-term deprivation during the occasional bad year, albeit with hardship. Longer series of unfavorable floods were more destabilizing and may have contributed to political turmoil throughout Egyptian history (Hassan 2007; Chaney 2013).

The landscape watered by the inundation had also changed in the centuries since the end of native pharaonic rule. At a macro-level, the Nile's channel has shifted to the east over the millennia (Schumm 2005, p. 185). This is observed most dramatically near the apex of the Delta, where the river has abandoned the ancient capital of Memphis and the royal burial complexes at Giza and migrated toward what is now the massive conurbation of modern Cairo (Lutley and Bunbury 2008). More important from the perspective of this chapter, however, is a single anthropogenic alteration to Egypt's landscape dated to the Hellenistic period. During the third century BCE, political pressures in the nascent Ptolemaic state resulted in a massive expansion of agricultural settlement into an area known today as the Fayyum, a geological depression west of the Nile in Egypt's Libyan Desert that had been minimally developed in the early part of the second millennium BCE but was otherwise still largely uninhabited (Manning 2003, p. 100). Seeking to increase their hold over the countryside through the settlement of Graeco-Macedonian veterans but unable to find sufficient lands elsewhere in Egypt, the first two Ptolemies reclaimed the entirety of the Fayyum by diverting a portion of the annual flow of the Bahr Yusuf, a seasonal side channel of the Nile that emptied into the depression during the flood and refreshed the shallow, marshy lake in its center, Lake Moeris. Massive canals were then excavated, which channeled irrigation water to dozens of newly founded villages, an irrigation system unlike any other in Egypt.

This project gradually reduced the size of Lake Moeris and opened up between 1200 and 1600 km^2 of new agricultural land, increasing Egypt's total cultivable area by 5 to 7% (Manning 2003, pp. 103–108; *id.* 2010, pp. 139–140). Officially dubbed the Arsinoite nome, the Fayyum reached its greatest extent during the early Roman period, its administrative area comprising nearly 1700 km^2. Boggy conditions in parts of the depression, a feature of its unusual hydrology, nonetheless prohibited intensive cultivation throughout the entirety of this massive area (St. John 1845, p. 182; Bonneau 1982; Haug 2015; *id.* 2017).

Yet the distinctiveness of the Fayyum does not imply an otherwise homogeneous Egyptian landscape. Rather, variations in topography throughout the Nile Valley created a diverse countryside with unique experiences of the inundation. Hard-pressed on either side by the rocky hills of the desert, the floodplains of Middle and Upper Egypt concentrated the Nile's annual water and silt deposits within a slender ribbon of fertile farmland scarcely more than a kilometer wide at its narrowest points in the far south. These tight quarters consistently boasted the country's most fertile soils and highest population densities. By contrast, the broad, flat expanses of the Delta and the Fayyum contained high amounts of marginal land, particularly the marshes of the northern Delta and the saline soils in the Fayyum (on which see Monson 2013). The lower productivity of both of these areas was long correlated with lower population densities prior to the advent of modern irrigation and drainage technologies, and the introduction of artificial fertilizers (Monson 2012, pp. 43–54).

Evidence

The archaeology of the post-pharaonic Nile Valley suffers by comparison to the earlier period. Dug out by farmers in search of fertile archaeological soil (*sebakh*), ransacked by antiquities- and papyrus-hunters, or plowed through in the search for pharaonic treasures, many Graeco-Roman sites in the Valley and the Fayyum were decimated before proper excavations could be conducted (Cuvigny 2009; Davoli 2015). The agricultural town of Karanis in the northeastern Fayyum is a notable exception thanks to extensive excavation by the University of Michigan from 1925 to 1935. Sadly, this pioneering project was never fully published, and its findings have been presented only in summaries and in articles on particular aspects of the site (summaries in Husselman 1979 and Gazda 2004). Work at Karanis recommenced in 2003, and its results are eagerly anticipated (Cook 2011; Cappers et al. 2013). Excellent work continues at the important Fayyum sites of Soknopaiou Nesos and Tebtunis as well, but little to nothing in their findings concerns agriculture (see in general Davoli 1998).

In contrast to the relative paucity of archaeological evidence concerning agriculture in the Valley and Fayyum (apart from the substantial finds at Karanis), excavations in the Dakhla and Kharga Oases in the Western Desert have provided considerable insights into agricultural life in a region of Egypt that has long been less familiar to scholars accustomed to working primarily with papyri (Kharga: Bousquet 1996; Dakhla: Bagnall 1997 and Bagnall et al. 2016). Due to considerations of space, however, the oases will be excluded from general consideration here.

As for the papyri, settlements on Egypt's best agricultural lands have preserved next to nothing thanks to their continuous inhabitation. Only abandoned and desiccated sites along the borders of the agricultural landscape have produced large caches of documents (Bagnall 1995, pp. 9–11). Multiple near-desert regions of Roman Egypt are thus known in great detail, while the majority of the country remains undocumented.

Biases are inevitable under such circumstances. Of great significance is the fact that rural documents survived in large numbers only in the Fayyum. Here, thousands of papyri were recovered from a ring of abandoned villages along the depression's outer rim. Thanks to these texts, the agricultural societies of these border settlements are relatively well known, while villages elsewhere in Egypt remain invisible. Even the Fayyum's continuously inhabited interior is obscured by a lack of documentation until the Middle Ages (Haug 2017). We must therefore be cautious about regarding liminal Fayyum settlements as microcosms of the rest of Egyptian agricultural society. Located at the tail-ends of the region's unique canal system, their backs to the encroaching desert, these villages were atypical.

Our view of urban Egypt during the Roman period is similarly dominated by documents from a single locale, Oxyrhynchus (see in general Parsons 2007). The city was sited at some remove from the Nile, lying instead on the western banks of the Bahr Yusuf on the outskirts of the floodplain. The slow eastward shift of the river and possible alterations to the course of the smaller Bahr Yusuf (Cooper 2014, pp. 101–102) may have prompted its abandonment sometime after the Arab conquest. Whatever the case, its rubbish heaps preserved the largest cache of metropolitan papyri from Roman Egypt. Thanks to their urban provenance, the Oxyrhynchus papyri primarily record the interests of the state – taxation, law and order – as well as the economic interests of urban landowners with holdings in the nome's countryside (Rowlandson 2007, pp. 211–212). The voices of the nome's country villages are correspondingly underrepresented.

An important supplement to the Fayyum and Oxyrhynchus finds are the carbonized papyri from the city of Thmuis, the Roman-era capital of the Mendesian nome in the northeastern Nile Delta. Although it contains two-thirds of Egypt's agricultural land, the soggy Delta cannot preserve papyrus in its natural state, and the carbonized rolls from Thmuis are thus a rare and precious find (Blouin 2014). Needless to say, this corpus has its own limitations. Produced in the municipal archives of a nome capital, these rolls contain cadasters, accounts of tax in arrears, and other fiscal documents. They are, in other words, schematic representations of the nome's landscape designed to facilitate the assessment and extraction of revenue. Further, the archive is dated to the end of the second to the beginning of the third centuries CE, a period during which Egypt was affected both by the Antonine Plague and an uprising led by residents of the Delta's liminal regions, the so-called Revolt of the *Boukoloi* ("herdsmen"). Documenting a society in some degree of disarray, the evidence of these texts is surely not representative of conditions in the northeastern Delta in all periods.

These qualifications, though essential, are far from a counsel of despair. Papyri have indeed been recovered from other parts of Egypt, albeit in smaller quantities than the bountiful Fayyum and Oxyrhynchus finds. Furthermore, papyrologists have exploited the parochial nature of much of the surviving documentary papyri to write compelling local histories (e.g. Rathbone 1991; Rowlandson 1996; Schubert 2007; Monson 2008; *id.* 2013; Blouin 2014). Scholars also increasingly subject their evidence to rigorous cross-comparison in the attempt to illuminate local and regional peculiarities, an approach that has resulted in significant increases in our understanding of Roman Egypt's variegated agricultural landscape.

Population and the Cultivated Area

Since population levels and the extent of the cultivated area are tied to aggregate production, consumption, and taxable surplus, estimates of these variables have a direct bearing on our overall impressions of the agricultural wealth of Egypt under Roman rule. Several caveats are once again in order. First, neither variable remained static over time. Modern estimates thus attempt to establish theoretical maxima: the highest numbers sustainable under ancient conditions. Second, no uncontested ancient evidence for either figure has survived. The debate has consequently been vigorous and consensus elusive, particularly since different scholars privilege different datasets and apply different standards of historical plausibility (this contribution is no exception). Our often impressionistic conclusions accordingly remain subject to revision in the light of new evidence and/or improved methodologies (for surveys, see Scheidel 2001b; Bowman 2011; Monson 2012, pp. 33–49; Tacoma 2012).

The two surviving attestations of Egypt's population in the Roman period are at wide variance. On the low end, Diodorus Siculus (1.31.6–9) claims a population of not less than 3 million persons in the first century BCE. In the first century AD, Josephus puts the figure much higher: 7.5 million, excluding Alexandria (Josephus *BJ* 2.385). While the latter figure, high even by comparison to Egypt in the 1880s, was once widely accepted, the most popular contemporary estimate is a more circumspect 5 million. This figure is reached by combining an urban population of 1.75 million – a rough guess at the populations of Alexandria and the c. fifty nome capitals – with a rural population of some 3 million. The rural figure is extrapolated from the average population densities of several Fayyum villages: 120 persons/km^2 (Rathbone 1990; Bagnall and Frier 1994, pp. 53–56).

Several objections to this conclusion have been raised. First, population densities along the Fayyum's margins were lower than those on better lands in the Nile Valley. Scattered ancient evidence suggests as much while data from the beginning of the nineteenth century show substantial variation throughout the country, including low density in the Fayyum (Monson 2012, pp. 41–46). A further objection (Lo Cascio 1999) asserts that although its many metropolitan nome capitals made Egypt one of the most urbanized regions of the Roman world, the roughly 35% urbanization rate that results from a population of 5 million is far too high. Moreover, accounting for the non-farming population of craftspeople and other service providers in Egypt's villages raises the non-agrarian share of this population still higher to c. 40%, far beyond the pale for the premodern world. Diodorus' population estimate of no less than 3 million is thus argued to refer only to adult male payers of the poll tax (*laographia*), i.e. males between 14 and 62 years of age, who ought to amount to 32.6% of the population under prevailing age and sex ratios (Bagnall and Frier 1994, pp. 91–102). This reduces the urban share of the population to acceptable levels but pushes the total population to nearly 9 million, beyond even Josephus' count.

The higher estimate nonetheless remains the more implausible of the two; indeed, nine million persons is an impossible figure under a premodern agricultural and technological regime in Egypt. Egypt's population only reached and sustained this level by the end of the nineteenth century following decades of agricultural modernization and increased productivity, sanitation improvements in the major cities, the expansion of health services, and subsequently rapid population growth. Yet 5 million may also be an undercount. Privileging comparative data once again, we see that Egypt's population hovered in the vicinity of 5 million in the early nineteenth century following a period of internal unrest, poor floods, invasion, and disease at the last decades of the 1700s (Crecelius 1998; Cuno 1992, pp. 30–32). That early Roman Egypt – technologically comparable, peaceful, prosperous, and plague-free – supported a similar population to this troubled era is questionable at the very least (Monson 2012, p. 48). A range between 6 to 7 million persons is an acceptable compromise between these two estimates: high enough both to account for denser inhabitation outside marginal areas like the Fayyum and to reduce the urbanized percentage to more reasonable levels yet still low enough to reflect an Egyptian population at peak premodern levels (much here depends upon Scheidel 2001a, pp. 201–208).

We gain perspective on this issue by linking demography to estimates of the size of the cultivated area. Here we dispose of only a single ancient figure. An inscription in the Ptolemaic temple of Edfu claims that Egypt farmed 9 million arouras, i.e. 24 804 km^2 (1 aroura = 2756 m^2), a figure widely cited in the scholarly literature as 25 000 km^2. Like Josephus' population count, the Edfu inscription is considerably in excess of later comparative evidence. Napoleon's *savants* estimated only some 13 000 km^2 at the end of the troubled eighteenth century, while a report to the British government of 1840 puts the figure at 14 700 km^2, surely indicating progressive recovery from its historic low at the end of the previous century (Bowring 1840, p. 13). Even the return of economic prosperity under Muhammad Ali and his successors, driven in large part by a massive and coercive expansion of cotton (Beckert 2014, pp. 131–132), produced a cultivated area of still less than 20 000 km^2 by the mid-nineteenth century, far short of the Edfu figure (O'Brien 1968, p. 172).

In fact, cultivation on 25 000 km^2 was never reached during the nineteenth century despite population growth, technological improvements, and constant agricultural expansion. Completed in 1861 and perfected in the 1890s, the Delta Barrage provided perennial irrigation to Lower Egypt, while the Ibrahimiyya canal in the south (1873) increasingly permitted perennial irrigation in Middle Egypt and the Fayyum. Yet even by 1889, with perennial irrigation reaching into the depths of the countryside, massive estates under cotton, and a population close to 9 million, only 23 269 km^2 were *potentially* cultivable with just 18 969 km^2 actually cultivated and paying taxes (Willcocks 1889, pp. 16–17). Egypt reached and sustained the 25 000 km^2 benchmark only in the 1950s, decades after the introduction of artificial fertilizers in 1902, the inauguration of the Low Dam at Aswan, and with a population in excess of 26 million persons (Scheidel 2001a, pp. 220–223; population figure in Robinson and El-Zanaty 2006, p. 24).

A cultivated area of 25 000 km^2 in the Roman period is therefore unlikely. If we accept the low population estimate of 5 million, we are compelled to believe that some 3 million Roman Egyptians performed agricultural labor equivalent to that of well more than 20 million twentieth-century farmers equipped with modern agricultural technologies. Even at the high estimate of 9 million persons, sustained cultivation on 25 000 km^2 by c. 6.75 million peasants still seems improbable for the same reasons. A maximum of 20 000 km^2 of cultivable land during the early Roman period is thus a safer bet. If between 80% and 90% were cropped in a given year, the taxable area would amount to 16 000–18 000 km², a plausible figure in comparative perspective.

This is an undeniably conservative estimate by the standards of contemporary scholarship, and readers should pursue the contrary arguments in detail (particularly Rathbone 1990). At the same time, these conclusions should not be regarded as pessimistic since it will be argued below that the average productivity of Egyptian fields has, by contrast, been underestimated. As a result, the smaller Egypt imagined here was as or more productive than the larger Egypt depicted by other authors.

Land Tenure and Taxation

Although significant complexity must be elided here, a general division between private (*idiotikê*) and public (*dêmosia*) agricultural land obtained in Roman Egypt, analogous to the distinction between *ager privatus* and *ager publicus* in Roman law. Public land owned by the Roman state derived in large part from the royal land of the Ptolemies (*basilikê gê*), but it also included temple lands (*hiera gê*) that had been transferred to the state administration during the Augustan period (Capponi 2005, pp. 98–99). Estates (*ousiai*) acquired by the emperor or members of the imperial family during the Julio-Claudian period and occasionally gifted to favored individuals were also transformed under the Flavians into a subspecies of public land (*ousiakê gê*) and administered like other public domains (on the *ousiai*, see Tacoma 2015).

The evolution of private land is more complex. Until recently it was believed that fully alienable private land did not exist under Ptolemaic rule save for small garden plots and orchards. On this view, some of the private lands attested during the Roman period originated in the conversion of a spectrum of Ptolemaic land categories into *idiotikê gê*. For instance, holders of plots of temple land on hereditary lease, already *de facto* owners by the late Ptolemaic period, became landowners *de jure* with full rights under Roman administration (e.g. *P.Mich.* 5.254; 260). The majority of private land, however, was thought to derive from the allotments (*klêroi*) possessed by Ptolemaic kleruchs (*klêrouchoi*) and cavalry settlers (*katoikoi hippeis*), military men holding plots of state-owned land in exchange for their service to the crown in times of need. Originally, *klêroi* were held for the duration of a kleruch's life and reverted to the state upon death. Lacking full ownership, kleruchs could not alienate their plots though they could cede them to fellow kleruchs. Over time, kleruchs gained more control: first, the ability to transmit their *klêroi* to their sons and later the right of alienation (Bingen 2007, p. 108; Fischer-Bovet 2014, pp. 225–237). Rome's conversion of kleruchic and katoikic land into fully alienable private land simply completed an evolutionary process already well under way at the end of the Ptolemaic period.

It has recently been demonstrated that this narrative, based almost exclusively upon the papyri of the Fayyum, overlooks the amount of private land that existed elsewhere in Egypt during the later Ptolemaic period. A rare glimpse of southern Egypt is illustrative: in 119/118 BCE, 72% of the cultivable land in the Apollonopolite nome (Edfu) was already private (*idioktêtos*), compared to only 2% held by kleruchs. This stands in stark contrast to the pattern of land tenure observed in the southwestern Fayyum village of Kerkeosiris during the same year. Data from the archive of Menches, *kômogrammateus* (village scribe) of Kerkeosiris, shows that 34% of the village's land was held by kleruchs, while a full 52% was in state hands (*basilikê*). Smaller percentages are given over to pasture, temple land, and derelict land, but no private land is attested. Earlier data from the eastern Fayyum village of Tanis dating to 240/239 BCE shows much the same pattern: 40% kleruchic and 45% public (Monson 2012, pp. 80–92).

Patterns of land tenure during the Roman period thus reflect distinctive regional histories. Though its kleruchies were indeed converted into private land, public land continued to make up more than 50% of the total in the Roman Fayyum, a legacy of its origin as a state project of the Ptolemies. But in nomes farther south where the footprint of the Ptolemaic state had always been lighter, percentages of Roman *dêmosia gê* descended from Ptolemaic *basilikê gê* were significantly lower: between 15% and 26% in areas from which evidence has survived (figures in Rathbone 2007a, p. 701). In such regions, Roman *idiotikê gê* also derived in large part not from kleruchies but from Ptolemaic *idioktêtos gê*, private land already in existence before the Roman annexation.

In their exploitation of private land, owners were free to work it themselves or to lease their plots out to tenant farmers in exchange for a rent in kind. Moderately prosperous urban landowners, the societal upper crust of Egypt's nome capitals, preferred leasing (*misthôsis*) as a low-investment, low-risk strategy for securing a modest and stable return (Rowlandson 1996). Owners of large estates, however, had the capital necessary to employ permanent and occasional labor forces for intensive, direct exploitation (Rathbone 1991, pp. 88–174).

Public land, on the other hand – at least in the Fayyum, where it was most abundant – was leased to groups of villagers known corporately as "public farmers" (*dêmosioi geôrgoi*). Represented by a body of elders (*presbyteroi*), the Fayyum's public farmers worked their plots on informal, customary terms rather than through written contracts (Rowlandson 1999, p. 148). Because these lands contained numerous marginal plots, allotments were periodically redistributed through a "communal leasing-out" (*koinê diamisthôsis*), in order to ensure that the better and worse parcels were shuffled among members of the group (Rowlandson 2005; Monson 2008).

Whatever the nature of their tenure, all cultivators owed a portion of their annual profits to the state. Orchards, vineyards, and market-garden plots tended to be taxed in cash since their produce was not sufficiently durable to permit in-kind payments. Although taxes on land under cereals could also be collected in cash (e.g. Rathbone 1993, p. 84; Blouin 2014, pp. 174–175), payments in kind were the norm. Public farmers paid between 3 and 5 artabas of wheat per aroura (1 artaba = 38.78 dry liters), while private plots were tariffed at an average rate of only 1 art./ar. (Bowman 2013, p. 247).

Compared to the high return on seed that could be expected on fertile and well-flooded land (see the next section below), tax rates on cereal lands were low. Yet even low rates would pinch in the case of a weak flood and a poor harvest, while a series of inadequate floods could drive farmers deep into arrears from which they could not hope to recover. In response, a process developed during the second century CE whereby holders of both public and private parcels could declare their land to be un-flooded (*abrochos*). These written declarations (e.g. *P.Mich.* 6.368) then occasioned an official inspection (*episkepsis*) and a subsequent alleviation of tax burden (Habermann 1997). Still, the periodic need for emperors and prefects to decry the inflexibility of the tax system and to offer amnesty or extended payment-plans to absconders in *anachôrêsis* (tax flight) indicates that the Roman fisc was not always nimble enough to respond appropriately to conditions on the ground (Rowlandson 1996, pp. 76–78; on *anachôrêsis*, see Jördens 2009, pp. 313–315).

Yet periodic interruptions to the revenue stream were not necessarily disastrous for the grain supply to the imperial capital. Verifiable data is, as ever, impossible to come by. The fourth-century *Epitome de Caesaribus* (1.6) claims that 20 million *modii* (4.4. million artabas) of grain were imported to Augustan-era Rome each year (1 artaba = 4.5 *modii Italici*). An edict of Justinian (13.8) later claims that Egypt's total annual dues – i.e. not just wheat for the capital – stood at 8 million unspecified units. The latter figure is generally thought to be measured in Egyptian artabas, a conclusion accepted here, but not all are convinced (artabas: Bagnall 1985, p. 304; uncertainty: Erdkamp 2005, p. 229).

Estimating the total annual needs of the city of Rome lends perspective on these figures. At a population of 1 million, Rome would have consumed some 30 to 40 million *modii* (6.6–8.8 million artabas) per year (Temin 2013, p. 31). According to Josephus (*BJ* 2.383–6), Egypt contributed one-third of Rome's needs, while North Africa supplied the remainder. This is surely simplistic, since wheat strains from Sicily, Sardinia, Gaul, the Chersonese, and Spain are also attested (Plin. *HN* 18.66). Still, if we include only North Africa and Egypt in our speculations, Egypt's contribution to Rome's 30–40 million *modii* subsistence may have amounted to some 10–13.3 million *modii* (2.2–2.9 million artabas).

Obviously, this falls short of the figure attested in the *Epitome*. Yet Rome surely imported more than pure need would dictate, both to provide surplus for storage and to account for losses through spoilage, contamination, and shipwreck. Moreover, some percentage of Egypt's total revenues would have been distributed within the country itself – e.g. to the army or to Alexandria – and, on occasion, used to provision cities in the eastern Mediterranean. The scale and the schedule (if any) of all such expenditures are again unknown (Wörrle 1971; cf. Rathbone 1989, pp. 173–174; Erdkamp 2005, pp. 232–235).

Justinian's 8 million artabas are as good a guess as any at the scale of Egypt's total revenue in a normal year: an amount well in excess of what was necessary to provision the imperial capital, leaving a sizable remainder for storage and for distribution within and outside of Egypt. If the figures for Egyptian cereal productivity proposed in the following section are on the right order of magnitude, such a levy would have weighed rather lightly on the backs of Egypt's peasantry in years of adequate flood, albeit only by expanding wheat cultivation to the detriment of agricultural diversity.

Crops and Diet

Sadly there are no Roman-period equivalents to the village-level crop surveys contained in the late Ptolemaic archive of Menches, *kômogrammateus* of Kerkeosiris (Verhoogt 1998). Nevertheless, the picture that emerges from Menches' archive is broadly representative of cropping patterns in the Roman period: a predominance of cereals (wheat followed by barley), leguminous vegetables (lentils, beans, vetch) in second place, and small amounts of the remaining land devoted to oil crops and fodder (Thompson 1999, p. 130; cf. Crawford [Thompson] 1971, pp. 112–118). To this should be added the produce of small parcels of orchard – including vineyard – and garden land, a minor but profitable agricultural sector (Sharp 1999).

Durum wheat was Roman Egypt's largest crop by far. Yet it was also a relative newcomer to the Egyptian countryside. In the millennia prior to the Ptolemaic period, emmer wheat (*olyra*) had been the staple of the Egyptian diet. Greek immigration soon marginalized emmer in favor of durum wheat (*pyros*), a product that could also be exported to the rest of the Greek world. Emmer rapidly declined into near-total obsolescence, and by 235 BCE it already accounted for only 1.7% of the crop in the Fayyum (an admittedly heavily Hellenized region). Wheat, by comparison, made up 74.6% of the cropped area and barley 14.5% (figures in Thompson 1999; for wheat exports, see Buraselis 2013).

Barley (*krithê*) was cultivated as a secondary grain both for animal fodder and bread making. Although its fiscal value was roughly half that of wheat, as much as one-fifth of grain land might have been given over to barley (Bagnall 1993, p. 25). In part, this owes to barley's hardiness; it tolerates levels of soil salinity that retard the growth of wheat, thereby making it an ideal alternative crop on land that had been over- or under-inundated and thus insufficiently cleansed of deleterious minerals. Barley is also the primary ingredient in beer, Egypt's alcoholic beverage of choice since the pharaonic period. Beer drinking was nonetheless on a long-term downward trajectory, and it virtually disappears in favor of wine in the later Roman period (Van Minnen 2001).

These two cereal crops occupied the overwhelming majority of Egypt's cultivable land. In the second-century Mendesian nome, 95.5% of all productive land in at least one toparchy (district) was under grain, while the minute remaining percentage was devoted to vineyards, gardens, beans, and reeds. Marshy areas of the nome's border zone (*limnai*) were also progressively converted to grain fields, thereby desiccating parts of the landscape, altering local flows of the river, and possibly causing social disruption due to the encroachment of grain cultivation into the lands of peoples living on the Delta's fringes (Blouin 2014, pp. 173–207, figure at pp. 190–191).

In addition to dominating the cultivated area, cereal productivity was exceedingly high by Mediterranean standards. Fields were sown at a rate of one artaba per aroura, and average yields have been calculated at 10:1 (Rathbone 1991, p. 243). To put this figure into perspective, estimates for the most fertile, well-manured estate lands in Roman Italy range from only 8:1 to 10:1, while peasant farms probably saw returns of 5:1 or 6:1. Roman Palestine was still less fertile, with average yields between 4:1 and 7:1 (Erdkamp 2005, pp. 34–53). A more pessimistic estimate puts average dry-farmed yields at between 3:1 and 4:1 in the premodern Mediterranean (Wickham 2009, pp. 362–363).

As impressive as a 10:1 yield is by comparison, the estimate should be revised upward. Our best ancient evidence derives from Theadelphia, a village on the western edges of the Fayyum. During the third century AD, estate production in Theadelphia ranged from 7 to 16.6 artabas per aroura for an average return of 13:1 (Rathbone 2007a, pp. 703–704). Yet the fertility of this marginal settlement surely did not compare to that of better lands elsewhere. In support of this supposition, comparative evidence from the Napoleonic *Description de l'Égypte* reveals considerable regional variability. Eighteenth-century harvests equivalent to 24 artabas per aroura are attested on the fertile fields of Upper Egypt, while the less fertile Delta and Fayyum saw returns equivalent to between 10 and 18 artabas per aroura. The nationwide average return on seed is set at 15:1 (Monson 2013, p. 132). Upper Egyptian yields in the 1830s are again impressively high, corresponding to some 18 to 25 artabas per aroura in Asyut and never less than 16.8 in Farshut farther south, while the national average amounts to 13.5 artabas per aroura (Bowring 1840, p. 16, 18).

These data once again remind us that our perspective has been skewed by a dependence upon Fayyum papyri. For the sake of argument, then, we may regard an average return of 13:1 and 15:1 as within the realm of plausibility. At this level, a cultivated area of 16 000 to 18 000 km^2, 95% under cereals, could have produced anywhere between 71 and 93 million artabas per year (cf. the figures in Rathbone 2007a, p. 704). This strongly suggests that aggregate cereal production in a good year far outstripped basic need, thereby making a sizable surplus available for taxation, trade, sale, and storage (1 artaba of wheat-equivalent per month provides sufficient energy for a very active adult male, Bowman 2013, p. 248).

In contrast to the prevalence of cereals, the other two pillars of the Mediterranean Triad, olives and grapes, were cultivated to a more limited extent due to environmental constraints. Only Egypt's slender coastal strip has a climate conducive to the growth of these two diagnostically Mediterranean crops (Hughes 2005, p. xxii). Indeed, viticulture flourished along the northern coastline, particularly in the area of Lake Mareotis near Alexandria, which long boasted a wine industry (Dzierzbicka 2010). Farther south, however, extreme heat and aridity, the annual flood, and Egypt's dense, silty, and poorly drained soils presented considerable environmental challenges to vine growers. Vineyard cultivation was nonetheless still possible on high-lying, un-flooded, and well-drained parcels that could be irrigated artificially. Still, the expense entailed in purchasing and maintaining irrigation machinery as well as providing the continuous human and/or animal power it required necessarily limited grape cultivation to wealthier segments of the population. Although modestly sized vineyards are attested in the papyri (e.g. 1.5 arouras in *P.Mich.* 5.266), owners of large estates were the most prolific viticulturists since they possessed the necessary capital for investment in land, artificial irrigation, and specialized vineyard laborers on a large scale (see Eyre 1994 for the pharaonic period and agro-environmental issues; Rathbone 1991; Hickey 2012 for late antiquity).

Olives, too, could be cultivated under artificial irrigation though they appear to have been much rarer than grapes. Attestations are few during the Ptolemaic period, and by the Roman period intensive cultivation seems to have been restricted to the Fayyum, where irrigation by canal was possible (Strabo 17.1.35; Thompson 1999; Blouin 2014, pp. 184–185). A potential exception is the Dakhla Oasis, where olives may have been cultivated more extensively and their oil transported by land across the desert for sale in the settlements of the Nile Valley (Bagnall 2005, p. 197).

With olive oil in limited supply, Egyptians were largely reliant upon other plants to supply lipids to the diet. In the Ptolemaic period, sesame, castor, safflower, linseed, and colocynth (bitter melon, *Citrullus colocynthis*) oil are all mentioned in the Revenue Laws of Ptolemy II. All are edible save for castor, which was more often burned in lamps. Unfortunately, references to these crops by name are few or nonexistent in Roman papyri. The most common oil crop is instead *lachanospermon*, "vegetable seed." The identity of "vegetable seed" was long mysterious – some variety of lettuce seed oil was once suggested – although a Greek-Coptic vocabulary list now makes clear that the term refers to sesame (Bagnall 1993, pp. 29–30; *id.* 2000).

For protein, Egyptians largely depended upon legumes. Because of their nitrogen-fixing properties, legumes were often grown in rotation on wheat fields to refresh the soil (Rowlandson 1996, p. 238). Numerous species are attested including lentils, chickpeas, and fava beans (Bagnall 1993, p. 26). The latter, cooked with vegetables and oil as *fūl* or mashed, spiced and fried as *ta'ameyya* – a variant of *falafel* – remains an Egyptian staple to this day. Served with flatbread and sesame (*tahina*) for dipping, this combination of cereal, vegetable protein, and vegetable fat is a modern descendent of the ancient diet.

The importance of this dietary triad was due in large part to the ease with which each crop could be stored. Oils such as sesame can be stored for months at a time without modern refrigerants. With a shelf life of many years, unprepared legumes are still more durable. Whole grain is the most stable and can be stored for decades if kept dry and pest-free. Shorter-lived food products, however – assorted greens, onions, garlic, and other flavorful additions to the diet – were often grown in household garden plots and quickly consumed. Fruits like dates and even olives could also be cultivated on smaller plots and their produce either eaten fresh or dried (Sharp 1999, p. 184; see *SB* 12.11113 for a date and olive grove near Karanis). Sadly, private home gardening is all but invisible in the documents, making it difficult to know to which fresh foods in what quantities the average peasant had access on a regular basis.

Consumption of animal protein is also difficult to quantify. Thanks to the Nile, Egyptian peasants, particularly those dwelling along the coastal lakes and lagoons, may have had greater access to fish than peoples elsewhere in the Mediterranean (Blouin 2014, pp. 228–230). Since fish rapidly spoils, salted fish (*tarichos*) are more often attested than fresh; an entire street was dedicated to the sale of salt-fish in the Fayyum's capital city Arsinoe (Marzano 2013, p. 93). Outside the commercial realm, household production of salt-preserved fish was, again, probably quite common. In a letter of the second or third century CE, an Oxyrhynchite writes on a personal matter to a man he dubs "brother," casually adding at the end of the letter, "if you are making little salt-fish (*tarichia*) for yourself, send me a jar as well" (*P.Oxy*. 6.928). For additional animal protein, Egyptians could also turn to fowling and the hunting of other small game in marshy regions of the countryside, particularly after the flood began to recede. Like home gardening, intermittent hunting and fishing also largely escapes documentation. The state nonetheless maintained control over larger bodies of water and leased out the right to hunt and fish within them (e.g. *P.Ryl*. 2.98; Blouin 2014, pp. 224–225).

Consumption of larger domesticated animals like beef, lamb, and mutton, or poultry was rarer still. Poultry was more useful as a source of eggs, while cattle were better utilized as sources of power for large agricultural tasks. Animals such as sheep and goats, sheared for their wool, were also valuable as producers of milk and cheese, the latter of which could be traded and stored (Rathbone 1991, pp. 202–206). Lacking more than scattered evidence, it is impossible to say what proportion of the average commoner's diet was composed of animal products. On balance, it is likely that plant products contributed the overwhelming majority of daily caloric intake.

In sum, the papyri reveal an array of edible plant and animal products that would have enlivened an otherwise banal diet founded upon cereals, legumes, and vegetable oils. Yet even in the absence of any fresh and flavorful supplemental fare, the average Egyptian did not face serious food shortages on a regular basis. The high productivity of the country in good years, the relative rarity of exceedingly poor floods, and the durability of staple crops surely went a long way toward alleviating the specter of poverty and starvation in the countryside (cf. Rathbone 2006).

But humans were not the only hungry animals in Egypt; animals, too, needed constant sustenance, and fodder crops (*chlôra*, *chortos*) were widely cultivated (Rowlandson 1996, pp. 236–239). Like legumes, fodder could be grown in rotation on cereal lands. Rather than harvesting the crop, cultivators might simply lease out grazing rights to nearby shepherds whose animals' manure further replenished the soils of fields exhausted by constant cereal production. Unsurprisingly, errant beasts occasionally wandered into fields growing crops for human consumption, trampling and devouring them. This routine fact of life caused constant friction between settled agriculturalists and the herders who plied the outskirts of the cultivated land (*P.Ryl*. 2.126, 131, 132; Rowlandson 1996, pp. 21–23).

But Egyptian agriculture was not entirely concerned with food, and a few brief words on non-alimentary crops are in order. First, documentary habits both in Egypt and abroad required the cultivation of papyrus (*Cyperus papyrus*) on a large scale. Marshy areas left waterlogged after the flood (*drymoi*) provided the perfect habitat for this aquatic sedge, especially if they could be supplied with artificial irrigation for intensive, continuous cultivation of this and other reed and brushwood crops (*P.Tebt*. 2.308; *P.Wisc*.1.31, 34, 35; Bonneau 1982; *ead*. 1983). Though the oil from its seeds is also edible, flax was also grown for linen textile production. Like papyrus, flax requires marshy lands ill-suited to cereals and was widely cultivated in the Delta (Blouin 2012; *ead*. 2014, pp. 223–239). Oxyrhynchus in Middle Egypt was also a significant clothing producer in antiquity. The area was famed for its linen and other textiles in the Middle Ages, a tradition that it may have inherited from the Roman past (Van Minnen 1986; Hickey 2012, p. 34).

Managing Nature

We return now to the issue raised at the outset of this chapter: the management of Egypt's natural resources. It was long asserted that the governance of Egypt's water and soil was a matter of state coercion organized through forced labor, a perspective that has tended to deny the agency of Egypt's peasantry (e.g. Rostovtzeff 1926, p. 259). Debates within Egyptology have dismantled this paradigm of despotic water control (Manning 2010, p. 37), and it is now fully accepted that no premodern Egyptian state possessed the administrative capacity to regulate irrigation centrally. Water control thus remained a local matter until the nineteenth century (pharaonic period: Butzer 1976; Willems 2013; Ottoman period: Mikhail 2010; *id*. 2011).

Yet the needs of the state (revenue) and the needs of the populace (sustenance) were consistently entwined, and Egyptian governments were in all periods eager to encourage and support local efforts (Michel 2005; Mikhail 2011). From his seat in Alexandria, a *dioikêtês* like Ulpius Aurelius exhorted his subordinates to round up local worthies who would oversee and direct the otherwise spontaneous process of canal cleaning, dyke maintenance, and irrigation. Accordingly, a dizzying array of local liturgical officials concerned with water and other agricultural matters is attested in the papyri (Bonneau 1993). Their precise duties are nonetheless imperfectly understood, and their official Greek titles may often conceal traditional rather than statist origins (cf. the informal "engineers" in the medieval Fayyum: Rapoport and Shahar 2012).

But these local coordinators could also be laden by the state with important tasks that villagers could not accomplish themselves. Hence, a petition from the Fayyum village of Kerkesoucha near Karanis in the northeast of the region (*SB* 4.7361). In 210/211 CE, all the farmers of the village, both landowners (*geouchoi*) and public farmers, collectively complain to a regional governor (*epistratêgos*) that local officials known as the supervisors of sowing (*katasporeis*) had failed to supply "the wood and brush they provide each year for the building up of the wattlework dyke called 'Log' by the village, nor did they provide any maintenance" (Youtie 1974; on the *katasporeus,* see Bonneau 1993, pp. 168–173).

Still, the most important task of local overseers was the coordination of human labor. In the Fayyum, this took the form of an institutionalized *corvée*, the *penthêmeros*, compulsory labor of five or more days on the nome's dykes and canals for which each participant received a written receipt. The receipts attest that most villagers were required to work on the canals of their own community (Sijpesteijn 1964, p. 79), something that most would have done anyway thanks to social pressure from their neighbors (cf. Crawford 1988; Trawick 2001a; *id*. 2001b; Lloris 2006; Mikhail 2011, p. 175). At the same time, however, there are attestations in the surviving receipts of villagers compelled to travel as far as 40 kilometers to work on the Bahr Yusuf itself as well as the "six-gated sluice" (*hexathyros*) at the village of Ptolemais Hormou, a structure at the entrance to the Fayyum that was the lynchpin of the entire irrigation system (Haug 2012, p. 138, pp. 216–217). Although such work was undeniably critical to the health of the Fayyum's canal network, we should not discount the potential hardship involved in drawing able-bodied men away from their home communities during this critical period of the year, something that must have occasioned intermittent avoidance or resistance (Figure 25.2).

Outright opposition to state coordination is best illustrated in an Oxyrhynchus petition of 245/246 CE (*P.Oxy*. 38.2853). Two overseers (*epimelêtai*) of a canal called "Thousand Arouras" (*Chiliarourai*) complain that they had approached two brothers and asked them to perform work on their share of the canal. The brothers allegedly refused and attacked the local officials with blows. More than this cannot be said with certainty about these events. Still, the name of the canal – Thousand Arouras – perhaps indicates a large public conduit on which two free riders hoped to avoid working while still reaping its benefits, a common problem in canal-irrigation communities (Ostrom and Gardner 1993).

Figure 25.2 Canal-cleaning at Karanis during the Michigan excavations, 1924. Source: KM Negative 0658 "Scenes at the canal when the South Bank broke. Repair work." @ Kelsey Museum of Archaeology.

At one and the same time, then, the management of Egypt's natural resources partook of both coordination and coercion. From the perspective of a Fayyum farmer required to clean and repair the canals and dykes of his home village, the *penthêmeros* was simply the institutionalization of routine and self-interested behavior; for the farmer dragged far from home, it was something else altogether. The incident recorded in the Oxyrhynchus papyrus further reminds us of the limitations of the system: the unwilling could always opt out, violently if necessary.

Conclusion: Looking Ahead

By the third century CE, a unit (*phrontis*) of the estate of a wealthy Alexandrian, by the name of Aurelius Appianus, had come to dominate the formerly bustling village of Theadelphia in the western Fayyum (Rathbone 1991; Sharp 1999). On the opposite side of the nome, estates similarly swallowed up much of the village of Philadelphia (Schubert 2007). The causes of this phenomenon are much debated. Although the widespread mortality and land abandonment accompanying the Antonine Plague of 165–180 CE are often cited as the primary cause of these developments, it has become clear that the plague was simply one of many factors influencing the evolution of Egyptian society and economy during this period (Schubert 2007, p. 156; Andorlini 2012; Harris 2012).

Whatever their origins, these large estates dramatically altered the agricultural landscape, at least in the Fayyum: small, scattered plots of public and private land once dedicated to grain were consolidated under a single owner and converted into massive vineyards producing wine for sale on the market. The irrigation requirements of these intensive viticultural operations further encouraged the spread of irrigation technology throughout the countryside, particularly the animal-powered waterwheel (Arabic *sâqiya;* Greek *mêchanê*: Rathbone 2007b).

By the middle of the fourth century, however, even the estates were gone. Theadelphia, reclaimed from the desert under the Ptolemies some six centuries prior, had once again been covered by sand and would not again be revealed until the later nineteenth century (Boak 1926). The abandonment of this and of other villages of the marginal Fayyum has often been regarded as a microcosm of Egyptian agriculture as a whole in late antiquity, a tale of decline and fall on the fringes of the empire (Bell 1917). Yet this process was slower than previously suspected and better characterized as a progressive contraction toward the more fertile and sustainable center of a uniquely fragile region rather than as a sudden and precipitous collapse (Keenan 2003; Haug 2015; *id.* 2017). More importantly, however, this chapter has continually stressed the danger inherent in writing Egyptian agricultural history from the evidence of one region and period. Indeed, as the Fayyum declines and fades from view, other areas come more clearly into focus, such as Hermopolis (Ashmunein) in southern Egypt (Van Minnen 2009). Formerly regarded as a period of collapsing state power and the rise of proto-feudal medieval estates based on viticulture, late antique Egypt is now understood as a period of relative stability and cooperation between the great estates of the countryside and the central state in Constantinople (Hickey 2012).

Much still remains to be done. Paleoclimatology is the most recent and exciting addition to the toolkit of the history of Graeco-Roman Egypt, one not yet fully exploited but already ripe with promise (McCormick et al. 2012). This integration of modern scientific methodologies with traditional papyrology, a marriage of macroscopic global perspectives with microscopic analyses of local socioeconomic conditions, will soon begin to reveal in greater depth the various ways in which natural systems and human decisions combined to shape the Egyptian agricultural landscape over the *longue durée*.

FURTHER READING

Although focused on a single large estate in the village of Theadelphia, Dominic Rathbone's (1991) *Economic Rationalism and Rural Society in Third-Century AD Egypt* remains the most thorough English-language study of agriculture in the Roman Fayyum. It should be paired with Paul Schubert's (2007) *Philadelphie. Un village égyptien en mutation entre le IIe et le IIIe siècle ap. J.-C.*, an equally penetrating study of another important Fayyum village. Jane Rowlandson's (1996) study of Oxyrhynchus is another comprehensive regional analysis focused on the economics and social relations of Egyptian agriculture from the perspective of urban landlords. Katherine Blouin's (2014) *Triangular Landscapes* offers the first substantial history of the Nile Delta in the Roman period and integrates contemporary environmental-historical perspectives and methodologies with a traditional papyrologist's keen eye for textual detail. Andrew Monson's (2012) *From the Ptolemies to the Romans* is perhaps the most important and challenging study of the institutional history of Egypt to emerge in a generation. Monson's reinterpretation of the transition from Ptolemaic to Roman rule is a path-breaking, if controversial, blend of Stanford-school social science methodologies and rigorous textual analysis. Lastly, the value of comparative perspectives is now broadly admitted. Alan Mikhail's (2011) *Nature and Empire in Ottoman Egypt* is essential reading for historians of Egypt in any period. Drawn from thousands of petitions preserved in the Ottoman archives of Cairo and Istanbul, Mikhail's work illuminates the ways in which an imperial state exploited the agricultural wealth of Egypt without the capacities afforded by modern technologies. Although comparative evidence should be treated with care, the book offers papyrologists an in-depth look at rural Egypt in the final moments before the onset of industrial modernity. Finally, Nicolas Michel (2005) has made direct and fruitful comparison between the Graeco-Roman and Ottoman periods in a seminal study of dyke maintenance, which highlights both continuities and ruptures in irrigation practices across the centuries.

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CHAPTER TWENTY-SIX

Agriculture in Iron Age Mesopotamia

Michael Kozuh

Introduction

The history of Iron Age Mesopotamian agriculture is one of bright spots and dark alleys, of cutting-edge work and long-unchallenged observations, and of information deluges and deserts. Perhaps, though, the issue that most bedevils an investigation like this one mirrors the one Cuomo identifies in her introduction to essays on ancient Mediterranean technology:

> [T]here are two surprising facts about ancient technology. One is how pervasive it was … Most of the remains, material or literary, that we have from the ancient world were the products of some form of technical knowledge. Once you start looking, there is no getting away from it: you find technology *everywhere* in the ancient world. All the more surprising, then, that the second surprising fact about ancient technology is how few people have been or are studying it. (Cuomo 2007, p. 1, emphasis in original)

The problems she goes on to relate, that technology had a ubiquitous yet largely unrecognized reach and that its study remains cloistered among a few technically minded experts, find parallels in the history of Iron Age Mesopotamian agriculture. Agriculture obviously shaped Mesopotamian society, whose ability to produce high yields gained fame even in antiquity. In addition, the Iron Age saw the rise of multiple rural, agriculture-based empires from Mesopotamia and its environs. While Iron Age Mesopotamians, unlike their antecedents, did not focus their learned contemplation on agriculture or farm life, much of our substantial written information from Iron Age Mesopotamia loosely concerns itself with the management of agriculture and its products. Indeed, this managed agriculture allowed Mesopotamia to reach high levels in art, politics, economic exchange, and intellectualism. Like ancient technology, agriculture was indeed everywhere.

Mesopotamian agriculture has an even smaller group of experts dedicated to its study, many of whom write about agriculture among a wider set of interests. Yet, given its ubiquity, agriculture is actually at the heart of some of the most innovative and exciting work currently

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in Mesopotamian studies. After decades of piecemeal (if essential) work, a project out of the University of Vienna is currently shining new light on the Mesopotamian economy, of which agriculture constituted a significant part (Jursa 2010a). Moreover, archaeologists are employing new approaches in satellite and ground surveying to revolutionize our understanding of how Mesopotamians transformed their landscape (Ur 2013; Ur et al. 2013; Dornauer 2016; Rosenzweig 2018). Given the current state of Mesopotamian studies, it is doubtful that more than just a few people will ever study these issues at any given time, so the great progress of the current generation testifies to the fecundity, diligence, and abilities of those who do.

The following takes a broad-brush approach to much of this new work, pointing out recent advances, explaining some of the discipline-specific approaches, and, where apt, suggesting new ways forward. In light of advances in archaeology and in the analysis of the vast trove of Iron Age cuneiform texts, the subject is ripe for detailed reevaluation.

Geography

Mesopotamia, the "land between the (Tigris and Euphrates) rivers," roughly encompasses the area north-to-south between the Taurus Mountains and the Persian Gulf and, east-to-west, the Zagros Mountains to the Euphrates river (Figure 26.1). Broadly speaking, the

Figure 26.1 Map of Mesopotamia. Source: From Ken Williams. Licensed under CC-BY-SA 3.0. From https://oi.uchicago.edu/sites/oi.uchicago.edu/files/uploads/shared/images/archive/Iraq_Site_300dpi.gif

northern part of Mesopotamia is called Assyria; the southern part, from about modern Baghdad to the Persian Gulf, is Babylonia. Assyria practiced rainfall agriculture – it received over the minimum of 240 mm of rain per year – although times of political ascendency saw the construction of expertly engineered canals drawing from tributaries to the Tigris river. Babylonia received little rainfall, but drew water in canals from the Euphrates river and its many branches on their path toward the Persian Gulf. The ability to engineer the Tigris for irrigation in Babylonia came late in the Iron Age.

To maximize access to irrigation water and plowing efficiency, the basic Babylonian plot of arable land took the form of a long rectangle rather than a square (Liverani 1990; Liverani 1996; Jursa 2010a, p. 351). One short side of the rectangle, along which date palms grew, bordered the canal. Other fruit trees, vegetables, and legumes grew under the date palms, taking refuge from the summer heat. Behind the date palms, running the length of the rectangle, grew long rows of cereal plants. At the other end of the rectangle pooled the run-off water from the irrigated field. Some Babylonians turned this area into fish and reed ponds, while in far southern Babylonia canal run-off water joined the slow south-east movement of water toward the Persian Gulf to form a large marshy area Mesopotamians referred to as the Sealand.

Archaeology

Archaeologists bring light to Iron Age Mesopotamian agriculture in a variety of ways, some of which have proved especially fruitful of late. They unearth material culture, from barley seeds, cuneiform tablets, and actual agricultural tools to the spatial organization of gardens and stables in a city. Looters unfortunately also find material culture, ripping it from any usable context. Second, archaeologists of the Near East pioneered the study of surface surveys of pottery around archaeological sites. Through these surveys they determine the chronological span and size of the occupation of a site throughout its history, which through aggregation of all the results helps to establish rough demographic and economic information. The 1989/90 Gulf War and its protracted aftermath dramatically slowed work on these first two areas of investigation, although some areas of Iraq have recently reopened for archaeology, while Syria has closed off. Finally, the examination of satellite images has expanded the macro-approach of the surface surveys, taking the relationship between cities and their hinterlands further (Ur 2013; Ur in press).

For material culture, bioarchaeology understandably tends to concentrate on the prehistoric (Zeist and Bootema 1999), and the wooden agricultural tools of Mesopotamia often do not survive for archaeologists to uncover. Even a metal plowshare might not be distinguished as such (Seidl 2003–2005; but see now Rosenzweig 2018.). We can, though, turn to depictions of tools and agricultural life on less perishable media. Certain plants and animals can be identified in Assyrian reliefs (Thompson 1949), and trees (Giovino 2007), animals, plants, and *Mischwesen* play a prominent role in divine iconography. Cylinder seals and royal reliefs from Assyrian palaces depict plows and agricultural activity (Salonen 1968; Hruška 1999) as well as the landscape (Radner 2000; Thomason 2001). Indeed, highlighting the centrality of agriculture, one of the best depictions of a Mesopotamian plow is used in the hieroglyphic writing of the names of both Assyria and Babylonia (Finkel and Reade 1996). For the find spots of cuneiform texts in general, see Pedersén (1998), and Heather Baker has investigated the layouts and morphology of Iron Age Babylonian cities (Baker 2003, 2014).

Moving beyond material culture, archaeologists have made great recent strides in exploring the relationships between cities and their hinterlands at the macro level. After painstaking

Figure 26.2 Iron agricultural tools from Nineveh. Source: Courtesy of Ministère de la maison de l'empereur et des beaux-arts. Victor Place and Félix Thomas (1867). *Ninive et l'Assyrie* Vol. 3, Pl. 71. Paris: Imprimerie impériale. Digital image from: https://digi.ub.uni-heidelberg.de/diglit/place1867bd3/0086

research up through the 1970s, Robert McCormick Adams used the results of pottery surface surveys in central Babylonia to argue that Iron Age Mesopotamia saw a rise in population after a decline at the end of the Bronze Age – growing by more than five times over the course of the first millennium BCE (Adams 1981, p. 178). This growth included a major increase in the size of cities (some of them with no Bronze Age predecessor), and already large cities reached new heights (Adams 1981, ibid.; Jursa 2010a, p. 39f.). This growth continued well into the Seleucid, Parthian, and Sassanian periods. The lattermost, in fact, saw Mesopotamian settlement at its greatest extent.

Then, the 1990s saw the declassification of Cold War American spy satellite images. Interestingly, many satellite images predate the widespread practice of scientific agriculture in the Near East, thus preserving images of areas that later came under intensive cultivation and thus obliterated important archaeological information. The combination of satellite imagery and ground confirmation continues to revolutionize our understanding of northern Mesopotamian settlement, and will certainly do the same for the south when ground conditions allow it (Ur 2013; Ur, Jong et al. 2013; Ur in press) The results of these new approaches await detailed synthesis, but Iron Age northern Mesopotamia saw planned expansion, with new capital cities, the resettlement of deportees, colonization, the sedentarization of nomads, and a manipulation of the natural environment through massive canal systems (Bagg 2000; Ur 2005; Dornauer 2016; Ur 2017; Rosenzweig 2018).

New data points and approaches are always welcome, and the work in northern Mesopotamia and southwest Iran shows great promise. Yet there are limits to the macro-view. Among other things, the Iron Age pottery sequence remains poorly understood, pottery coverage is generally a tenuous indication of site surface size, and pottery surveys only capture a slice of central Babylonia (Brinkman 1984; Jursa 2010a, p. 41). Observations from satellite images need corroboration on the ground; archaeologists have made vast strides to that end in some parts of the Near East (especially in parts of Iraqi Kurdistan, Iranian Khuzestan, and, until recently, the Habur basin of Syria), while other areas remain closed off to investigators.

Moreover, one must make connections between broad survey observations and economic or administrative trends with caution. Jason Ur, for example, differentiates between landscapes modified "by the aggregate actions of their inhabitants" and those modified "by royal will" (Ur 2017). Indeed, we know from textual evidence that relationships between cities and their hinterlands reach high levels of sophistication in Iron Age Mesopotamia – robust traffic and trade sailed on the Euphrates; urban elites traded and improved some alienable land; the Mesopotamian economy became partly monetized; the crown contracted with entrepreneurs to ship food to the capital to settle dependents; temples and agricultural entrepreneurs entered into business relationships with partners at a great distance; kings embarked on great building projects, which required feeding a dependent population; and the agricultural regime of central Mesopotamia moved toward intensive date palm cultivation. To push this further, scholars cite Adams' demographic work as partial evidence for population pressure and labor shortages in Iron Age Mesopotamia, which affected wages and institutional relationships with farm labor. Yet for a society with a monumental building tradition, concepts like labor shortages reflect policy (i.e. "royal will") as well as demography – building a palace (e.g. Beaulieu 2005) prioritizes one use of labor over others. While nothing gives us reason to doubt that expected pre-industrial city/hinterland relationships held general sway, texts do show us that elite desires in consumption, infrastructure, and monumental building, all tied into imperial projects, could greatly affect the macro-image.

But it should be emphasized that these surveys surprise only in scope – all the evidence suggests that Iron Age Mesopotamia saw both urban and population growth on a large scale. It is, though, unfortunate that the eras during which we find continuous, strong growth – the Hellenistic, Parthian, and Sassanian periods – are right when our rich source of cuneiform texts begins to die off and written information generally becomes scarce. These areas need more attention in general.

Texts

We have a rather stunning amount of textual evidence for aspects of Iron Age Mesopotamian agriculture, particularly in administrative and legal documents. Very few of these texts come from controlled archaeological excavations; looters found some (and the damage of the past 20 years of looting remains to be assessed), but most texts come from a quasi-archaeological pillaging of Mesopotamian sites by the British, French, and Americans in the early twentieth century. Scholars/explorers sent crates of texts to different museums worldwide; many texts also made their way to the nascent antiquities market, only to wind up piecemeal in private collections. With tens of thousands of texts to go through and a limited number of researchers, the process of publication moved slowly. Published line drawings of texts (itself a very time-consuming process) reproduced a small percentage of any particular collection, and texts from the same ancient archive were too scattered worldwide for deep, systematic inquiry. Until recently the laborious process of cataloguing, collating, and understanding the texts precluded large-scale investigations into agricultural history.

The 1970s and 1980s saw three major inroads into a deeper understanding of Iron Age Mesopotamian agriculture. The first systematic study of any aspect of Iron Age Mesopotamian agriculture was Cocquerillat's *Palmeraies et cultures de l'Eanna d'Uruk (559–520)* (Cocquerillat 1968). Although limited to date palm horticulture, her terminology and approach frame the discussion today. The mid-1980s saw the formation of the Sumerian Agricultural Group, which brought together experts in cuneiform, archaeology, historical botany, and animal management. This group later published a series that attempted to cover the full scope of ancient Mesopotamia (Powell 1999). The technical contributions have general import, and van Driel's and Postgate's submissions (Postgate 1984a, 1984b, 1985, 1987b, 1987a, 1992; van Driel 1988, 1990, 1993, 1995) spoke directly to Iron Age matters. This also extended to Van Driel's other publications (van Driel 1989, 1999, 2000a, 2000b, 2002). Stolper's work on the Murashu firm (Stolper 1985), along with the work of Joannès (Joannès 1982), remains seminal. One can see the influence of this work in the fact that in 1994 Cuneiform Studies' main disciplinary conference was dedicated to agriculture (conference proceedings published in Klengel and Renger 1999).

In many ways, all these works laid the foundation for what are in effect the two major publications on institutional Mesopotamian agriculture (Jursa 1995 and Janković 2013, but see also Da Riva 2002 and the bibliography in Jursa 2010a, p. 316f.). Of late we have gained both in depth and breadth. The recently published archive of Judeans in Mesopotamia (Pearce and Wunsch 2014) mostly concerns the administration of agriculture and agricultural products, but brings no new practices to light. We can say much the same thing for the famous archive of the Egibi family of Babylon (Wunsch 1999, 2000, 2003) – the family had an interest in land, and involved itself with shipping agricultural products to the capital, but the archive itself contains little information on agriculture as a practice.

In general, these pockets of text-rich information, with most texts documenting the movement, storage, dispersal, and legal maneuvering over agriculture and its products, show us that agricultural regimes and their documentation consisted in effect of two slow-moving, interrelated systems. One system rendered the land abstract, circumscribed it by measurement and survey, exploited it through agreements, laws, and rules, accounted for it in ways that the participants found meaningful, attached people, technology, and animals to the land, and attempted in a variety of ways to plan for harvest utilization and future agricultural productivity. In this system, we encounter multiple hierarchies attempting to bring land and its exploitation under control, monitor and direct its produce, and maintain a social order. The other system consists in the patterns of behavior that affected agricultural practice: new people moved in (at times not by choice), new political associations formed as old ones fell into disuse, different systems of exploitation were tried, new market and imperial demands taxed agricultural production, food and drink tastes changed, infrastructure was built, canals interconnected, new land opened up, and new armies pressed supplies. This created a highly complex set of interrelations. Old institutions took new names (Stolper 1989), real changes often hid behind old labels (Jursa 2010b), political events changed the elite's relationship to land (Dornauer 2016, p. 187ff.), and established patterns, slowly fading away, held vestigial importance.

Flora[1]

The general Mesopotamian diet was cereal based, complemented by vegetables, fruits (especially dates), legumes, pulses, meat, and fish (on eating in general, see Jursa 2016). The Iron Age evidence fits this pattern, although we do see greater utilization of the date palm and date products (Jursa 2010a, p. 171ff.) and have some hints at increased meat consumption (Waerzeggers 2010, p. 258ff.; Kozuh 2014). Certain genres of Mesopotamian texts – namely, lexical and medical text – recognize a variety of types of cereals, legumes, vegetables, and herbs (Salonen 1968). Texts associated with the administration of agriculture reflect institutional concerns and deal in the main with barely and dates, often undifferentiated by quality or type. Other cereals (wheat, emmer, and sesame) occur less frequently, while certain vegetables (like onion or garlic) appear with regularity in particular archives.

Iron Age Mesopotamians ate barely as their staple (in general, see Potts 1997, p. 56ff.), which was the principal ingredient for bread and beer (for changes in beer consumption, see below). Compared to other cereals, barley is heartier, ripens earlier, yields more, and tolerates soil salinity better (but see also Powell 1985). There seems little doubt that the Iron Age saw an intensification of barley farming; texts suggest closer furrowing and seeding, which led to higher yields (Jursa 1995; Janković 2013). Although barley farming was ubiquitous, central Mesopotamia began to turn toward intensive date plantations in the early part of the first millennium BCE, whereas southern Mesopotamia and the marshy Sealand area remained predominantly barley-growing. Wheat was the second most common cereal, but we also find spelt, einkorn, rye, sesame, and flax. Sesame is a summer crop, planted immediately after the barley harvest. Its seeds have uses in cuisine, but Mesopotamians primarily pressed it for oil (Stol 1985). They cultivated flax for linen (Zawadzki 2006, p. 23ff.).

Legumes and vegetables, while amply attested in non-economic texts, did not lend themselves to the types of long-term, heavily documented relationships that we find for various cereals. That said, we find lentil, various types of pea, chickpea, broad bean, lettuces, cabbages, cucumber, carrots, radishes, beets, and turnips (Postgate 1987b; Stol 1987; Potts 1997, p. 62f.). Vegetables that can be transported and stored do find good attestation in business records. The transport of onions (or garlic, the term is unclear) from the hinterland

1 In general, see the articles in *Bulletin on Sumerian Agriculture* for specific information on cereals, vegetables, legumes, vetches, and timber, and add Powell 2003, Stol 1983–1984, Jursa 1995, Janković 2013, and Potts 1997.

to the capital was one of the specialties of the Nur-Sin branch of the Egibi family, who grew them as a cash crop (Abraham 2004, p. 143ff; Jursa 2010a, p. 391ff.). For herbs and spices, we have solid attestations of coriander, cress, cumin, fennel, fenugreek, leek, marjoram, mint, mustard, rosemary, rue, saffron, thyme, dill, and hyssop (Potts 1997, p. 65f.; Bertman 2003). There are, of course, dozens if not hundreds of spice and herb plants grown in Iron Age Mesopotamia whose modern identification is unknown.

The date orchard took pride of place in the everyday Mesopotamian farmstead. The palms themselves, growing canal-side, provided shade against the harsh summer for intercropping of smaller fruit trees, vegetables, and legumes. One of the most interesting changes in Iron Age Mesopotamian agriculture is, in central Mesopotamia, a movement toward intensive date palm cultivation to the detriment of arable farming; the visibility of the move is evident in multiple archives from that area (see below, p. 554). Jursa even stresses that this intensive date cultivation resulted in a change in drinking habits. Mesopotamians, rather famously, drank barley beer (Stol 1994); in the Iron Age, Jursa finds the "beer of dates was the preferred drink in Neo-Babylonian times; it had replaced the barley beer of earlier times, which in the first millennium was nearly exclusively used for offerings to the gods" (Jursa 2010a, p. 212). Although dates predominate, a variety of other fruits appear in Mesopotamian sources (e.g. apples, apricots, cherries, figs, melons, mulberries, pears, plums, pomegranates, grapes, and quinces) although rarely in administrative ones (Powell 2003).

Fauna

The key animal for Mesopotamian agriculture was, of course, the ox – the specially trained, often castrated male bovine. In addition to pulling the plow, oxen transported agricultural produce to river stations, towed boats back upriver, and fertilized the soil with manure. We do not have information on the training of an ox to the plow, but it seems to have begun in the steer's second year, as that was when, in temple texts, they were removed from the breeding herds. Indeed, administrative texts only rarely differentiate between breeding bulls and oxen. In fact, administrators seem much more concerned with those males that appear to be "markless" – that is, fit for sacrifice – than with the difference between bulls and oxen. Some texts mention cows pulling a plow (Janković 2013, p. 34). Although attested in early Mesopotamian history, there is no Iron Age evidence for donkeys or horses used in agricultural work.

Sheep and goats played an enormous role in the Mesopotamian economy – the Eanna temple had around 80 000 under its control at any given time in the mid-first millennium (Kozuh 2014, p. 13). Their role in agriculture, though, is minimal. Even those aspects of sheep and goat care that would have affected agriculture (such as the manuring of fields or disputes between farmers and pastoralists over grazing rights) do not appear in the available documentation. The keeping of fish, poultry, and birds is also very well documented, although of limited direct interest for the practice of agriculture (Janković 2004; Kleber 2004).

The Agricultural Calendar

For barley and wheat, the agricultural calendar began in about the middle of the Babylonian year (month VI, or August/September). The harvest and post-harvest work of the previous season was tapering off, the land was dry, and the temperature hot. From then until about month X (November/December) came the plowing and sowing. Irrigation then followed in the early spring (month XII through the new year, months I and II; around February, March, and April), with the majority of the harvest collected in month II, although, depending on conditions, collection could move into months III and IV. The work of preparing and storing the harvest lasted up until and through the next plowing (Jursa 1995; Potts 1997; Janković 2013, p. 404).

For other major crops, the date harvest took place in Babylonian months V–VII (roughly July through October). Unlike wheat and barley, sesame was planted in summer, which created particular difficulties for irrigation and management (Jursa 1995, p. 176ff.). As Janković shows (Janković 2013, p. 404), the temple issued sesame seed in months III and IV of the Babylonian calendar (roughly May to July), so just following the barley harvest. Temple administrators registered yield estimations, which took place right before the harvest, in months VI and VII (roughly August to October).

Technology

The writing stylus is perhaps the least appreciated piece of agricultural technology from Mesopotamia. By aiding Mesopotamians in creating hierarchical, long-lived, and highly complex relationships around agriculture and the exploitation of land, a vibrant writing tradition did as much as plows, oxen, or iron to transform the Mesopotamian landscape. It did so in ways that left no trace of recoverable material culture other than the texts themselves. Indeed, in the same way that texts preserve the memory of these relationships for us today, they also allowed Mesopotamians to enter into sophisticated relationships across large distances, for long periods of time, and between a diverse array of people.

High-level control of land often found its way into ceremonial and display writing. In the Mesopotamian *kudurru* tradition (Brinkman 2006; Paulus 2013), royal administrations codified complex agricultural arrangements with temples on monuments, usually of stone, which preserved the text of the agreement surrounded by exceptionally ornate and unusual divine iconography (Seidl 1989, and Figure 26.3). The legal arrangements on *kudurru*s often detail the size of the land (and any villages included with it), the division of the harvest, and reciprocal tax and service obligations and exemptions. Although meant to last in perpetuity, some *kudurru*s demonstrate that arrangements fell into disuse (Woods 2004). As the *kudurru* tradition died off in the early Iron Age, control of land was marked in royal inscriptions and private tablets. Claims to age-old rights and privileges could be reinstated when Mesopotamians unearthed a long-lost *kudurru* or other type of text detailing similar rights and privileges. Such documentation allowed officials to approach a new regime with their rights and privileges after political change, which brought stability and long-term exploitation. High-level writing, then, codified the responsibilities, rights, dues, and privileges for large tracks of land in a physical referent, one whose force could be reinstated, reinforced, and brought to bear when challenges to those rights arose.

The basic cuneiform text provided even more flexibility (Baker 2011). Like *kudurru*s, clay texts marked long-term arrangements over land (Ries 1976; Wunsch 2000; Jursa 2004c; Janković 2013, p. 337ff.; Paulus 2013, p. 338ff.), allowed authorities to manage land and agriculture from afar (MacGinnis 1995; Jursa and Wagensonner 2014), challenge claims, track deliveries, record and challenge instances of thefts and corruption (Holtz 2009), manage disbursements, codify harvest estimates (Cocquerillat 1968; Janković 2013), and control distribution. We also have cadastral surveys and other graphic agricultural texts (Nemet-Nejat

Figure 26.3 A Babylonian Kudurru. Source: Permission of Sailko. Licensed under CC-BY- SA 3.0. From https://bit.ly/2tPzaTI

1980; Nemet-Nejat 1982; Jursa 2010a, p. 386ff., and see Figure 26.4a, b). Moreover, remote monitoring of lands and harvests let urban elites and temples manage land and estates from a city. As canal building and interlinking opened up more land in Mesopotamia, this ability played a crucial part in its exploitation.

But one should not take this too far – among other things, the curses against noncompliance often take up the greater part of a *kudurru*, which indicates that relationships, even if codified in writing, sustained challenges. The cadastral surveys, however interesting, are rudimentary and of uncertain use. Measurements are about as precise as they could be, culturally determined and particularized, and not necessarily meant to hold up under scrutiny (not that we should expect them to have been scrutinized). Even the vast cuneiform legal and administrative text tradition holds an uncertain relationship to validation (Kozuh 2015). Indeed, perhaps most telling is that the era during which the site and satellite surveying shows major growth and land reclamation – the Hellenistic through Sassanian periods (Morony 1981, 1984, pp. 99–124; van der Spek 1985, 2000, 2006; Aperghis 2004, p. 36ff.) – are ones for which we have the least amount of written evidence, especially for the quotidian aspects of

Figure 26.4a Late Babylonian field plan (BM 78148), obverse. Source: © The Trustees of the British Museum. All rights reserved.

land management. Thus, widespread writing on inexpensive media is not a necessary prerequisite for large-scale agricultural exploitation. It is instead one technology among many.

For technologies specific to agriculture, the relationships codified on cuneiform tablets allow us to see the process by which authorities *wanted* to employ the technological system associated with agriculture. We can then contrast that with the ways Mesopotamians actually put that system into practice. In other words, various authorities envisioned an ideal plow-and-oxen system of technological exploitation and tried to put that ideal into operation; the process by which that ideal failed or succeeded to find reality on the ground is the process that turns up in many of our texts.

For example, the so-called edict of Belshazzar (van Driel 1987–1988; Janković 2013), issued to the rent farmers of the Esagil temple of Babylon, prescribes an exact management routine for the exploitation of temple land and date plantations. It details "the size of the plots, the means of production (tools, draft animals, plowmen, seed) assigned to [the rent farmers], the expected revenues, and the administrative fees" (Janković 2013, p. 38). In general, the edict sees one plow team, consisting of a plow and four oxen, working 30 *kurru* of land (just under 40 hectares), 25 of which were expected to produce 300 *kurru* of barley (about 54 000 liters) for the temple. Five *kurru* of land were set aside for administrative costs, fodder, rations, and seed corn. For date plantations, it prescribes 40 *kurru* (7200 liters) of dates for every *kurru* of land. But van Driel points out some basic issues here: it makes no mention of the age of the trees or the number of trees per measure of land (van Driel 2002, p. 168f.).

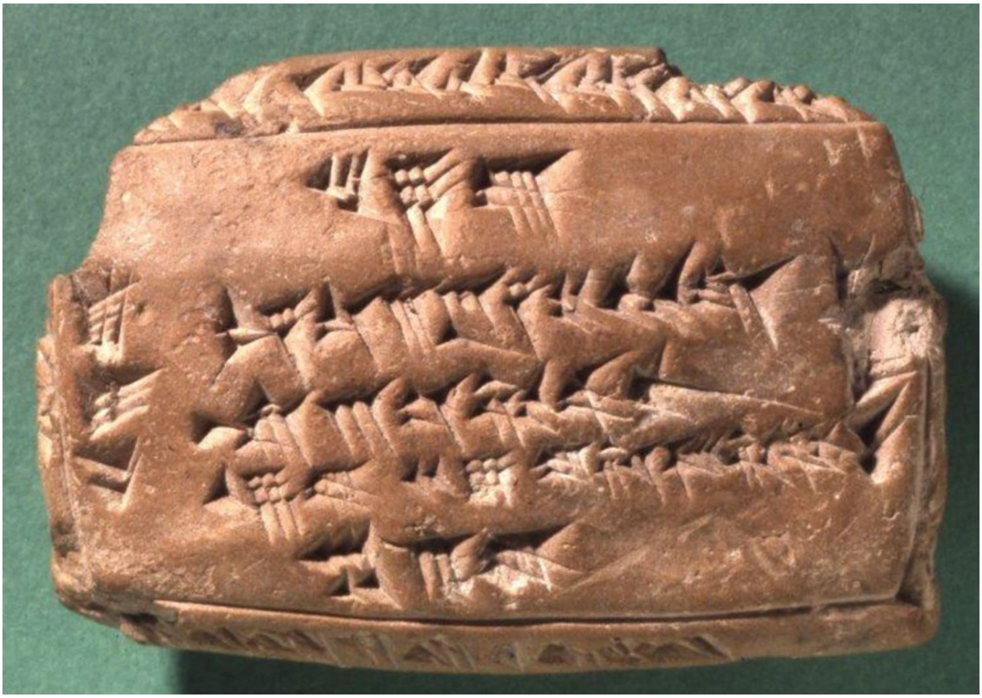

Figure 26.4b Late Babylonian field plan (BM 78148), reverse. Source: © The Trustees of the British Museum. All rights reserved.

Although the edict deals in particular with the land of the Esagil temple of Babylon, a copy of the edict was preserved at Uruk, so it is thought to have something like Mesopotamia-wide applicability (van Driel 2002, p. 167). Many have investigated the stipulations of the edict; Janković, in particular, works through the way it may have been applied at Uruk (e.g. with potential seeding rates, furrow widths, and plow speeds). She concludes that the stipulations of the edict "must have been understood as guidelines – something like a generally applicable yield factor (here: 12) cannot have existed since yields were largely influenced by such variables as the quality of soil and seed, availability of water and climatic conditions" (Janković 2013, p. 41).

Yet it is not clear how – or even that – temples employed the edict as an administrative guideline. Rather, as van Driel discusses, the edict probably functioned more to define relationships between the various parties identified in the text than to set administrative standards (van Driel 2002, p. 166; Janković 2013, p. 48f.). We see a similar situation in livestock management (Kozuh 2014; Kozuh 2015). Indeed, temples had another administrative regime, centered on *imittu* ("estimation") texts, that reported estimates of a field or orchard's production and determined the dues to the temple just before the harvest (Cocquerillat 1968, p. 53ff.; van Driel 2002, p. 168f.; Janković 2013, p. 137ff.).

If nothing else, the documentation shows Mesopotamian administrators trying to bring order to the agricultural economy, and central to that order was the plow-and-oxen system. Institutions often supplied plows and oxen on contract, either temples to their large-scale rent farmers or agricultural contractors like the Murashu firm to their tenants (Stolper 1985, 2005; Jursa 1995; Janković 2013). We do not have much Iron Age information on how

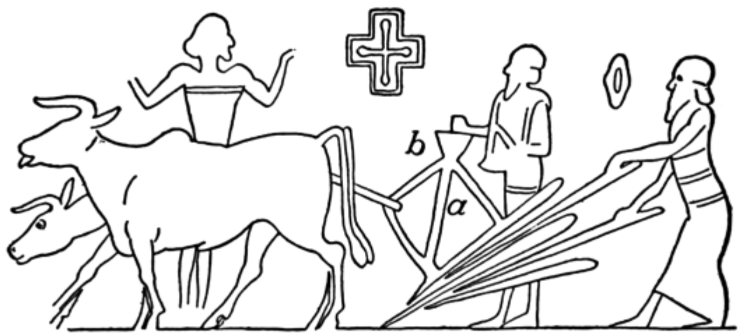

Figure 26.5 Image of the seeder plow. Source: Courtesy of Potts (1997).

plows, or other major tools of agriculture, were stored or repaired. Temples supply us with the best information, meager as it is, on tool manufacture (Zawadzki 1985; Bongenaar 1997; Payne 2008), but little on upkeep and storage. Some of the best information on these aspects of agriculture date to early Mesopotamian history (Hruška 1999), yet there is good reason to assume, given the institutional background of the texts, that Iron Age Mesopotamia saw similar conditions and maintenance regimes. If that is the case, at least among sectors of society that generated texts, plowing as a skill and technique remained associated with institutional agriculture, not that of the yeoman farmer. We simply do not find instances of the household farm with a plow in the shed, nor examples of cooperative farming with communal oxen and plows.

For the plow as a technology, most attention focuses on the seeder attachment ("a" in Figure 26.5):

The seeder has been called "arguably the most important piece of technology ever developed in Mesopotamia … [which] was undoubtedly the key to the exceptionally high yields recorded there" (Potts 1997, p. 78f.). There are a few issues here, and Hruška's work (Hruška 1988, 1999) is crucial. First, the importance of the seeder plow comes in its economical use of seed, not in its ability to affect yields (Halstead 1990). Second, Mesopotamian depictions of the seeder usually show a technology entirely unworkable as engineered; the parts are shown without connections to each other (i.e. without ropes or bolts), and, as in Figure 26.5 *part a*, the seeder is often shown as part of a mechanism attached directly to the animal yoke, which makes a weak attachment between the plow and the yoked oxen. The pull-force from the oxen against the resistance of the ground would immediately break the seeder off. Third, depictions of the plow are often in a context that we can broadly call mythological or supernatural and not one of everyday life. Finally, farmers prefer seeding by hand and, given the choice, eschew the seeder and its regulation of the seeding. This probably explains why seeder funnels have little currency in other agricultural regimes in world history. Given the would-be connection between the seeder and dramatically increased agricultural productivity, one would think that this surprisingly simple addition would have taken root in other societies.

All of this points toward a line of inquiry that needs further investigation. Rather than a technological innovation in agriculture, the seeder strikes me more as an administrator's technology, one whose proper categorization belongs not with shovels and hoes but with measuring sticks and scales. To put it another way, by controlling the means of production and the land, scribal accountants and authorities took an interest in what we can broadly call control and efficiency. This obviously manifests itself in the vast body of texts from ancient Mesopotamia, but any technology that encourages and regulates authoritative precision, or that produces uniformity (like in furrows and seed depths), is one that is largely in the purview of administrators, not farmers and peasants. This is one of the main points of the Sumerian *Debate between the Hoe and the Plow* (Vanstiphout 1984); the plow belongs to administrators and the elite, the hoe to workaday Mesopotamians. The depictions of unworkable seeders in mythological contexts only add to this point – they depict administration and control, not quaint farm life. One can, as many scholars do, stress the actual benefits of the seeder to agriculture, or its fitness for large-scale agriculture; at the same time, the fact that it did not have widespread adoption in plow societies, and was generally eschewed by farmers, reveals obvious counterarguments. Evidence for the use of the seeder in a non-institutional Mesopotamian context might challenge this observation, but I am unaware of any. Whatever the case may be, we need to take caution is attributing a direct causal relationship between the seeder and the would-be high yields of Iron Age Mesopotamia.

Major Aspects of Agriculture

Five issues in Iron Age Mesopotamian agriculture have attracted substantial attention. The first is the connection between a wetter Iron Age climate and empire in northern, rain-fed Mesopotamia. Second is large-scale agricultural contracting, for which Mesopotamian temples and the Murashu firm provide the most comprehensive documentation. Third involves the settling and integration (to various degrees) of outsiders on Mesopotamian land – some of whom migrated in, others settled on Mesopotamian land in exchange for military service, and still others were forcibly moved to Mesopotamia under the imperial traditions of the first millennium BCE. Fourth is the establishment of an infrastructure for opening up new land and moving water and goods throughout Mesopotamia. Finally, we can see the effect of this infrastructure building on the specialization and intensification of regional agriculture in Mesopotamia.

Relative to the Bronze Age, a wetter Iron Age climate brought about an expansion of arable land in northern, rain-fed Mesopotamia in the early first millennium BCE. Dornauer estimates that, between 900 and 750 BCE, northern Mesopotamia saw an expansion of between 23 000–35 000 km^2 of new surface area brought securely into the minimum 350–400 mm isohyet for rainfall agriculture, with another 19 000–28 000 km^2 on the rainfall margins (Dornauer 2016).

Contemporaneous with this wetter climate, the Assyrian empire embarked on a program of land reclamation and settlement. Using established political and legal institutions – namely, the administration of *kapru*-land – the empire settled unfree populations (of deportees, slaves, and sedentarized nomads) on newly and marginally productive land. This land directed resources to the Assyrian elite and ensconced a dependent population in place (see also Rosenzweig 2018). As in late Bronze Age Assyria, the land had limited alienability, with restrictions working to thwart long-term and inter-generational control. As Dornauer argues, this reclamation worked as a slow-moving land improvement project. It kept desertification at bay, but the system of centralized administration, feudal economic incentives, and limited alienability generated a middling regime of land exploitation. Following political turmoil in the mid-eighth century, the Assyrians seem to have opened up this land to full alienability, which, in turn led to more intensive use, capital, and state investments in water-moving projects, and capitalist-like economic motivations.

In Babylonia, the institution of the rent farmer (also called the fermier général or Generalpachter; see Janković 2013, p. 145f.), known primarily through the Eanna temple of Uruk and the Ebabbar temple of Sippar, is one of the prominent features of Iron Age

Mesopotamian agriculture. Smaller archives of texts show involvement in similar contracting at less expansive levels (Jursa 2005b, p. 60ff.). These temples put large tracts of land and date orchards under the control of individual contractors for a stipulated, contractually set amount of the harvest. Temple contracts included limited access to institutional manpower and technological capital, but also anticipated that the contractor would bring in his own labor and capital, and sharecrop part of the land. Temples also directly employed sharecroppers on some land, and farmed other land with their own personnel (Jursa 1995, p. 81ff.; Janković 2013, p. 62ff.).

Most analyses of the rent farmer system contemplate how the contractor profited from his relationship with an institution (Jursa 1995, 2002; van Driel 1999; Janković 2013) – how (or if), in effect, he met his contractual obligations, offset his own contributions in manpower and capital, and then had overage left for himself. As a result, scholars largely frame the discussion in economic and administrative terms such as efficiency, inputs, outlays, profit, risk mitigation, and institutional income guarantees. These analyses, while certainly capturing important aspects of this relationship, hit some obstacles (van Driel 1987–1988, 1999; Jursa 2010a, p. 288ff.). Among other things, it is not altogether clear that, just in terms of expectations and raw numbers, a contractor *could* profit from this relationship with a temple (Janković 2013, p. 46ff.; for the parallel in animal management, see Kozuh 2014). Some obstacles certainly stem from the nature of the evidence, but others, I think, will eventually find resolution in new lines of inquiry.

The Murashu family firm leased and managed the land of state feudatories around the city of Nippur in the fifth century BCE (Stolper 1985). These feudatories, grouped into units called *hatru*s, leased their land and water rights to the firm, which paid them rent and taxes in exchange. The firm then subleased the land to its tenants, usually along with agricultural capital (mainly oxen, plows, and seed corn). Of the expenses, "the major determinant of the tenants' costs was the livestock and equipment needed to work the land … as a general condition, land was cheap but stock and harness were costly" (Stolper 1985, p. 130). The firm also managed the estates of Persian notables and made loans in silver.

The common bond between the rent farmers and the Murashu firm seems evident enough – following a common pre-Industrial pattern, Mesopotamian institutions, primarily temple and state, controlled vast amounts of land but had limited access to manpower, water infrastructure, and technological capital in farm equipment and animal power. The contractors – entrepreneurs in the etymological sense (Jursa 2010a, p. 286ff.) – had the ability to bridge this gap. We wish we had a better understanding of this ability, as glimpses at it prove interesting and tantalizing. Some temple contractors, for example, had connections to the crown in Babylon (Jursa 2004a; Kleber 2008; Kozuh 2014); one particular contractor attracted attention, much of it negative, from the Eanna's upper-level administration (Jursa 2004b; Janković 2013; Kozuh 2014). Moreover, the Murashus collected rents in kind and paid its lessees and other clients in silver (Stolper 1985), which bridges another sort of gap of major importance for the economic and social history of Iron Age Mesopotamia (Jursa 2005a, 2010a, p. 469ff.).

Iron Age Mesopotamia saw the settlement (or perhaps the reformulation) of a variety of new ethnic groups. Some, like Persians or Macedonians, came in as conquerors, often with multinational armies in tow. Others apparently migrated in during the upheavals of the late Bronze and early Iron ages. Of these, the two most prominent groups were the Arameans and the Chaldeans (Brinkman 1977; Fales 2003, 2011; Frame 2014; Younger 2015). The Arameans, who maintained their tribal identity, held territory along the Euphrates, in spots throughout central Babylonia, and then along the Tigris between Mesopotamia and Susiana. Arameans were both settled and nomadic, and one finds Arameans associated with agricultural work (with other West Semites) among the lower-rung population in Mesopotamia. The Chaldeans are more difficult to assess. They appear in texts largely Babylonianized – mostly settled, living in cities, taking Babylonian names, but maintaining a tribal structure and identity (Frame 1992, p. 32ff.). The Bīt Yakīn, one of the three main Chaldean tribes, may have controlled a vast cereal producing land in far southern Babylonia (Beaulieu 2002; Jursa 2010a, p. 91ff.). Moreover, empires settled victims of its mass deportation policy on Mesopotamian land (Oded 1979). The archive of resettled Jews, mentioned above, is concerned mostly with routine agricultural matters (Pearce and Wunsch 2014). It is also possible that some ethnic enclaves were set up in order to facilitate trade (Bongenaar and Haring 1994; Waerzeggers 2006; Kleber 2008).

These newly arrived Mesopotamians were integrated into an expanding agricultural infrastructure, especially in northern Babylonia. Some of this infrastructure was the result of imperial policy – Radner, for example, argues that Assyrian kings were intimately familiar with the land, which helped to launch them on a series of reclamation and expansion programs (Radner 2000; see also Thomason 2001; and Dalley 2013). In the seventh century, early Neo-Babylonian kings constructed an extensive canal network (anchored by the *nar sharri* "the king's canal") in northern Babylonia, opening up a vast quantity of new land. The most informative evidence for this reclamation comes from the Ebabbar temple of Sippar (Jursa 1995; Da Riva 2002), although the management and exploitation of this new land can be seen in various ways, and at various levels, in almost all archives from northern Babylonia (Jursa 2010a, p. 316ff.).

This imperial building policy generated a second-order infrastructure. The canal network, for example, facilitated intercity and city-to-hinterland connections; these connections then created new social institutions, intensified markets, and circulated money (Jursa 2010a, p. 750ff.). In terms of agriculture, we find regional specialization and intensification of certain sectors of agriculture in the mid-first millennium BCE. The texts show, from a variety of angles, that northern Babylonia underwent an intensive transformation to cash-crop date farming, and the marginalization of arable farming, in service of urban markets (Jursa 2010a, p. 324ff). This amply documented process is not something that one finds Babylonia wide – Nippur, as seen through the Murashu archive (Jursa 2010a, p. 405ff.), does not seem to follow a similar pattern, nor does Uruk in southern Mesopotamia (Janković apud Jursa 2010a, p. 418ff.). Neither of these places shows evidence of large-scale infrastructure building nearby. This transformation of northern Babylonia bespeaks important changes of various other sorts – behind the planting of cash-crop date plantations is the assumption of long-term stability, not only in politics and administration, but also in markets and infrastructure. Moreover, the business behind this long-term stability took place in cities, which generated further secondary effects, such as the creation of strong administrative and intellectual classes. In other words, long-term stability, coupled with regional interconnections and interdependencies, the influx of immigrants, and a learned urban class, provided the base for the cosmopolitanism and sophistication that has long been associated with Iron Age Mesopotamia.

Changes in the Practice of Agriculture

Other than the transformation of northern Babylonia toward intensive date farming, changes in economic, administrative, social, and political aspects of agriculture all represent, in their own ways, continuities to age-old agricultural practice in Mesopotamia. Agricultural contracting has its pre-Iron Age precursors (Wilcke 2006); the Iron Age only saw changes in scale and purpose, with considerably more land and capital put under the control of connected individuals. Royal involvement in temple land contracting seems novel, but is of a kind with the *Palastgeschaft* of earlier periods (Renger 1994, 2000). Empire, of course, had its world historical origin in Mesopotamia (Foster 2016), and the Bronze Age saw instances of new settlement in Mesopotamia. For the Iron Age, again, the changes in mass deportation were a matter of a dramatic increase in scale coupled with the building of a permanent infrastructure to move and settle people. Indeed, over the course of its history, Mesopotamia regularly incorporated outsiders into its larger culture. The absorption of deportees and military settlers involved deliberate policy rather than slow migration. Moreover, those settlers did not bring radical new farming techniques or technology – some brought a simplified writing system (Beaulieu 2006) and perhaps they tended to plants from their homeland in local or imperial gardens – but, to the extent that we can discern, they readily adapted to Mesopotamian agricultural and administrative techniques.

In this sense, then, we do not find (nor should we expect to find) major technological or social changes to the practice of agriculture – as others have noted, the incorporation of iron into the plowshare may have had some effect, but it is difficult to discern (Jursa 2010a, p. 48; Janković 2013, p. 41). There are, however, four areas where we find perhaps not innovation but technological prowess in the practice of Iron Age Mesopotamian agriculture. The first, discussed above, is simply in the adjoining of the canal network in lower Mesopotamia – this seems to reach its florescence in the Sassanian period, but has clear antecedents in the early–mid first millennium BCE. Also, the Iron Age saw Mesopotamians learn how to draw from the Tigris for regular irrigation (Adams 1981, p. 7). Second are the gardens of Nineveh, which, as Dalley has shown, were almost certainly misattributed to Babylon in antiquity (Dalley 2013). We can connect the Nineveh gardens to the third area of prowess, which is the construction of gardens to symbolize and embody empire (Stronach 1990; Tuplin 1996; Novák 2002). Finally, the Assyrian king Sennacherib built a highly sophisticated canal network in Assyria, which we know both from Assyrian sources, satellite images, and ground confirmation (Bagg 2000; Ur 2005). Sennacherib's description of his canal system seems to include references to water lifting technology that is very much like the Archimedes screw (Dalley and Oleson 2003).

Debates and Trends

Mesopotamian studies as a field is not quite in a place that encourages analytical debates. There are, however, six issues that should provoke future scholarship:

First, which aspects of agricultural change and development can we attribute to elite policy, and which may have resulted from unplanned economic, cultural, and technological change? This is not a simple question with a zero-sum answer; among other issues, it assumes a much deeper understanding of Mesopotamian political relationships than we currently have. Moreover, we need a better understanding of what institutional policy might entail – certainly building and water-infrastructure projects, but can we assume there was a royal agriculture policy that had tangible effects? If so, what did that policy aim to achieve? To whose specific benefit and by what means? When it comes to the business of agriculture, what of the age-old conflict between an entrenched aristocracy and the *nouveau riche*? The field would provide the enterprising researcher with interesting source material – the macro-view from satellite imagery and ground surveys and the ample micro-histories of the cuneiform text tradition. The distance between the two opens space for real exploration. Unfortunately Rosenzweig's work came to my attention only late in the drafting of this article, but is very promising in carving out new ways forward (Rosenzweig 2018).

Second, related to the first, how exactly did the documentation relate to the economy? We lack clarity as to why Mesopotamians documented some things over others, in some ways over others. Jursa (Jursa 2004a) gives two poles for thinking about documentation – either for policing or for planning/prognostication – but this needs further nuancing (Kozuh 2015). If nothing else, we need a better understanding of what policing and planning mean. Here, approaches that consider path dependency, the history of accounting, the history of pre-industrial institutional planning and infrastructure management, and *longue dureé* Mesopotamian history should prove fruitful. One might push this further and investigate which aspects of the cuneiform-heavy Iron Age survived as cuneiform died off as an administrative medium.

Third, how might we understand rent farming beyond profit and economic rationality? To put the issue bluntly, the rent farmers had control over land and people, the two main sources of capital in the pre-industrial world. That in itself should raise skepticism that using only economic approaches to their motives give us a full picture. The texts show interesting – and at times colorful – connections between rent farmers and the crown in Babylon, so we do not necessarily have to draw deep from the well of political science to establish some productive assumptions. Here one might turn to Holloway's (2001, p. 238ff.) suggestive discourse on imperial patronage and clientship for inspiration.

Fourth, issues related to the storage and channels of distribution of agricultural produce need further study. Jursa's work on market mechanisms and monetization brilliantly shows one aspect of this (Jursa 2010a, p. 500ff.), but broader connections between empire, storage, and distribution need exploration. Although well before the Iron Age, Tate Paulette's work (Paulette 2015, 2016) provides some very interesting vistas.

Fifth, how do we balance the evidence, as problematic as it is, for higher yields and population growth against the static nature of premodern populations, as Johnathan Tenney (see also the discussion in Jursa 2010aff., p. 781ff.; Tenney 2017) discusses.

Sixth, as this chapter indicates, work is much needed on post-cuneiform agriculture in Mesopotamia. Van der Spek's work is invaluable, and Pirngruber's book is much appreciated (Pirngruber 2017). But the Parthian and Sassanian empires, for which the archaeology shows tremendous growth and expansion, need serious attention.

GUIDE TO FURTHER READING

Jursa, M. 1995. *Die Landwirtschaft in Sippar in neubabylonischer Zeit*. Vienna: Institut für Orientalistik der Universität Wien, is the founding contribution of the Vienna school, concentrating on agriculture in the area of Sippar. Janković, B. 2013. *Aspects of Urukean Agriculture in the First Millennium BC*. PhD Thesis: University of Vienna, is the only work in English explicitly on agriculture, but incorporates and expands upon the Vienna school's insights. Kozuh, M. 2014. *The Sacrificial Economy: Assessors, Contractors, and Thieves in the Management of Sacrificial Sheep at the Eanna Temple of Uruk (ca. 625–520 B.C.)*. Winona Lake, IN: Eisenbrauns, studies the administration of the Eanna temple's vast resources in sheep. For northern Mesopotamia, see Dornauer, Aron. 2016. *Assyrische Nutzlandschaft in Obermesopotamien: natürliche und anthropogene Wirkfaktoren und ihre Auswirkungen*. München: Herbert Utz. Jursa, M. 2010. *Aspects of the Economic History of Babylonia in the First Millennium BC: Economic Geography, Economic Mentalities, Agriculture, the Use of Money, and the Problem of Economic Growth*. Münster: Ugarit-Verlag, is clearly monumental and important, with large sections dedicated to agricultural issues. It is still in the process of digestion by the field. All of these works require background knowledge in cuneiform studies. Jursa's 2010 contribution assumes some knowledge of economic history.

At a more general level, Klengel, H. and J. Renger, eds. 1999. *Landwirtschaft im Alten Orient: ausgewählte Vorträge der XLI : Rencontre Assyriologique Internationale Berlin, 4.-8.7.1994*. Berlin: Reimer, is the collection of papers presented at the 1994 annual meeting of Cuneiform Studies, dedicated to the study of Mesopotamian agriculture. The submissions are of uneven quality. *Bulletin on Sumerian Agriculture*, published intermittently between 1984 and 1995, contains many of the foundational works for the subfield, with outsiders contributing scientific and anthropological contributions. It is very light on Iron Age information, the work of Van Driel excepted. Most submissions are in English. Potts, D.T. (1997). *Mesopotamian Civilization: The Material Foundations.* London: Athlone and Moorey, P.R.S. (1999). *Ancient Mesopotamian Materials and Industries: The Archaeological Evidence.* Winona Lake, IN: Eisenbrauns, are both accessible to the non-expert, although ranging widely in coverage.

The work with spy satellite images moves very quickly – the following websites are regularly updated:

Erbil Survey: http://scholar.harvard.edu/jasonur/pages/erbil
Greater Zab Survey: http://archeo.amu.edu.pl/ugzar/project.htm
Eastern Haburn Archaeological Survey: https://jasonherrmann.net/research/ehas/
Sirwan Regional Project: http://www.gla.ac.uk/schools/humanities/research/archaeologyresearch/projects/sirwanregionalproject/
Italian Archaeological Mission in Iraqi Kurdistan (MAIKI): http://iraq.routes-assn.org/en/maiki.all
The Center for Ancient Middle Eastern Landscapes (University of Chicago): https://oi.uchicago.edu/camel

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CHAPTER TWENTY-SEVEN

Iran and Central Asia in the Achaemenid and Hellenistic Periods

Rachel Mairs

The zone from the Zagros Mountains and the Iranian plateau to the Amu-darya and Syr-darya river valleys of southern Central Asia has historically supported a close symbiosis between settled agriculture and a mobile pastoral economy. In the second half of the first millennium BCE, this region formed the northeastern marches of the Achaemenid Persian empire and the Seleucid empire. These empires, which will be the primary focus of this chapter, struck a balance between centralized management of agriculture and careful maintenance of effective local systems of controlling the natural environment and maximizing resource extraction.

Across such a vast and geographically diverse region, two areas have been the focus of particular scholarly attention: the Zagros mountains of present-day western Iran, and the rivers and endorheic basins of Afghanistan, Turkmenistan, and Uzbekistan. Both are regions of great agricultural potential, but are vulnerable to changes in climate and poor management; conversely, individual and state intervention, especially in the management of water resources, can increase productivity.

Farming and Water Management in Central Asia

Southern Central Asia, the northeastern fringe of the Achaemenid and Hellenistic empires, is characterized by large expanses of arid land, unsuitable for arable farming. Rivers originating in the region's mountain ranges, most notably the Hindu Kush, make settled agriculture possible. Several micro-regions – the alluvial fans of the Balkh and Murghab rivers, and smaller-scale irrigation systems based upon the course of the upper-mid Oxus/Amu-darya – have been subject to archaeological investigation, and form the basis of my discussion here. Agriculture has in turn supported the development of urbanism in river oases: the cities of Merv in the Murghab delta and Bactra in the Balkh oasis. The Persian province and later Greek kingdom of Bactria extended from the Pamir Mountains in the east, along the basin of

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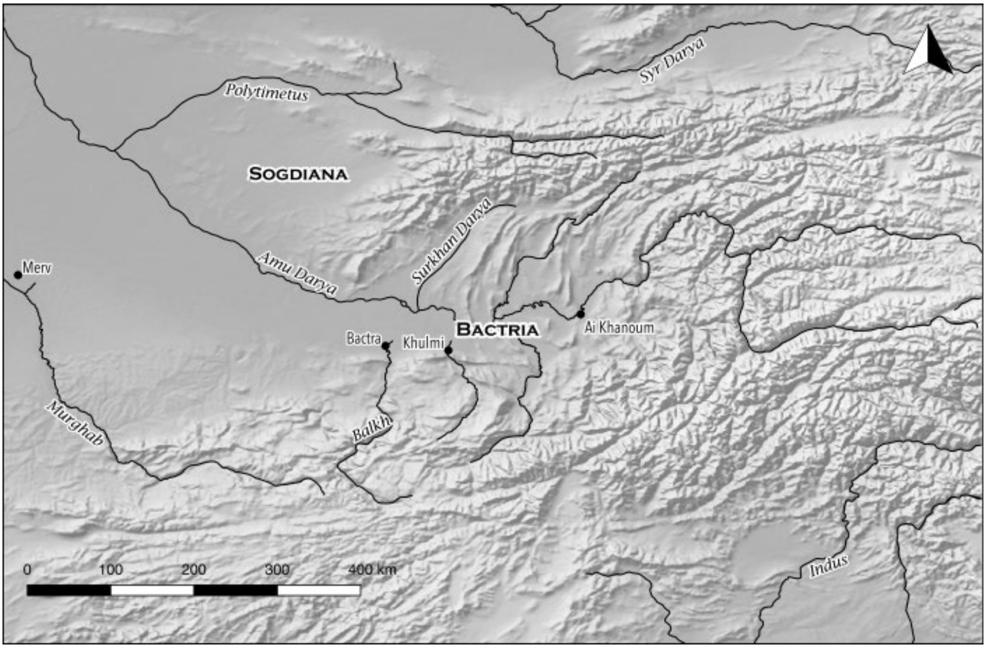

Figure 27.1 Map of Bactria. Source: Map by David Hollander using QGIS, Natural Earth raster data, and map files from the Ancient World Mapping Center. "supplRivers.shp" and awmc-osm-rivers.shp". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm]

the river Oxus, including the valleys of tributaries such as the Balkh and Surkhan-darya rivers. The Murghab delta was ancient Margiana.

The Balkh and Murghab rivers both originate in the Hindu Kush and currently form endorheic basins. The Balkh river once flowed into the Oxus, but the diversion of its waters for irrigation, from antiquity, means that it no longer reaches the larger river. The Balkh river has exhibited "extreme mobility" over time (Fouache et al. 2012, p. 3425), caused, inter alia, by tectonic activity. Regular seasonal floods deposit alluvium, providing rich soil for agriculture, but impeding archaeological excavation. The Achaemenid period is marked by agricultural expansion, with the irrigation of land alongside new and existing channels, but also the renovation of abandoned Bronze Age channels. A huge defensive system was constructed to protect the irrigation network. To the south, a fortress at Chesme Shafa marked where the river emerged from the mountains into the plain. In the north, another fortress at Altin Dilyar and a vast line of walls protected the edges of the irrigated land (Fouache et al. 2012, p. 3425; on the defenses in later periods, see de la Vaissière et al. 2015). It is this area that will have generated at least some of the agricultural production attested in the Bactrian Aramaic documents, discussed further below (Figure 27.1).

The Murghab delta, in present-day eastern Turkmenistan, was also intensively irrigated and protected by defensive systems (Cerasetti 2004). Archaeological field survey and GIS analysis have revealed more about the Bronze Age exploitation of the land than the (Achaemenid and Hellenistic) late Iron Age, but a similar picture emerges of great investment in time and effort to create and maintain irrigation systems – without which agriculture and human habitation would be difficult or impossible. At present, cotton monoculture prevails in the Murghab delta, as in much of lowland Central Asia, but historically cereals were grown (see, e.g. Salvatori et al. 2008, p. 120, on grain processing at a Late Bronze Age site).

In the 1970s, a major geographical and archaeological project was conducted in Eastern Bactria in the hinterland of the well-known Greco-Bactrian city of Ai-Khanoum (Gentelle 1989; Lyonnet 1997; Gardin 1998). As Gérard Fussman has persuasively argued, city and countryside must be considered together, and the best explanation for the location of the city and its development in the Hellenistic period is "the exploitation of farming possibilities on a well-irrigated countryside, associated with the possibility of building a large fortified town on a convenient site" (Fussman 1996, p. 246). Evidence for Achaemenid-period investment in the region has, in my view, been comparatively neglected (Mairs 2014a).

Eastern Bactria has also been subject to agricultural exploitation and artificial irrigation since at least the Bronze Age. Ecological and climatic conditions allow for dry cultivation of cereals such as millet, rye, and barley, wild varieties of which are endemic to the region. Rye is especially well adapted to local conditions, due to its ability to thrive even in dry years. Other potential cultivars include sesame, the post-harvest remains of which can also be dried for animal fodder. With irrigation, the possibilities expand to include legumes, fruit trees, and flax (Vallino and Marinucci in Gentelle 1989, pp. 184–189). Irrigation also allows the growing season to be extended, and creates an artificial ecosystem which attracts wildfowl (Vallino and Marinucci in Gentelle 1989, p. 193).

Agricultural developments in Eastern Bactria should not be matched too closely to the historical record (Gardin 1998, p. 109), as I shall discuss below. Irrigated agriculture expanded considerably over the course of the first millennium BCE, and this is not to be associated solely with either Persian or Greek imperial control. In the immediate area of Ai-Khanoum, however, we can look more closely at how the creation of a major urban settlement affected agriculture. The ceramic record shows an intensification of rural settlement in the plain of Dasht-i Qala, around the city, in the Hellenistic period. Previously unirrigated areas were brought into cultivation, and a new canal was constructed. Jean-Claude Gardin cautions against facile assumptions that "la supériorité de la génie grec" was responsible for bringing culture and development to Eastern Bactria (Gardin 1998, p. 112). What Hellenistic period developments represented, above all, was an expansion and intensification of a preexisting system of agricultural exploitation that was both extensive and elaborate.

More recent field projects along the Surkhan-darya and Sherabad-darya rivers, in present-day Uzbekistan, offer similar opportunities to examine long-term development and irrigation of an area for agriculture. They also generate ethnographic data of interest to archaeologists, and are considered in the final sections of this chapter.

Agriculture in the Bactrian Aramaic Documents

A small number of Aramaic documents are available from Bactria, written on leather and on wooden sticks and dating for the most part to the final decades of the Achaemenid administration, and the very early years of the Greco-Macedonian takeover, in the late fourth century BCE. Most represent correspondence between a regional governor, Bagavant, at Khulmi, and Akhvamazda, the satrap at Bactra (discussed by Naveh and Shaked 2012, pp. 16–18). The management and disbursement of agricultural products is one of the most important topics of this correspondence (Naveh and Shaked 2012, pp. 33–35). Sheep and cattle could be listed as either at pasture (*šrk*) or under shelter (*syt*). Beasts of burden include camels, donkeys, and horses. There are also chicken and geese. Millet and barley were present, and probably also wheat (Naveh and Shaked 2012, p. 34). Grain and flour of different qualities were allocated according to social status. Secondary agricultural products include oil (for consumption and lamp fuel), several different types of wine, vinegar, cheese, and sour milk. Some items (for example, a "purple wool garment of Cappadocia") may have been imported. The agricultural economy was therefore based on a mixture of local grain cultivation; herding of animals for meat, wool, and dairy products, with poultry for meat and eggs; and probably also olive and viticulture.

Some documents pertain to the practicalities of arable farming. Akhvamazda held agricultural estates away from the capital, which Bagavant was charged with administering. Akhvamazda berates him for failing to bring seed corn and sesame into the granary in time (A6). Crops were vulnerable to pests, as can be seen in a letter (A4) from Bagavant to Akhvamazda in which the former requests that soldiers who had been assigned to build a fortification instead be allowed to gather in the harvest, because: “There are locusts, heavy and numerous, and the crop is ripe for reaping. If we built this wall, then the locust, the blight that is in the town, will increase.” Akhvamazda agrees, and orders the troops to destroy the locusts and gather in the crop before returning to their building work. The date of the letter, and thus the harvest, is either June 21, 348, or June 10, 347.

Other documents give less insight into the practice of farming, but tell us much about the centralized management of agricultural products. Text C4, best known for its dating to year 7 of Alexander the Great, gives a detailed account of how grain was collected and disbursed. The date is June 8 324 BCE, the time of the local grain harvest. At a place named Ariavant, an official named Nafabarzana assesses the barley crop and determines how it is to be distributed. Other officials then take these allocations and convey them to other locations, as rations for various “servants,” i.e. those in official employ. The documents naturally concern themselves with state-owned and –directed agricultural ventures: estates farmed to supply rations to employees, and perhaps also for commercial profit. Smaller-scale subsistence farming by private individuals is not represented in the written sources to the same degree.

This is how the local agricultural economy operated under normal circumstances. As the document dated to the reign of Alexander shows, the local administration continued to function after the Macedonian conquest. A document of November/December 330, immediately before the conquest, shows what the satrapy was capable of raising in an emergency. The context is the flight of the usurper Bessus, who had adopted the name Artaxerxes V, into Central Asia, pursued by the army of Alexander. The document in question (C1) lists “Provisions to Bayasa [Bessus] in Maithanaka, when he passed from Bactra to Varnu.” It includes live animals as beasts of burden (a horse and donkey), as well as large numbers for food and/or dairy products (100 grazing sheep, 33 sheltered sheep), along with lambs, cattle, chickens, and geese. Fodder is also supplied. The dry goods provided are flour, meal, and spices; liquids include oil, vinegar, wine, and sour milk. We do not know how much of a strain this provisioning of Bessus’ army put on the local agricultural economy, and population. Flour evidently remained in storage from the grain harvest six months earlier, but there was another six months to go before the next harvest, and it is unclear how far supplies were already exhausted. The loss of so many sheep – especially young sheep – not only took away immediate sources of protein (meat and milk) but also had potential long-term effects, in reduction of breeding stock and loss of wool which would have been sheared in the spring.

Far fewer documentary texts are available for the third century BCE – and few of these concern agricultural matters – so it is difficult to determine how far continuity in the management of the land and its produce persisted into the Hellenistic period. An Aramaic-script ostrakon from Ai-Khanoum, of uncertain date, bears a fragmentary list of names and a quantity of barley (Harmatta 1994, p. 390). Some of the Greek jar inscriptions from the Ai-Khanoum treasury, which date to the mid-second century, concern quantities of olive oil (Rougemont 2012, Nos. 117–120). The rest of the texts from the treasury concern coins, and the archaeological finds from the structure include luxury goods such as lapis lazuli, supporting the notion that olive oil is an imported product of comparatively high value.

Agriculture and Pastoralism in the Zagros

Like Central Asia, the upland and mountain landscapes at the western edge of the Iranian Plateau have supported human exploitation of natural resources for millennia (on human management of plant and animal food sources in the Neolithic Zagros, see Matthews et al. 2013). The natural environment, however, is very different: a long mountain range that separates lowland Mesopotamia from the elevated, varied landscape of the Iranian plateau. The Zagros receives seasonal rain and snow, and historically was more heavily forested than at present (Briant 1982, 64). Different flora and fauna, and thus modes of subsistence, are supported at different altitudes, and vertical pastoral transhumance has historically been crucial to the local economy. The middle Zagros, in particular, benefits from year-round water courses and zones of flatter ground suitable for arable farming (Boucharlat in Briant and Boucharlat 2005, pp. 249–255). Two major Achaemenid urban and administrative centers, Persepolis and Pasargadae, are located in the southern Zagros, in present-day Fars province. Archaeological field survey has revealed systems of canals, dams, and sluices in the neighborhood of these cities, in a region where run-off from the mountains makes agriculture from surface water possible (Henkelman 2012, pp. 959–960; Kleiss 1991; Kleiss 1992) (Figure 27.2).

As in Central Asia, our evidence for Achaemenid and Hellenistic agriculture comes from a combination of archaeological and textual evidence, but the balance is toward the latter.

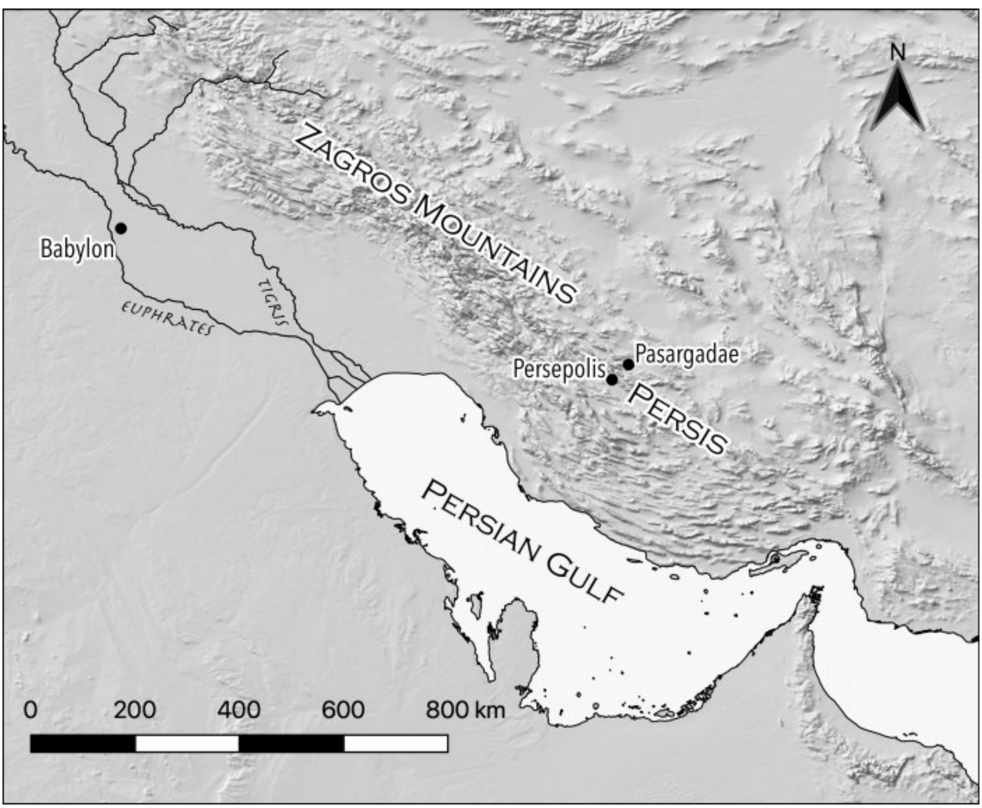

Figure 27.2 Map of Persis. Source: Map by David Hollander using QGIS, Natural Earth raster data, and map files from the Ancient World Mapping Center. "supplRivers.shp" and awmc-osm-rivers.shp". <http://awmc.unc.edu/wordpress/map-files/> [Accessed: May 31, 2018 4:13 pm]

Western Iran, the Achaemenid heartland, has, ironically, yielded less archaeological material from the Achaemenid period than regions such as Central Asia or Mesopotamia – for reasons that include scholarly neglect (Boucharlat in Briant and Boucharlat 2005, p. 221). As regards the relevance of the region to the history of agriculture, earlier scholarship proposed that Achaemenid north-western Iran was the place of origin of the *qanāt*, an irrigation technique that then spread throughout the Middle East and North Africa under Achaemenid initiative. More recent research suggests instead that the *qanāt* was not used in Iran before the first millennium CE (Boucharlat in Briant and Boucharlat 2005, pp. 277–278). Current archaeological projects offer the promise of future insights into the agricultural and pastoral economy of the Zagros and western Iranian plateau (for example, the work of the Central Zagros Archaeological Project: www.czap.org).

The most important body of written evidence for agriculture in the region comes from the Persepolis Fortification Archive and Treasury Archive: tens of thousands of clay tablets, principally in Elamite and Aramaic, excavated at Persepolis in the 1930s (Briant et al. 2008). They date from the late sixth to mid-fifth centuries CE, and come from a single centralized records office, secondary to the primary transaction of business and creation of records at other smaller administrative centers. Toponyms in the texts often cannot be securely identified with locations on the ground, still less excavated archaeological sites (Potts, and Henkelman in Briant et al. 2008, pp. 275–316). As a body of evidence, the archive is of exceptional interest and utility, but the vast number of tablets means that I must restrict myself here to some broad comments on the information they offer on agriculture and its products in the Achaemenid southern Zagros.

Much uncertainty derives from the fact that the texts are concise, and the terminology they use is often obscure (on the types of exchange, payment, and transportation of commodities, and other transactions documented in the texts, see Hallock 1969, pp. 4–8, 13–69). Hides, barley, sesame, flour, bread, wine, fruit (dates, figs, mulberries), oil, and wine are mentioned in contexts that may relate to taxation, or to distribution for other purposes, such as the payment of officials (Tuplin in Briant et al. 2008, pp. 317–383). A small sub-corpus of Aramaic texts, all marked with a single seal and dating to 502–496 CE, document the disbursement of grain rations for feeding horses and donkeys, as a supplement to grazing or other fodder (Azzoni and Dusinberre in Kozuh et al. 2014, pp. 1–16). Otherwise, produce is for human use or consumption.

These terse documents provide evidence only for the processing and distribution of produce after harvest, not for agricultural production itself. The journey of the grain from granary, to mill, to store is documented in texts such as the following:

> 1132 (BAR of) grain (for making?) flour was taken (to) the *nupištaš* (i.e. the mill?). (Hallock 1969, p. 30. The unit of volume for dry goods written with the BAR sign is equivalent to around 9 liters.)
>
> 320 (BAR of) flour, supplied by Pirrena, was taken (to) Persepolis for the (royal) stores. 21st year. Bakabada received (it). (Hallock 1969, p. 30)

Quantities of grain were set aside for seed, but again we are given no information on the processes of sowing or reaping:

> 9 (BAR of) grain, supplied by Amusa(?), the workers (for whom) Uštana (does) the apportioning set aside for seed. 23rd year. (Hallock 1969, p. 436)
>
> 7 (BAR of) grain was set aside (for) seed. (It was) entrusted to Bakubeša. 18th year. (Hallock 1969, p. 448)

The documents therefore provide evidence for arable farming, although not its location, or the precise mechanisms by which it was carried out. The pastoral economy is also represented. Animals (sheep, goats, cattle, camels) yield meat, dairy products and hides, as may be seen in delivery documents such as these:

> 1 (male) goat, 1 ram, 4 (female) goats, 7 ewes, 4 female lambs, total 17 small cattle (at) the stockyard, supplied by Bakabana, were slaughtered. Their hides Ampirdawiš and Šakāda received, and delivered (them) to the treasury (at) Hiran. 18th year. (Hallock 1969, p. 448)
>
> 6(?) (female) goats, 3(?) rams, total 9 small cattle, supplied by Irtam, were slaughtered. Their hides they delivered to the treasury (at) Shiraz. Šakāda (and) Irtima his companion received (them). 19th year. (Hallock 1969, p. 59)

As was the case with plant products, however, there is no information available on how animals were raised, their meat and milk processed, or their hides tanned. The Persepolis Administrative Archive, in summary, tells us much about the products of farming, but little about farming techniques and technology.

The Macedonian Conquest

The conquest of the Iranian plateau and Central Asia by Alexander the Great in the 320s BCE represents a political rupture, but not necessarily a socioeconomic one. The Bactrian Aramaic documents show continuity in the local administration, at least in the first years after the conquest. Persepolis was partially destroyed, but Pasargadae appears to have continued to function as a local administrative center (Boucharlat in Briant and Joannès 2006, pp. 464–465). It was in the conquerors' interests to maintain the administrative structures, which allowed them to maximize resource extraction (Mairs 2014b, pp. 27–56). Whether the Macedonian conquest resulted in a change in basic methods of subsistence – agricultural and pastoralist – is another question. Traditionally, scholars have followed the judgment of Greek and Roman historians that Alexander engaged in a policy of sedentarization in the Zagros mountains and on the Central Asian steppe. Arrian, for example, says of the peoples of the Zagros (characterized as "brigands") that:

> All these tribes Alexander reduced, coming upon them in winter-time, when they thought their country unapproachable. He also founded cities so that they should no longer be nomads but cultivators, and tillers of the ground, and so having a stake in the country might be deterred from raiding one another. (*Indica* 40.8, trans. E. Iliff Robson)

Plutarch likewise claims that Alexander "taught the Arachosians to till the soil" (*On the Virtue or Fortune of Alexander* 5). The context – a discussion of barbaric foreign practices including incest, patricide, and adultery – makes it clear that arable farming is taken as a benchmark of Greek civilization.

This rhetoric of an Alexandrian *mission civilisatrice* has been slow to die in the scholarship. Pierre Briant's classic 1982 study of pastoralism in the ancient Near East, however, argues that the mobile pastoral economy of Zagros communities was largely left intact (Briant 1982, pp. 94–112). While Greek and Roman historians delineate a clear nomad-settled divide, the two methods of subsistence were deeply interconnected and dependent upon one another.

Similarly, an apparent attempt by Alexander to forcibly sedentarize mobile populations along the Syr-darya, in Central Asia, represented a break with the status quo that was strongly resisted. In the analysis of Frank Holt, this disruption of a symbiotic relationship between steppe and river valley, animal herders and settled agriculturists, was responsible for the fierce resistance encountered by Alexander (Holt 1988, pp. 55–59).

When we turn to the archaeological and documentary evidence (much of it published since Briant and Holt produced their studies in the 1980s), we find confirmation that a laissez faire approach worked best, and was indeed deliberately adopted by the Greco-Macedonian conquerors in most places. The material from Bactria is most telling. The Aramaic documents from Bactra show continuity in the personnel and administrative processes used to manage agricultural produce. The field survey data from eastern Bactria shows no dramatic rupture; the intensification of irrigation and agricultural production in the Hellenistic period was a long-term process, building upon existing local structures.

Comparative Ethnographic Approaches

In both of the regions I have discussed – the Zagros mountains and western Iranian plateau, and lowland southern Central Asia – archaeological and historical evidence is best at establishing broad patterns: cultivars, irrigation methods, changing modes and extents of agricultural exploitation, and the balance between arable farming and other subsistence methods such as pastoral transhumance or nomadism. For finer details – tools, processing techniques, the agricultural calendar, etc. – ethnographic studies offer a useful point of comparison to our ancient evidence.

Ethnographic data cannot be used to "fill in the gaps" in the archaeological record, but it can remind us of important practicalities of, and constraints upon, farming. The Surkhan-darya province of southern Uzbekistan is an excellent example. Within a comparatively small area, one finds land suitable for dry farming, irrigated farming, and seasonal or year-round pasture: "from a human point of view it therefore makes sense to combine different types of exploitation of the landscape, and the ethnographic sources show that this was the case until recently" (Stride 2007, p. 104). In the nineteenth-century Surkhan-darya valley, different ecological niches were occupied and exploited by different social and ethnic groups, with economic strategies ranging from semi-nomadic pastoralism to settled arable farming on irrigated land. Mobile pastoralism, however, leaves much less of a material signature than settled farming, with its permanent buildings and infrastructure such as canals. The bias in the archaeological and documentary record toward farming and its products has already been noted. Studies of the more recent Surkhan-darya valley make it clear that herding and farming did not merely coexist, but were interdependent. Their practitioners came into regular contact, relied upon one another's produce and trade goods, and often shared the same resources (Stride 2007, p. 106). There is no reason to suppose that the situation in antiquity was much different.

In the neighboring Sherabad-darya district, a similar situation prevails. The major archaeological site of the region is Jandavlattepa, a settlement with a raised citadel, the currently excavated portions of which date mostly to the first half of the first millennium CE (Abdullaev and Stančo 2011). It therefore provides a later counterpart to the Achaemenid and Hellenistic material discussed in this chapter. Remains from the site show how closely the arable and pastoral economy were interrelated, with both sheep bone and cereals present (Abdullaev and Stančo 2011, p. 36, 190, 192). An elevated part of the site, with concentrated layers of cereal grains, appears to have been used for winnowing (Abdullaev and Stančo 2011). Another area apparently served as a production and storage area for the winnowed grain, with grindstones and querns (Abdullaev and Stančo 2011, p. 50). Textile production at the site is attested by spindle whorls and loom weights (Urbanová in Abdullaev and Stančo

2011, pp. 105–117), although it is not clear whether the fibers came from pastoral (wool) or arable (flax, hemp, etc.) sources, or a combination of both. In the present-day, the area around Jandavlattepa continues to support farming and herding: cotton is grown in the fields, while shepherds use the raised citadel to keep watch over their flocks (Abdullaev and Stančo 2011, p. 27).

The archaeological and historical evidence available to study farming in western Iran and southern Central Asia in the second half of the first millennium BCE is restricted, but several key patterns nevertheless emerge. First, as I have repeatedly stressed, arable farming and livestock herding were practiced in close proximity to one another, and farmers and herders interacted with one another and were interdependent. Second, the Achaemenid and Hellenistic states possessed large and complex bureaucracies to manage agricultural produce. For the most part, our evidence relates to the treatment of the end products of agriculture (harvested crops, meat, dairy), but occasionally we find evidence of state intervention in the practice of agriculture as well (storage of seed, labor directed toward harvesting crops). Third, the systems and techniques that facilitated the exploitation of natural resources in this period built upon much earlier foundations. Bronze Age agriculture and pastoralism in the Zagros and Central Asia were well developed, and irrigation systems could be maintained over centuries, or even millennia.

FURTHER READING

The Aramaic documents from Bactra, the most important source on the Achaemenid administration and economy in the region, are published by Naveh and Shaked 2012. Among the vast literature on the Persepolis archives, the volume edited by Briant et al. 2008 is to be especially recommended. Pierre Briant's classic study on *The State and Pastoralists in the Ancient Middle East* (Briant 1982) may still be read with profit, especially for its discussions of pastoralism in Greek and Roman sources. The Eastern Bactria survey is published in three volumes: Gentelle 1989; Lyonnet 1997; and Gardin 1998. Mairs 2014b discusses the history and archaeology of Hellenistic Bactria, including agriculture and economic history.

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PART V

COMPARATIVE AGRICULTURAL HISTORY

CHAPTER TWENTY-EIGHT

Ancient Agriculture in the Indian Subcontinent: The Archaeobotanical Evidence

Ravi Korisettar

Introduction

The aim of this chapter is to survey the origins and development of early subsistence production as evidenced by archaeobotanical data sets from early Neolithic/Chalcolithic sites in the Indian subcontinent. The term *Indian subcontinent* is preferred to either South Asia or India. India, Pakistan, Bangladesh, and Bhutan together constitute a natural geographic entity as these regions are mutually inclusive and reveal prehistoric cultural continuity.

There have been several authoritative processual reviews and updates on this subject published from time to time by archaeobotanists, which discuss the broader issues of transitions, climate–agriculture relationship, domestication morphology, genetics, and such other fundamental aspects of archaeo-ethnobotany (Murphy and Fuller 2016; Fuller and Murphy 2014). Similarly relevant information on the reconstruction of Holocene monsoon, climate change, consequent vegetation changes, and the vegetation context of early agriculture is now available to contextualize ancient agriculture in its natural setting across the subcontinent (Duplessy1982; Korisettar and Ramesh 2002; Fuller and Korisettar 2004; Chauhan 2012; Lone, Khan, and Buth 1988; Singh, Wasson, and Agrawal 1990; Singh I.B. 2004, 2005). Nonetheless, owing to a lack of research emphasis on Neolithic/Chalcolithic archaeobotany in some regions of the subcontinent, our knowledge of early agriculture reveals geographical gaps. In particular, the humid coastal lowlands, the Lesser Himalayan and sub-Himalayan plateaus, the Ganga-Brahmaputra delta (including Bangladesh), and the northeastern humid uplands have yet to be subjected to systematic survey and bioarchaeological investigations. Some of these regions have remained in isolation since Paleolithic times (Korisettar 2007); however, the sequence of socioeconomic changes in the well-investigated regions, the transition to sedentary settlements and a food-producing way of life is securely dated by the AMS radiocarbon method. This data has enabled reconstruction of the spread of cultivation as well as diffusion of crops and movement of populations and language families (Fuller 2003a,b,

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

2006a, 2007, 2011b; Bellwood 2005). As a result, the dated archaeobotanical record reveals a slow pace of expansion into the contiguous provinces within the subcontinent, indicating uneven events of population movements affecting different culture-historic divisions at different times.

Early Transitions in the Old World

The period between 12 000 and 4000 BP witnessed the transition of prehistoric hunter-gatherers to village-based first farmers and herders in different geographical regions of the Old World (Bellwood 2005; Bar-Yosef and Meadow 1995). This transformation was not merely limited to subsistence production and modification of landscape but also involved a visible cultural shift – "habitat, technology, demography, social organization, settlement and the use of space, and artistic and religious expressions were equally involved" (Cauvin 2007, p. 4; also see Bellwood 2005).This time bracket covers a series of events leading to the formation of the complete package of food crops that characterizes the food habits of the inhabitants of the subcontinent and elsewhere in the Old World. Regional dietary habits that once formed the distinctiveness of various culture-historic divisions disappeared during the last five thousand years with the rise of intensive agriculture.

The development of early agriculture in the subcontinent can best be understood against the background of early developments in two distinct geographical regions: Southwest Asia (the Fertile Crescent in particular) and East Asia. In comparison with these two regions, agriculture came to the subcontinent relatively late, as attested by archaeological and radiocarbon dating (Figure 28.1). During the last three decades, the archaeology of the Neolithic/Chalcolithic cultures in these regions has focused on the role of climate, environmental change, and demography in the rise and development of an agricultural way of life. To date, the best documentation of the transition from hunting and gathering to a sedentary agricultural way of life has been documented through excavations and multidisciplinary analyses (for details, see Chapters 7 and 29 in this volume). The archaeology of the Neolithic in these regions is important because many cultivars documented from the subcontinent's Neolithic/Chalcolithic cultures were introduced either from the Southwest Asia, Africa, or East Asia.

The radiocarbon chronology of Southwest Asian and East Asian Neolithic sites has delineated a rapid development of socioeconomic changes. The timescales developed by the excavators suggest that very little time separates the first village farming communities from the first urban civilizations, and then from the first industrial civilizations. The radiocarbon chronology has also clearly established the fact that it was in Southwest Asia that Neolithization first arose, without any external influence. All other early centers of Neolithic cultures experienced the "Neolithic Revolution" later, with diffusion and migration playing important roles in the development of staple food crops in contiguous geographical regions: "episodes of human movement occurred from time to time … as different populations developed or adopted agriculture and then spread farming, languages, and genes, in some cases across vast distances" (see Bellwood 2005, p. 1).

Geography and Environment

The subcontinent is a large, natural, and continuous continental landmass lying between the Himalayas in the north and the Indian Ocean in the south (Figure 28.2). The mainland subcontinent (excluding Bangladesh, Nepal, and Bhutan) covers an area of 3 744 068 km^2.

	Southwest Asia		Indian Subcontinent										China				Lower Yellow river	Coastal Thailand
Calendar Age	Levant	Mesopotamia/ Zagros	Baluchistan and the Indus-Sarasvati Basin	Himalayan region: Kashmir and Swat Valleys	Vindhyan region: The Belan and Son Valleys – Kaimur hills	Middle Ganga Plain: Uttar Pradesh and Bihar	Eastern India: Odisha, Chhattisgarh, and Jharkhand	North Gujarat	Eastern Rajasthan The Ahar –Banas Culture	Western Madhya Pradesh Kayatha and Malwa Cultures	West Deccan Malwa and Jorwe Cultures	Mid-Deccan	Lower Yangzi	Middle Yangzi	Upper Yangzi	Yellow river		
			Mehrgarh Tradition (7000 BCE)	**Burzahom Tradition (2500 BCE)**	**KaimurTradition (3000-2500 BCE)**	**GangaTradition (3000 BCE)**	**Utkal Tradition (2500 BCE)**	**Anarta Tradition (5000 BCE)**	**Mewar Tradition (3000 BCE)**	**Malwa Tradition (2500 BCE)**	**Deccan Chalcolithic Tradition (2000BCE)**	**Ashmound Tradition (2700 BCE)**	**Shang**					
1500 BCE	Late Bronze Age										Jorwe							
				Burzahom II	IV. Chalcolithic	Chalcolithic		Rangpur III			Malwa	Ashmound Tradition III						
			Late Harappan								Pre-Malwa							
2000 BCE	Middle Bronze Age							Late Sorath			Savalda (2000 BCE)	Ashmound Tradition II						
					III. Mahagara			(Sorath) sedentary, native millets				Nativemillets, pulses, sedentary						Shixia rice cultivation
					Late Neolithic sedentary, rice, pulses, live stock						Kayatha							
									Ahar		SW Asian suite sedentary							
2500 BCE			Mature Harappan	Burzahom I SW Asian cereals	II Neolithic Koldihwa Rice cultivation? Herding? Mobile Damdama, Mahadaha		Rice cultivation			Kayatha and Malwa Traditions (2500 BCE)			Liangzu	Longshan				
	Early Bronze Age		Early Harappan/ Kot Dijian									Ashmound Tradition I mobile farmers			Daxi			
3000 BCE						Advanced Mesolithic Wild rice? Chickens?			Balathal SW Asian suite sedentary		?		Songze	Yangshao			Dawenkou	Non Nor Con Co Nguacermics w/o agriculture
													Majlabang					
		Uruk	Pre-Harappan village cultures															
4000 BCE	Chalcolithic										Mesolithic		Hemudu rice, pigs					
									?			Mesolithic						
		Ubald									?							
5000 BCE	Late Neolithic (PNB)	Halaf		?				Anarta Tradition pastoralism cultivation of native millets					?			Dadiwan	Beixin	
		Late Neolithic (Hassuna/ Susiana)			I. Mesolithic Chopani-Mando hunting, fishing wild rice use									Pengtoushan/ Bashldang rice		Peiligang millets, chickens		
6000 BCE	Late Neolithic (PNA)												Xianrendong domestic rice phytoliths					
	Pre-Pottery Neolithic C	Late Aceramic Neolithic																
						Mesolithic												
7000 BCE	Late Pre-Pottery Neolithic B	All Koshcaprines, cereals, lentils	Mehrgarh 1A SW Asian crops, sedentary Zebu domestication sheep? Introduced goats and cereals											Yuchan cave wild rice, phytoliths			?	
		GanjDreh domestic goats	Mesolithic?															
8000 BCE	Pre-Pottery Neolithic B																	
						Sarai-Nahar-Rai												
9000 BCE	Pre-Pottery Neolithic A												Xianrendong, wild rice, phytoliths, wild boar, wild buffalo					
		Epi-Paleolithic														Nanzhaungtou Pig? Chicken?		
10,000 BCE					Epi-Paleolithic													
11,000 BCE	Late Natufian																	
12,000 BCE																		
	Early Natufian																	

Figure 28.1 The subcontinent's early agropastoral provinces in relation to Southwest Asia and East Asia. Source: Illustration by Ravi Korisettar

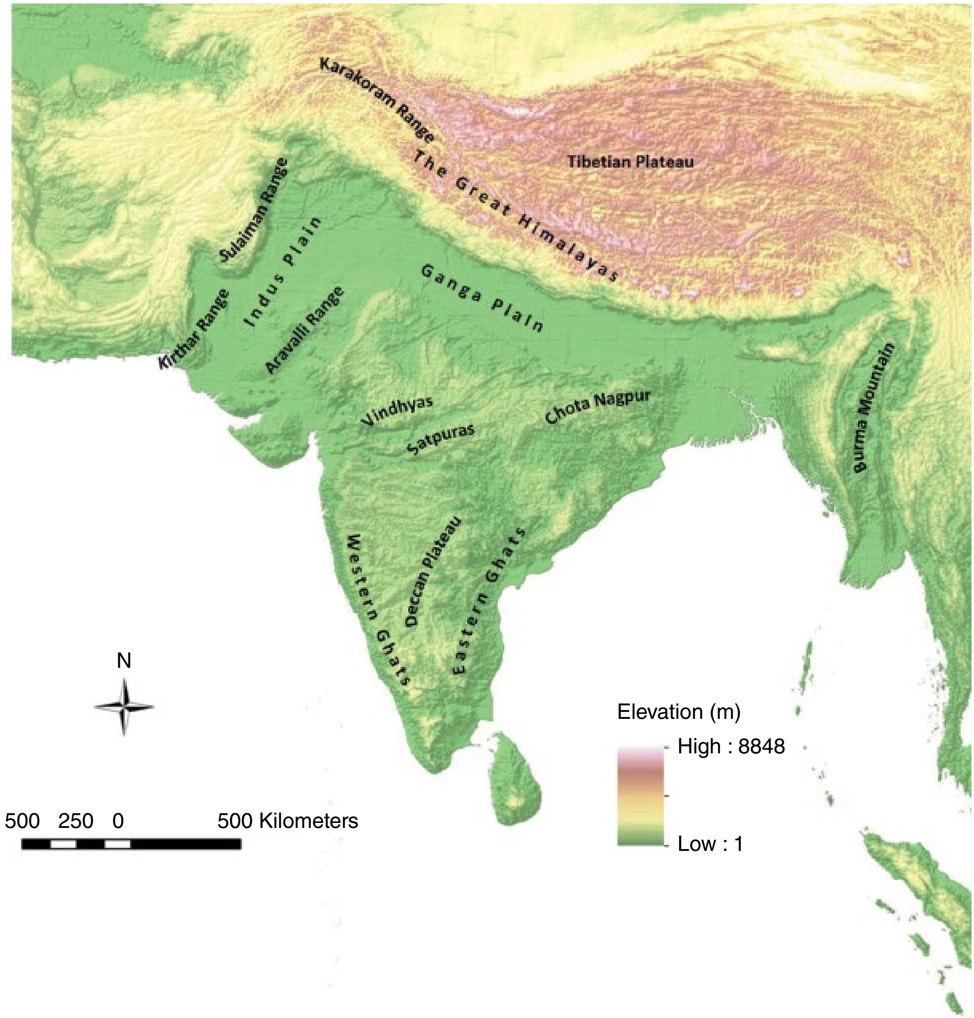

Figure 28.2 Physiographic subdivisions of the Indian subcontinent. Source: Illustration by Ravi Korisettar

Modern India extends 3200 km in the north–south direction and 2960 km in the east–west direction. It has 15 200 km of land frontier and 57 000 km of sea frontier. The Himalayas occupy a 2400 km long and 250–300 km wide area along its northern and eastern frontiers. The northwestern region is an extension of the Indo-Ganga Plain bounded on its west by the Baluchistan Mountains. The major part of the well-inhabited area of Pakistan consists of the vast Indus alluvial plain flanked by the interconnected Punjab (including the eastern and western sectors), as well as the Gomal and Kachi plains. The southern part of the basin consists of the Indus delta and the Makran coast. The major river systems originating in the western and northern highlands drain the entire basin, making it one of the most well-watered regions of the world.

The Indo-Ganga Plain, an area of 700 000 km^2, is the second largest well-watered alluvial plain, drained by the Himalayan rivers and those arising in the northern slopes of the

Peninsular Bulge (Vindhya Plateau). Vast plateau areas have formed on the Indian Peninsula, in the central and western parts, e.g. the Deccan Plateau, stretching between the Vindhyas in the north and the Nilgiris in the south. The peninsular south has three large river basins, the Godavari, Krishna, and Kaveri, including several subsidiary basins. Montane; inter-, intramontane, and submontane; alluvial plains; hill ranges (*ghats*); rocky plateaus with braided stream networks; coastal plains; and a vast expanse of desert dunefields are all characteristic topographic features of the subcontinent. This physiographic configuration has facilitated the formation of the regional climate, particularly the monsoon circulation (Southwest and Northeast) over the region (Wasson 1995; Kale and Rajaguru 1987; Duplessy, 1982; Van Campo 1986) on the one hand, and the formation of a network of vegetation zones governed by the latitudinal and longitudinal variation in the distribution of rainfall between the proximal southwestern peninsula and the distal Tibet Plateau in the north, on the other hand (also see Korisettar and Rajaguru 2002).

Evolution of Holocene Climate and Monsoon Habitats

The Indian subcontinent is a monsoonal region, and monsoon circulation has governed the availability of fresh water resources across the region since at least the Pleistocene. In addition, groundwater resources in the form of aquifers produce spring discharge, causing gentle overland flow of water. Movement of groundwater is primarily responsible for the formation of perennial drainage networks across the land surface and in turn the formation of diverse habitats (Korisettar 2007). The fluctuation of monsoonal flow in response to short-term global changes has been the dominant variable in studies of transition to sedentism and agriculture. Undoubtedly these changes affected the vegetation patterns and the distribution of wild progenitors of food crops (e.g. see Figure 28.3); however, one needs to examine the importance of a weak monsoon and aridification as causes of agricultural transition as well (Cauvin 2007), especially in the regions where transition to agriculture and sedentism was as late as Mid- to Early Late Holocene.

Regional variation in the precipitation regimes has led to the formation of a network of distinctive ecosystems that are characterized by endemic plant and animal communities. The internal physiography of the subcontinent that regulates the latitudinal and longitudinal variation in the intensity of precipitation regimes across the subcontinent has given rise to mangrove, tropical evergreen, deciduous, savanna, semi-arid and arid evergreen scrublands, and desert ecosystems. Hunter-gatherer and early agropastoral settlements have been documented from these ecosystems, revealing the fact that fluctuating paleoclimate regimes favored human adaptations during times of climate amelioration as well as deterioration (Figure 28.4). The strong seasonality of the Indian monsoon also regulated the mobility range of these communities, providing access to endemic seasonal food resources. Despite short-term fluctuations in the rainfall regimes, these ecosystems persisted through the Holocene, providing critical local food crops in pre-domesticated form to transitional agricultural communities.

Holocene summer monsoon over the subcontinent penetrated deep into continental regions but was characterized by a spatial pattern of variation across the region that was partially governed by intra-continental physiographic/orographic features. The Indian Ocean cyclonic storms are part and parcel of monsoonal circulation and trigger inland movement of moisture-bound winds from the ocean. With the exception of the Shillong plateau (northeast India), the summer monsoon rainfall over India is highest in two geographical regions: the

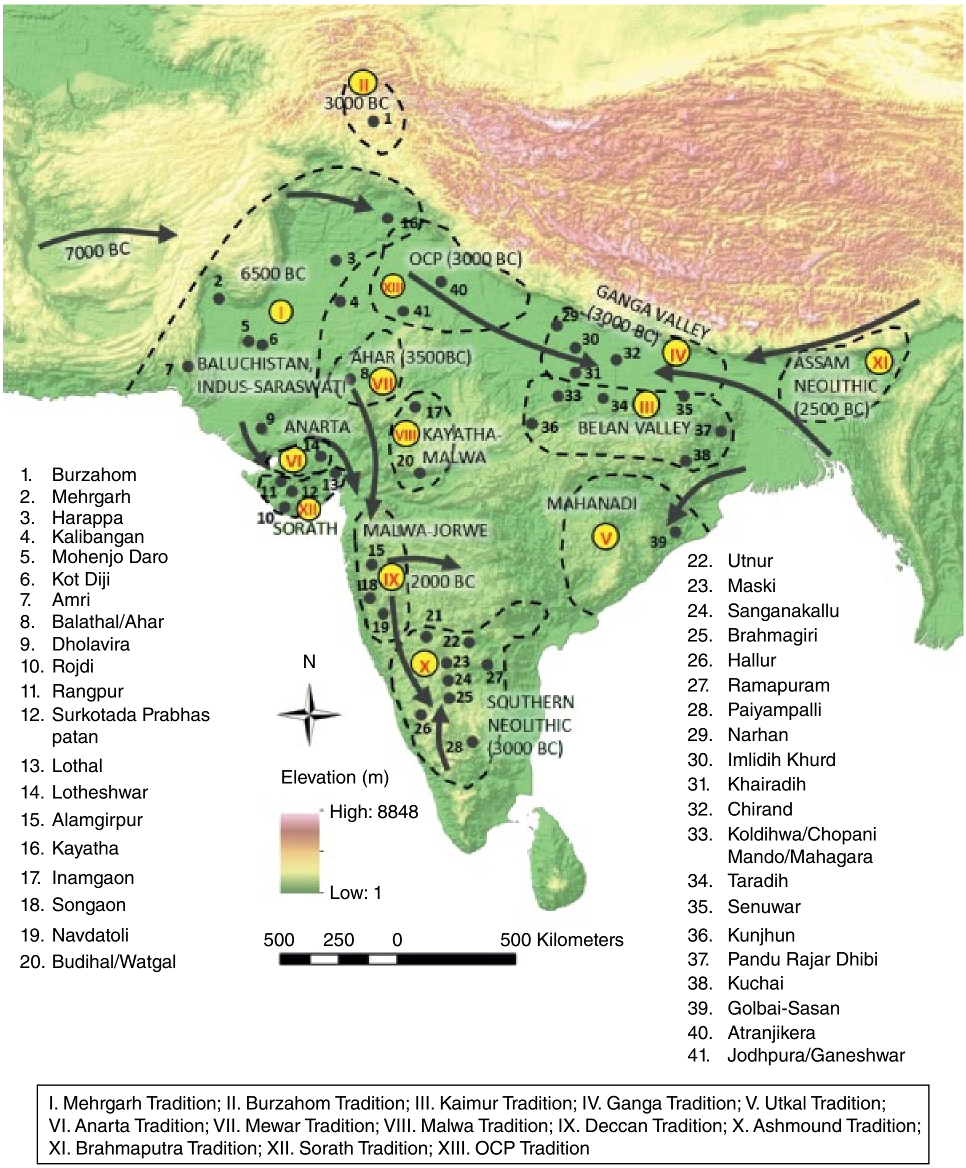

Figure 28.3 The distinctive culture-historic divisions across the subcontinent, showing important excavated sites and radiocarbon dates for the development of early agriculture. Further research is likely to expand the area covered by each of these culture-historic divisions. Source: Illustration by Ravi Korisettar

Indo-Ganga plains and the Western Ghats. Most of the monsoon rainfall on the Western Ghats quickly drains into the rivers on either side of the continental divide. There is also a sharp north–south gradient in the summer monsoonal rainfall along the west coast, between 4000 mm along the Karnataka coast to 300 mm in the Saurashtra and Kachchh coast of Gujarat (Overpeck et al. 1996).

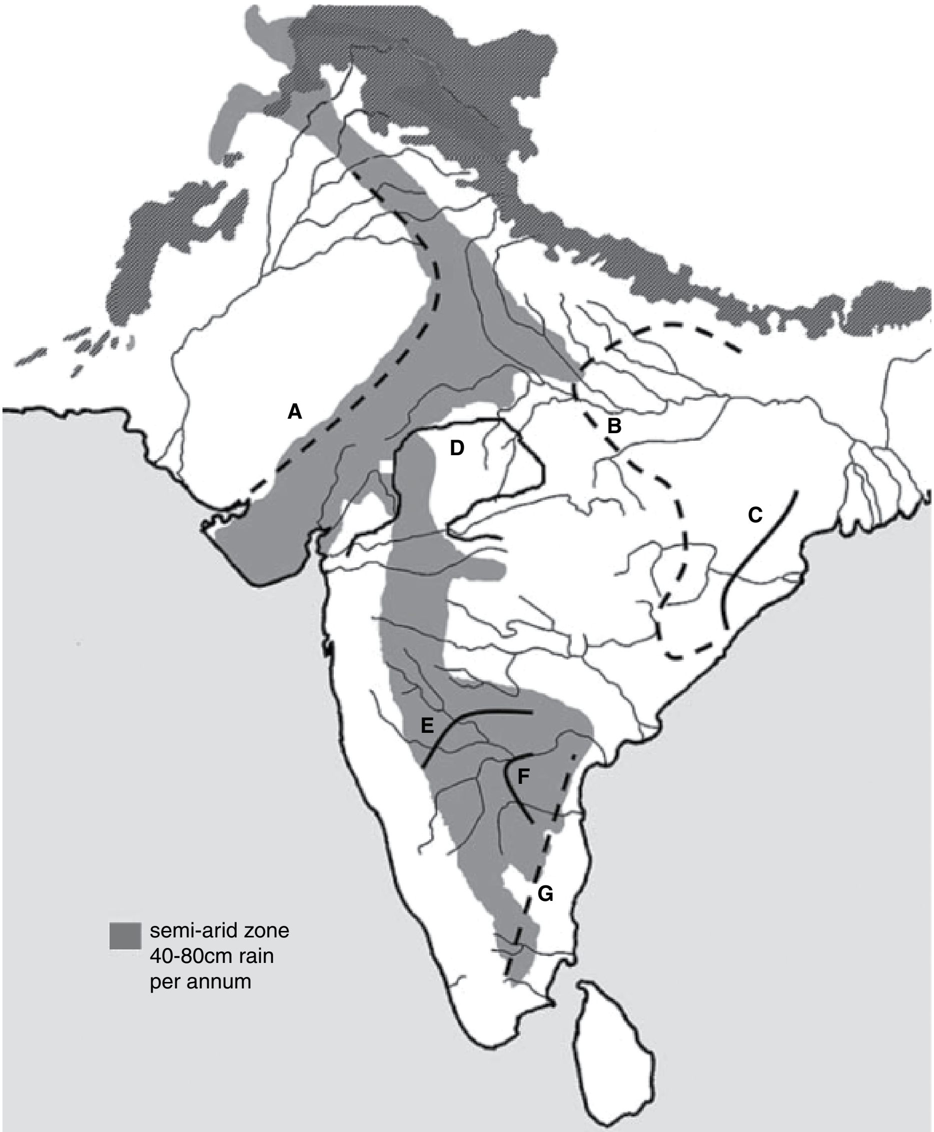

Figure 28.4 Major natural frontiers that contributed to the geography of agricultural origins in India: solid lines, geological; dashed lines, climatically controlled. A. The western boundary of sufficient monsoon rainfall for reliable dry cropping; this boundary is likely to have shifted further eastward during the mid-Holocene. B. The western margins of the distribution of annual wild rice, *Oryza nivara*; this frontier might have retreated eastward with aridification toward modern conditions. C. The frontiers between the Odisha uplands and the coastal plain. D. The northern frontier of the Deccan Volcanic Province and water-retentive black cotton soils. E. The transition from the black clay soils of the Deccan Volcanic Province (west Deccan) and the sandy soils of the mid- and Southern Deccan Archaean rocks. F. Erramalai hill ranges that separate the granitic Southern Deccan from the quartzites, limestones, shales, and dark soils of the Cuddapah-Kurnool region. G. The transition between predominantly summer monsoon and important input from the north-east winter monsoon After Fuller 2006. Source: Illustration by Ravi Korisettar

The High-Amplitude Monsoon Fluctuation: Evidence for Climate Change?

Understanding the prevalent monsoon conditions during oxygen isotope stages 2 and 1 provides a background to reconstructing the development of ancient agriculture. Oxygen isotope stages (OIS or MIS) are the alternate glacial and interglacial climatic events reconstructed from marine sediment cores. They form a standard stratigraphic scale and are used widely to correlate Quaternary (the last 2 to 2.5 million years) climatic events. Stages 2 and 1 in the marine record cover the time period from 25 to 12 ka and from 12 ka to the present, respectively. Stage 1 is the ongoing Holocene. Monsoon fluctuation during the Holocene have been found to be less significant compared to the previous isotope/interglacial periods (3 and 5); however, some argue that monsoon fluctuations were large enough to influence the rise and fall of early civilizations. Abrupt shifts in monsoon precipitation have also been documented (Berkelhammer et al. 2012).

High-amplitude monsoon fluctuations are equated with climate change, but generally they mark short-term wet and dry phases, causing expansion and contraction of forests, grasslands and deserts, and the rise and fall of lake levels, thus impacting settlements with river fluctuations. Evidence of climatic and vegetation changes has been obtained for earlier vegetation belts (see Fuller and Korisettar 2004; Vasanthy 1988; Singh, Wasson, and Agrawal 1990) and paleolakes (Swain, Kutzbach, and Hastenrath 1983). Research on the peats in the Nilgiris (south India) and salt lakes in Rajasthan (northwest India) have also focused on reconstructions of monsoonal flows. Low-monsoon regimes during LGM and around 4000 C^{14} years BP and increased monsoonal precipitation at the onset of the Holocene have been documented (Table 28.1).

The Southwest summer monsoon covers the major part of the subcontinent from Kerala in the southwest to the western Tibetan plateau. Lake levels and river discharge in northern India and Tibet are controlled by the flow of summer monsoon, and more than 80% of moisture is contributed by the Southwest monsoon rather than the melting of Himalayan snow. Von Rad et al. (1999) have reported high monsoon runoff from the Indus around 3700, 2600, 1800, and 1500 BP and low runoff during 2200–1900, 1100, and 700–400 BP, indicating a spatial pattern in paleomonsoon. This, when compared with the records from other parts of India, reveal that the spatial pattern of the monsoon exhibited significant variability similar to that of the present-day monsoon (Table 28.1).

The retreat of the Thar Desert and stabilization of sand dunes occurred during climate amelioration around 5000 BCE (Balbo et al. 2013, 2014a,b). Multiple investigations of the Holocene monsoon not only from the region of the subcontinent but elsewhere in Africa and Southwest Asia clearly show a trend toward aridification from the mid-4th millennium BCE that gradually led to establishing the present condition by about 2000 BCE. This time period witnessed the establishment of early village economies across the subcontinent, including the rise of urbanism in the Greater Indus Valley. The monsoonal circulation since the Mid-Holocene has been found to be relatively consistent over the peninsula (Poton et al. 2012; Prasad, Phartiyal, and Sharma 2007; Prasad et al. 2014).

Endemic Domesticates in the Contiguous Regions of the Old World

Food processing implements such as ground stone tools, querns, grinding stones, bedrock mortars, pit silos/granaries, and such other artifacts indicating grain processing and vegetal

Table 28.1 Paleoclimate evidence for the Holocene in the subcontinent. Modified after Schug 2011. Source: Table by Ravi Korisettar

Evidence	*Date*	*Climate*	*Reference*
Riverbank sequence stratigraphy (western India)	3000–700 BCE	Arid phase	Kale and Rajaguru 1987, 1988; Enzel et al. 1990; Jain and Tandon 2003
Lake sedimentology, palynology (Rajasthan)	3000 BCE–CE	Arid phase in the Thar; complete desiccation of the lake after 3000 BCE	Bryson and Swain1981; Prasad et al. 2007, 2014; Roy et al. 2008; Singh et al. 1972, 1973, 1974, 1990; Sinha et al. 2006; Swain et al. 1983
Isotope from lake cores (Rajasthan)	5000 BCE	Arid phase commenced	Prasad and Enzel 2006
Cores from coastal estuaries (Konkan, Maharashtra)	2500 BCE	Arid phase commenced	Kumaran et al. 2005
Arabian Sea cores	2000–1000 BCE	Arid phase	Caratini et al. 1991, 1994
Pollen (Garhwal Himalaya)	2000–1000 BCE	Arid phase (minimum rainfall around 1500 BCE)	Phadtare 2000
Varves in Pakistan	3000 BCE to CE	Increasingly arid 3000–1900 BCE, maximum aridity 1900–1500 BCE in South Asia and West Asia. Precipitation minimum at 200 BCE–CE	von Rad et al. 1999
Pollen, isotopes (Ganga Plain)	3000–1000 BCE	Arid phase peaked 1000 BCE	Sharma et al. 2004, 2006
Sediment core from tropical montane forest, central Sri Lanka	12 700–11 300; 9700–8500 and 7000–6800 BCE	Stepwise increase in monsoon around	Prematilake and Risber 2003
As above	5900–1500 BCE	Semi-arid	Ibid.
As above	1500 BCE–the present	Stable monsoon, with a hyper-arid event	Ibid.
Lake levels/shore line in central Tibet	9500, 8800, 6300, 3900, and 1600 BCE	Millennial scale fluctuations of weak monsoon	Hudson et al. 2015; Hudson and Quade 2013; Liu et al. 2016
	7000 and 3000 BCE	Lake levels stable and higher than modern	
ODP site 723, cores 2502G, 291G, 3268G, and 3104G	4800, 2500, 1800, and 1500 BCE	Dry and arid phases weak monsoon	Sarkar et al. 2000
	6900, 4000, 1200, 1500 and 700 BCE	Humid peaks	

food processing constitute good evidence of agriculture, yet remain indirect evidence. The increasing intensity of archaeobotanical research over the last three to four decades has revealed the existence of independent centers of early agriculture based on cultivation of native crops, including millets, pulses, and cereals, none of which presented contemporaneity with either Southwest Asia or East Asia (China), where agricultural origins have been traced to the Early Holocene (Figure 28.1).

A variety of wild plant food resources occurring across the subcontinent has helped identify a suite of native food and other economic crops, including cereals, millets, pulses, oil, and fiber seeds. While some have widespread distribution, others are restricted to particular ecosystems. For example, small millets are known to have a widespread distribution in monsoonal semi-arid regions of peninsular India and Gujarat and native pulses in the deciduous ecosystems of the Western and Eastern Ghats (see Fuller and Murphy 2017). Archaeobotanical research at a number of agropastoral settlements from the 3rd to 2nd millennia BCE has revealed the importance of native small millets and pulses in the early agricultural societies in these regions.

Crops involved in the development of early agriculture in the subcontinent during the Neolithic/Chalcolithic phases and the Bronze Age (2600–1800 BCE) Harappan Civilization (also Indus-Sarasvati Civilization) included cereals, millets, and pulses of multiple origins, including Southwest Asia, northern Africa, East Asia, and the subcontinent. Thus, the archaeobotanical record of the subcontinent presents a complex suite of indigenous and introduced cultivated crops ranging in time from the Neolithic to Early Historic.

The Southwest Asian cereals and legumes were introduced to the subcontinent in domesticated form with the possible exception of barley, which could have been domesticated locally in Baluchistan. The African millets and legumes were first introduced to the Harappan Civilization through a maritime contact between Mesopotamia and the Greater Indus Valley. The two main millets from Africa, sorghum and pearl millet, were introduced around 2000 BCE. The African legumes, cowpea (*Vigna unguiculata*) and hyacinth bean (*Lablab purpureus*), were introduced during Late Harappan times (1800–1300 BCE). Finger millet is another African crop (Ethiopian origin), known from south Indian Neolithic-Iron Age sites.

Among the East Asian crops, the most important is Asian rice (*Oryza sativa*), a domesticate from the Yangzi basin of China. There is no clear evidence of early domestication from local wild rice, the long-grained (*indica*) variety that came to be incorporated into the domesticated crop package in the rice economy of the Ganga Valley. Two other millets of external origin found in Protohistoric and later Prehistoric contexts include foxtail millet (*Setaria italica*) from the Yellow River valley of China and broomcorn millet (*Panicum miliaceum*), a Central Asia domesticate.

Domesticated crops native to the subcontinent were the rain-fed small millets, pulses, and legumes. Black gram, green gram (*Vigna* sp.), and horse gram are known from the Ghats region and the Deccan plateau. Minor millets belonging to *Paspalum* and *Chenopodium* genera and *Brachiaria ramosa* and *Setaria verticillata* are known to have been locally developed in southern India, during the time period from 3000 and 1000 BCE. Toward the end of this period, the crop package including the native and exotic food plants came to support both rain-fed and irrigation agriculture, paving the way for intensive agriculture during the Iron Age. Thus, there are nearly a dozen varieties of small millet species cultivated in India, and they have different geographical origins. In the context of identifying independent centers of agricultural origins within the Indian subcontinent, our knowledge of their provenance is critical to elucidating the process of domestication in the archaeological context.

The Southwest Asian crops cultivated in India include wheat (*Triticum* spp.), barley (*Hordeum vulgare* L. *sensu lato*), lentils (*Lens culinaries* Med.), chickpea (*Cicer arietinum* L.), peas (*Pisum sativum* L.), grass pea (*Lathyrus sativus* L.), and linseed/flax (*Linum usitatissimum* L.). Beginning with the Mehrgarh Neolithic, these crops were well established by the time of the Mid-Holocene Harappan Civilization. Goats in domesticated form were introduced into the subcontinent, whereas sheep are a local domesticate. Zebu cattle are native to Baluchistan and inner India.

Africa provided a variety of millets and legumes with their origin in the different geographical regions of northern, central, and Sahara Africa. They include sorghum or great millet (*Sorghum bicolor* (L.) Moench); ragi or finger millet (*Eleusine coracana* (L.) Gaertn); bajra/pearl millet (*Pennisetum glaucum* (L.) R. Br. syn. *P. americanum* (L.) Leeke, syn. *P. typhoides* Rich); cow pea (*Vigna unguiculata* (L.) Walp); and hyacinth bean (*Lablab purpureus* (L.) Sweet). Among the several varieties of sorghum of African origin, the bicolor race is reported from Neolithic/Chalcolithic and Harappan contexts. This race is best suited for high-rainfall areas; it is found to be grown in the Eastern and Western Ghats high-rainfall zones. The Durra race is also widely cultivated in India and Pakistan. Though it is of African origin, its cultivation began much later there. It is speculated that the domestic sorghum may have been evolved in India from the early introduction of a bicolor and that it was reintroduced during the Arab conquests in Africa.

Introduced crops from Central Asia/China include foxtail millet (*Setaria italica* L.) Beau); proso millet (*Panicum miliacum* L.); hemp (*Cannabis sativus* L.); and rice (*Oryza sativa* L.).

Some tree crops were introduced through overland trade in fruits and nuts from 2000 BCE onward. Also, the Bactrian camel was introduced into the subcontinent. Horses also came, but the antiquity of domestication has become an issue of controversy. Some of the tree crops of the Late Harappan (1800–1300 BCE) period found in Kashmir are peaches (*Prunus persisa* (L.) Batsch), apricot (*Prunus armeniaca* L.), and walnut (*Juglans regia* L.) from Central Asia and west China. Almonds (*Amygdalus communis* L.) came from Southwest Asia.

Food crops native to north India include rice (*Oryza sativa* L.), moth bean (*Vigna aconitifolia* (Jacq.) Marchal), black gram (*Vigna mungo* (L.) Hepper), cucumber (*Cucumis sativus* L.), ivy gourd (*Coccinia grandis* (L.) Voigt), and citrus fruits. Rice appears to have been a domesticate in China and north India on two different occasions. Similarly, chicken and water buffalo were domesticated in China and India, independently at different points of time.

Neolithic/Chalcolithic Culture-Historic Divisions

Below, 11 major Neolithic/Chalcolithic culture-historic divisions are discussed, some of independent agricultural origins and others originating from diffusion (Bellwood 2005; Fuller 2006, 2011) (Figure 28.3). Recently, a case has been made for Gujarat as an independent center of agricultural origins (Garcia-Granero et al. 2016). The Neolithic/Chalcolithic cultures of India have been divided into several culture-historic divisions by various scholars, with no two scholars agreeing. Consequently, I discuss below a series of culture-historic exemplars that represent stages in the spatiotemporal development of early subsistence economies during the Holocene. For the purpose of this discussion, distinctive culture-historic divisions based on ceramic traditions have been considered (Sankalia 1974; Allchin and Allchin 1982).

The Neolithic/Chalcolithic archaeobotanical record reveals spatial and temporal variation in the rise of agricultural economies. These divisions also reveal distinctiveness in terms of staple crops: wheat and barley in the Indus-Sarasvati basin; rice in the northeast and Middle

Ganga valley; and millets in western and southern India. Some of these zones have been identified as independent centers of agricultural origin (Bellwood 2005; Fuller 2006a, 2011b; Garcia-Granero et al. 2016). While the northwest of the subcontinent witnessed Early Holocene (7000 BCE) transition to subsistence production and its gradual expansion covering the whole of the Indus-Sarasvati basin leading to the emergence of the first urbanization, the rest of the subcontinent continued with hunting and gathering until Mid- to Late Holocene times.

During the 3rd and 2nd millennia BCE, a series of regional Neolithic/Chalcolithic cultures, with clear evidence for a mixed subsistence economy, emerged across the rest of the subcontinent, outside the Indus-Sarasvati basin. While some of these regional cultures have been named after a type site or local river, the others have been designated either Neolithic or Chalcolithic (e.g. Ahar-Banas culture in Mewar; Kayatha-Malwa in Malwa; Anarta in Gujarat; Savalda, Malwa-Jorwe in west Deccan; Southern Neolithic in the mid- Deccan; and Vindhyan Neolithic).

Archaeological and Archaeobotanical Profiles of the Food-Producing Cultures

Archaeobotanical research lays emphasis on recovering microbotanical remains as important proxy data for reconstructing plant domestication. Phytoliths and starch grains provide evidence related to irrigated agriculture, dry farming, and vegeculture, including crop-processing activities. The advantage of microremains is twofold: (1) they increase the scope of identification of taxa and (2) facilitate recognition of taxa from leaves, roots, tubers, and fruits. In addition, stone tools such as grinding stones also provide direct evidence of dietary habits of the agricultural communities. The recovery of these remains was the main objective of archaeobotanical investigations in the culture-historic divisions of the subcontinent.

On the basis of the current reconstructions, the abovementioned culture-historic divisions can be broadly divided into two groups: (1) Early Holocene culture-historic trajectories and (2) Mid- to Early Late Holocene culture-historic trajectories.

Early Holocene Culture-Historic Trajectories

Baluchistan and the Indus-Sarasvati Basin: Mehrgarh Tradition

Mehrgarh is a key site located on the Bolan River in the Kachi Plain. The north Kachi Plain is a semi-arid region with natural xerophytic vegetation. Here, three environmental zones (hills, plains, and perennial rivers) come together. The prehistoric settlement covers an area of more than 200 hectares, making it one of the largest settlements of Neolithic culture between the Indus and the Mediterranean. Of this, about 700 m^2 was excavated in six field seasons. The 9-m-thick cultural deposit has been divided into seven periods, from Aceramic (Pre-Pottery) Neolithic down to the third millennium BCE. Excavations have revealed remains of a Pre-Ceramic Neolithic culture with a suggested date of 8000–7000 BCE. The first occupants of the Aceramic Neolithic stage lived in rectangular rooms of smaller size. One room of a house complex measured 2 m × 1.80 m. Mud bricks were used to construct multi-roomed houses and storage units. The inhabitants ate goat meat, but meat from hunting of ungulates seems to have been preferred (Jarrige 2008).

The first ceramic stage begins around the 7th millennium BCE and the second around the 6th, during which time sheep, goat, and cattle were domesticated. Cattle breeding replaced hunting as the dominant form of animal exploitation (see Meadow 1981). At this stage, barley was being cultivated, and rows of large compartmented storage buildings were built in well-defined areas. The settlement had now grown to more than 10 ha in size but the socioeconomic pattern remained unchanged during the course of the 6th and 5th millennia BCE. However, toward the end of the 5th millennium, there was a marked change in the settlement pattern, and by this date six medium-sized settlements sprang up in this area. Cultivation of wheats, which previously had been very limited, became important.

The archaeological and archaeobotanical evidence from Mehrgarh suggests that the first farmers arrived east of the Indo-Iranian borderlands around 10,000 years ago, equipped with sheep, goats, and cattle and a cool-season complex of crops (e.g. barley, emmer, flax, lentil, and chickpea). Three varieties of wheat, two forms of barley, and local zebu are the early domesticates, and later introductions include sheep, goat, and cattle varieties. Flax, safflower, and South West Asian pulses were later introduced in waves from the late 5th millennium BCE, whereas cotton appears to have cultivated prior to the 5th millennium BCE (Costantini 2008).

It has been postulated that during the Late Pleistocene, hunter-gatherers fed themselves by collecting wild grasses and fruits in the foothills and by hunting animals on the open slopes and on the plain near watering points, but by the early seventh millennium BCE, cereal cultivation in flooded fields played an important role in the subsistence economy in this area. A study of 30 mud bricks or large fragments found in the excavation produced 5956 identifiable impressions. The proportions of the various taxa are 91% six-row barley; 4% einkorn/emmer; 2.5% wild barley/two row barley; 1.8% hulled six-row barley; and 0.7% durum bread wheat. From these data, it is clear that cereal cultivation was almost entirely limited to naked six-row barley, which was perhaps not completely domesticated. Other cereals grown include wild barley, einkorn, and emmer, and durum bread wheat; the latter are significant because wild wheats are not known from this part of the world today. Thus, the most important point in this context is the preponderance of barley, particularly six-row barley, in the aceramic Mehrgarh and the limited presence of wheat in this level. Among the fruits, mention may be made of zizyphus, grapes, and date palm. In addition, cotton seeds (*Gossypium* sp.) were also found from a building of Period I.

Mehrgarh represents a combination of domestication of crops introduced from Southwest Asia and local zebu cattle. This evidence suggests that domestication of cattle took place twice at different times between Southwest Asia and Baluchistan.

Mid- to Early Late Holocene Culture-Historic Trajectories

The Himalayan Region: The Kashmir and Swat Valleys – The Burzahom Tradition

Burzahom is a key site located about 16 km northeast of Srinagar, surrounded by hills covered with forest as well as lakes and swampy areas. This geographical setting provides an ideal place for fishing, fowling, and hunting. The habitation remains of this site comprise subterranean dwelling pits. A series of flat-bottomed, circular, and oval pits were excavated containing ashy deposits. The largest was bell shaped, measuring 4.57 m in diameter and 3.96 m in depth. Plastered with clay, a number of these pits also contained stone hearths. The presence of postholes on the periphery suggested the existence of a birch cover supported on wooden posts as protection against inclement weather. At Burzahom, pit-dwelling gives place to mud or mudbrick architecture in Period II c. 1500 BCE.

Stone implements comprise chisels, adzes, pounders, maceheads, and pins. The rectangular harvester with a crude cutting edge and two or more holes on either side makes its appearance in Period II at Burzahom; however, the microlithic component seems to be absent at this site. In addition, a developed bone tool industry is a diagnostic trait of the Burzahom Neolithic. These bone tools comprise harpoons, needles with or without eyes and awls, spearpoints, arrowheads, and daggers for hunting game and scrapers.

The absence of seeds in the earliest levels at Burzahom suggests that there is no positive evidence for cultivation of cereals. But the presence of a stone quern in one of the pit chambers indicates the processing of grains. Animal bones from the kitchen middens suggest that hunting and fishing were practiced. Remains of pig, Kashmir stag, nilgai, and domestic sheep have been found from Period I. Period III has yielded bones of dog, sheep-goats, humped cattle, and even buffalo – all of the domesticated variety. The wild animals include the wolf and the Kashmir stag.

Other excavated sites in the Kashmir Valley include Semthan, Ghaleyghay, Birkot-Gwandhai, and Gufkral (Allchin and Allchin 1982; Sharma A.K. 1986; Buth, Khan, and Lone 1986; Lone, Khan, and Buth 1993). Semthen and Gufkral have yielded botanical remains. Here, the first settlers subsisted to some extent on cereal farming and stock raising supplemented by hunting. Grains of domesticated wheat, barley, lentils, and pea have been identified, and bones of domesticated sheep and goat, suggesting herd management in sub-period IA. Among the hunted animals, bones of ibex, bear, wild sheep/goats, wild cattle, wolf, and Kashmir stag have been identified.

The Vindhya Region: The Son and Belan Valleys – The Kaimur Tradition

Koldihwa, Mahagara, and Chopani-Mando on Belan River show the transition from intensified food gathering and selective hunting through incipient food producing to settled village farming (G.R. Sharma et al. 1981; Pal 1986; P. Singh 2010). The Mahagara excavations in particular have revealed as many as 20 houses, and blades and microliths, pottery, querns, mullers, sling balls, celts, bone arrowheads, terracotta beads, and animal bones were found scattered on the house floors. The existence of a cattle pen is attested by the large number of hoof impressions of cattle. Outside the pen, near the hut clusters, were found hoof marks of sheep or goats.

The animal remains comprise cattle, sheep, goat, horse, deer, and wild boar. The archaeobotanical remains include rice husk used in the paste of the pottery and indicate that rice was widely cultivated in the area. The wild rice (*Oryza nivara*) from Koldihwa, Mahagara, and Indari and bone fragments of deer, antelope, bear, and bird suggest that hunting and collecting of wild plant food was as important as domestication and cultivation. The Neolithic site of Senuwar further east in the Kaimur Hills has also yielded carbonized grains of cultivated crops that inclue rice, barley, field pea, and lentils dated between 1770 and 1400 BCE (Saraswat 2004, 2005).

The Middle Ganga Basin: The Ganga Tradition – An Independent Center of Rice Cultivation

The Neolithic/Chalcolithic sites in the middle reaches have presented archaeobotanical data with potential for tracing the transition from hunting-gathering/foraging to systematic management of local cereals and their eventual cultivation and domestication (Saraswat 2004; Muphy and Fuller 2014; Fuller 2011a,b). Archaeobotanical research in the Middle Ganga basin has produced a good data set of crops, with clear evidence for cultivated rice in the beginning of 2000 BCE.

Jhusi, Hetapatti, Bhunadih, Waina, Sohgaura, Imlidih Khurd, Lahuradewa, Senuwar, and Chirand in Uttar Pradesh and Bihar have yielded material culture as well as organic remains helping in characterization of the Ganga valley Neolithic culture. Chirand on Ganga is a type site with a cultural stratigraphy from the Neolithic to Chalcolithic whose calibrated radiocarbon dates indicate subsistence production beginning around 2200 BCE. This period (2000–1800 BCE) witnessed the introduction of winter crops and livestock from the Indus valley and south Indian pulses such as mung bean and horse gram (some of the salient features have been described; see P. Singh 2010; B.P. Singh 2004; Tewari et al. 2003, 2006, 2008). Houses were either circular or oval in plan with wattle-and-daub structures, a common feature of the Neolithic huts. Other structural features include hearths, pit silos, etc. An agropastoral economy is evident. A variety of cereals and pulses including rice, barley, wheat, field pea, lentil, green gram, etc. have been documented from the Neolithic levels. Domesticated animals included cattle, buffalo, sheep, goat, and pigs.

Domesticated animals include humped cattle, Indian buffalo, sheep, goats, and pig. Among the wild animals, rhinoceros, swamp deer, and chital seem to have been hunted. A number of fish bones and teeth as well as mollusk shells suggest that fishing was popular. Water buffalo were probably wild throughout most of the subcontinent. Major vegetable crops native to this region are cucumbers (*Cucumis sativus*), snake gourd (*Trichosanthes cucumerina*), bitter cucumbers (*Momordica* spp.), and ivy gourd.

Rice husk impressions on pottery and rice microbotanical remains from Lahuradewa, Koldihwa, Senuwar, and Chirand show that after 2000 BCE, rice assumed a certain importance when hybrid-*indica* replaced the indigenous and morphologically wild proto-*indica*. Evidence of rice remains from Mahagara, Koldihwa, Senuwar, and Lahuradewa and their radiocarbon dating has ushered in an ongoing debate on the antiquity of rice cultivation in India, and the dated evidence from Lahuradewa has intensified this debate. However, archaeobotanical analysis suggests that the direct date of 6400 cal BCE on rice indicates the plausibility of recognizing the Ganga Plain as an independent center of rice cultivation of the subspecies *indica* through a protracted and complex process (Fuller 2006a, 2011a,b; Murphy and Fuller 2016).

At Lahuradewa, there is evidence for sedentary settlement and ceramics dating to c. 7000 BCE. This early date is suggestive of early use of rice or systematic management or non-domestication cultivation. But morphologically domesticated rice appears around 2000 BCE, and non-shattering domesticated spikelet bases appear during 1800–1600 BCE, and therefore it is argued that older occurrences of rice are likely proto-*indica*, "which was managed by non-intrusive cultivation and harvesting methods," and domesticated *indica* only appears after 2000 BCE in association with the first sedentary settlements established by 2500 BCE, prior to the introduction of non-native crops (Fuller and Qin 2009; Fuller et al. 2010; also see Fuller 2011a).

Eastern India: The Utkal Tradition – An Independent Center of Rice Cultivation

Among the three modern states of eastern Neolithic Chhattisgarh and Jharkhand, the region of Odisha has witnessed intensive archaeobotanical research. Our knowledge of the Neolithic culture of Odisha is based on excavations at Kuchai, situated about 8 km to the north of Baripada in the Keonjhar district. Odisha finds a prominent position on the map of ancient agricultural settlements of the Neolithic/Chalcolithic phase in the subcontinent because of its geological variety with respect to natural resources on the one hand and biological/ecological diversity on the other. The excavations at Golbai Sassan, Gopalpur, Harirajpura, Talapada, and Khameshwaripali have revealed cultural layers ranging from the early 3rd millennium to the early 1st millennium BCE, from the Neolithic to early Iron Age, with the main phase of occupation beginning in the middle of the 3rd millennium BCE (Behera 2001; Dash 2000; Mohanta 2003). The archaeobotanical assemblage comprises rice, peninsular pulses, and local pulse red gram (Harvey et al. 2006; Harvey and Fuller 2005). The ceramic types and bone tools reveal an affinity with the Ganga valley sites of Chirand, but wheat and barley are distinctly absent.

North Gujarat: The Anarta Tradition – An Independent Center of Millet Agriculture

An integrated multi-proxy study of two sites in north Gujarat with earliest evidence of agropastoral activity has yielded charred seeds, phytoliths, and starches (Figure 28.5). Varahvo Timbo has hunter-gatherer occupation (5600 to 5000 BCE), and Loteshwar has both hunter-gatherer (5168–4708 BCE) and Anarta sedentary culture (3681–2243 BCE). Holocene archaeological research in this region has identified a distinctive sequence of cultures showing the existence of hunter-gatherer (microlith-using Mesolithic communities), semi-nomadic agropastoral, and urban Harappan settlements well adapted to arid to hyper-arid environments (Possehl 1992; Ajithprasad 2002, 2004, 2011; Ajithprasad and Sonawane 2011). The majority of later prehistoric settlements are associated with interdunal depressions, with assured water resource during most of the year, even though the area receives less summer monsoon relative to other areas of the subcontinent. Anarta culture is placed between hunter-gatherer microlithic tradition and Harappan urban tradition. Not more than 20 sites of the Anarta culture are known from this region (Ajithprasad: personal communication, May 2017). The microlithic sites mark the presence of human settlements during the Mesolithic period dating back to the 7th millennium BCE. The Mid-Holocene congenial climate appears to have witnessed diffusion of hunter-gatherer communities.

Recent integrated multi-proxy study of two sites, Loteshwar and Varahvo Timbo, by Garcia-Granero et al. (2016) has led to establishing the Anarta tradition as yet another independent center of agricultural origins. The potential of this region for such an identification was recognized early on (Fuller 2006a, 2011a,b; Gadekar et al. 2006; Balbo et al. 2013, 2014a,b). At both the sites, the earliest levels are represented by hunter-gatherer activity indicated by the microlithic assemblages. A systematic sampling and identification of macro-botanical and phytolith remains was carried out (see Garcia-Garnero et al. 2016 for details; Korisettar 2016 for comments). A study of faunal remains has indicated the potential of the region for local domestication of cattle. The Anarta levels from Loteshwar were dominated by an assemblage of *Setaria verticillata* (bristly foxtail) and *Setaria pumila* including hulled grain of yellow foxtail. Other taxa include cf. *Panicum sumatrense* (little millet), *Brachiaria ramosa* (browntop millet), *Digitaria* sp., and *Echinochloa* cf. *colona* (jungle rice). Fragments

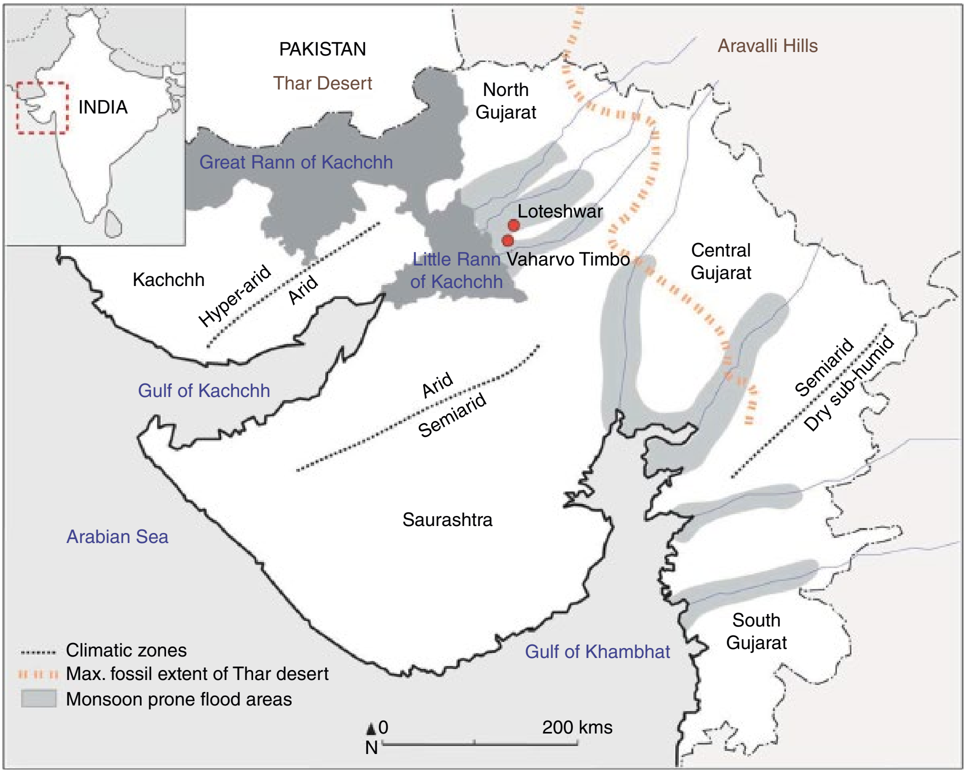

Figure 28.5 Map of Gujarat showing the geographical subdivision and climatic zones and the location of investigated sites in north Gujarat. Source: García-Granero et al. (2016). Reproduced with permission of University of Chicago Press.

of mineralized *Coix lacryma-jobi* (Job's tears) were also found as well as grass remains including *Dactyloctenium aegyptium* (crowfoot grass), several fragmented grains of C_3 cereals (*Triticum* sp.), and some unidentified grasses. Phytoliths and starch grains were recovered from grinding stones. Microremains, however, have proved difficult to identify.

Armed with these sets of data, the authors set out to test (1) a generalized hypothesis on the origins of agriculture in the semi-arid regions (Fuller 2006a), including Gujarat; (2) the existence of a local, millet-based agricultural economy prior to the establishment of Harappan urban settlements and (3) whether Anarta was an independent center of agricultural origins prior to the expansion of Harappan Civilization. While all the earlier archaeobotanical evidence came from Harappan sites and a non-Harappan site of Padri in Saurashtra, this evidence from north Gujarat is a major breakthrough. This research has pushed back the antiquity of agricultural origins to the 4th millennium BCE, and the evidence from Anarta clearly points toward the existence of ecologically suitable conditions for an early transition to agriculture focusing on local millets. In view of the ubiquity of small millets in the Saurashtra region of Gujarat, the possibility of early domestication of monsoon-adapted local millets, particularly *Panicum sumatrense* and *Setaria* was hypothesized, pending documentation from non-Harappan archaeological contexts (Fuller 2006a).

The evidence presented here by Garcia-Granero et al. clearly indicates the existence of sedentary agriculture from the mid-3rd millennium BCE and antedates the similar evidence from Southern Neolithic of India (Fuller et al. 2007). The presence of wild *Sesamum* sp.

grains is significant and that it was present in the region during the Mid-Holocene is important. The Anarta region appears to be sensitive to Holocene climate change. Being an arid to hyper-arid environment, the weakening of the summer monsoon would have caused dramatic impact on the life of hunter-gatherer communities, who would have responded by cultivating local millet crops and maintaining a semi-nomadic agropastoral way of life.

The Banas Valley (Eastern Rajasthan): The Mewar Tradition

The Ahar-Banas culture sites are located in the Mewar region of Rajasthan contiguous to the Aravallis, the source of variety of rocks, minerals, and metals. The Ahar-Banas culture falls in the radiocarbon time bracket of 3700–1830 BCE. More than 111 sites of this culture have a linear settlement pattern along the Banas River and its tributaries (Sankalia, Deo, and Ansari 1969; Hooja 1988). Excavated sites include the type site at Ahar and the nearby sites of Balathal, Gilund, and Ojiyana (Misra 1997, 2005; Misra et al. 1995).

Single to multi-room houses were rectangular, squarish, or circular. They were mainly made of stone, mudbrick, and mud. Many houses contained both aboveground and underground silos for storing grains, U-shaped hearths (*chulas*), stone saddle querns, and rubberstones for grinding or processing grains. The subsistence economy was a mixed one – cultivation, animal husbandry, and hunting. Wheat (*Triticum* sp.), barley (*Hordeum vulgare*), lentil (*Lens esculenta Moench*), the common pea (*Pisum arvense L.*), finger millet (*Eleusine coracana L.*), Italian millet (*Setaria italica* (L.) *Beauv.*), and panicum millet (*Panicum sp.*) were cultivated. At Ojiyana, remains of barley, dwarf wheat, bread wheat, rice, varieties of millet, horse gram, lentils, peas, moth bean, chickpea, sesame seeds, and sunflower were found.

Domesticated animals included cattle, buffalo, sheep, goat, and pig and they also hunted wild animals such as gaur (*Bos gaurus*), nilgai (*Boselaphus tragocamelus*), chausingha (*Tetracerus quadricornis*), and blackbuck (*Antilope cervicapra*). Remains of turtles, mollusks, and fish have also been recovered, reflecting a varied diet based on local available resources.

Malwa (the Chambal, Betwa, and Narmada Valleys): The Kayatha and Malwa Traditions in Malwa

Kayatha culture sites are located in the vast expanse of fertile black soil in western Madhya Pradesh. The Chambal and its tributaries drain the region. Over 40 sites of the Kayatha culture are known, and Kayatha and Dangawada have been excavated (Ansari and Dhavalikar 1973; Dhavalikar 1970, 1984). Both these sites have yielded all three regional Chalcolithic cultures – Kayatha, Ahar-Banas, and Malwa – and preliminary radiocarbon dates suggest a chronological presence between 2400 and 1800 BCE (Wakankar 1967; Wakankar and Khare 1981; Dhavalikar 1970).

The Malwa culture is more widespread than the Kayatha culture with more than one hundred sites reported from various river valleys such as the Narmada, Betwa, Chambal, and their tributaries. Among them, Nagda, Kayatha, Navdatoli, and Eran have been excavated (Sankalia, Deo, and Ansari 1971; Sankalia, Subbarao, and Deo 1958). Navdatoli on Narmada was subject to horizontal excavation that revealed rectangular and circular wattle-and-daub residential structures, house floors, and hearths. At some sites, defensive walls have also been found. Excavations at Nagda yielded multi-roomed houses made of mud and bricks, which were baked in both sunlight and in a kiln. Saddle querns, elongated rubbing stones, and hammerstones were also recovered. At Dangwada, the Malwa horizons yielded a possible shrine made of bricks and plastered with mud, and terracotta female and bull figurines have been found at several sites, prompting discussions about a "mother goddess" cult (Dhavalikar 2002).

The people of the Malwa region cultivated cereals, legumes, oil seeds, and fruits. Cereals included bread wheat (*Triticum compactum*) and rice (*Oryza sativa L.*). Among the pulses and legumes were lentil (*Lens esculenta*), black gram (*Vigna mungo*), green gram (*Phaseolus mungo*) and *khesari* (*Lathyrus sativus*). The presence of linseed (*Linum usitatissimum*) has been documented as well as wild jujube (*Zizyphus jujube*). Domesticated cattle, sheep, goat, and pig are present.

West Deccan: The Tapi, Godavari, Upper Krishna, and Bhima Valleys – The Deccan Chalcolithic Tradition (Malwa and Jorwe Cultures)

The Deccan Chalcolithic is characterized by the development of an agropastoral economy identified by ceramic styles: (1) Savalda (c. 2200–1800 BCE), Late Harappan (c. 1800–1300 BCE), Malwa (c. 1600–1400 BCE), Early Jorwe (c. 1400–1000 BCE), and Late Jorwe (c. 1000–700 BCE). The Malwa and Jorwe culture settlements have received the most attention – there are more than 200 Chalcolithic sites, of which 15 have been excavated (Dhavalikar 1988; Dhavalikar, Sankalia, and Ansari 1988; Sali 1986; Sankalia 1955; Sankalia et al. 1960; Sankalia, Deo, and Ansari 1971; Shinde 1990, 2000, 2002; Panja 2002).

Deccan Chalcolithic settlements have a linear distribution pattern governed by the dendritic network of the Tapi, Godavari, Pravara, Bhima, and Krishna rivers. These cultures flourished in the heartland of the Deccan Volcanic Province with well-developed black brown soils, highly productive under the prevailing seasonal monsoon (ranging from 250 to 1150 mm per year). With the exception of the west-flowing Tapi River, the east-flowing drainage network is flanked by high banks with narrow flood plains and semi-arid scrublands suitable for animal grazing and rocky interfluves with occasional woodland that facilitated hunting and foraging. A variety of fauna including *Elephas maximus* (Asian elephant), *Panthera tigris* (tiger), *Panthera pardus* (leopard), *Felis caracal* (caracal), *Felis lynx* (lynx), *Hyaena hyaena* (hyena), *Sus scrofa* (wild pig), *Cuon alpinus* (wild dog), *Melursus ursinus* (sloth bear), *Antelope cervicapra* (black buck), *Axis axis* (spotted deer, or *chital*), *Tetracerus quadricornis* (four-horned antelope), *Cervus unicolor* (sambar), *Bos gaurus* (gaur), *Herpestes edwardsi* (mongoose), *Lepus nigricollis* (hare), and *Ratufa macroura* (grizzled giant squirrel) occur in the region.

Excavations at a number of sites including Nevasa, Daimabad, Inamgaon, Walki, and Kaothe have revealed mud and mudbrick houses, wheel-thrown pottery, and copper implements (sparingly). Houses were both rectangular and circular in plan, paved with layers of silt, ash, clay, and cow dung. Pit dwellings are known from Inamgaon and Kaothe. In the Jorwe phase, rectangular houses built of mudbrick were common. The Malwa and Jorwe phases (found throughout the region) were a period when the population sizes began to grow, new settlements were founded, and double cropping took hold to feed the growing populations. The Savalda and Late Harappan phases are only found in the Pravara valley at Daimabad. Copper artifacts are sparse, but microliths are common.

A mixed subsistence economy is also typical of the Deccan Chalcolithic cultures, which raised both kharif and rabi crops. There is evidence for the cultivation of barley (*Hordeum vulgare*), wheat (*Triticum* spp.), and rice (*Oryza sativa*). Three additional species of African millets were adopted in the Early Jorwe phase: finger millet (*Eleusine coracana*), sorghum millet (*Sorghum bicolor*), and Kodo millet (*Paspalum scrobiculatum*). Deccan Chalcolithic people also cultivated peas, beans, and lentils, including some species imported from southern India. Pulses found in the floral remains at Daimabad and Inamgaon included lentils (*Lens esculenta*), common pea (*Pisum arvense*), horse gram (*Macrotyloma uniflorum*), hyacinth bean (*Dolichos lablab*), black gram (*Vigna mungo*), and mung bean (*Vigna radiata*). Oil seeds included linseed (*Linum usitatissimum*) and safflower (*Carthamus tinctorius*).

The domesticated animals comprised *Bos bubalus* (buffalo), cattle (*Bos indicus*), sheep/goat *(Capra/Ovis*), and dog (*Canis familiaris*). Hunted animals included blackbuck *(Antelope cervicapra*), chital *(Axis axis*), sambar (*Cervus unicolor*), and four-horned antelope (*Tetracerus quadricornis*). There is also evidence of jujube (*Ziziphus jujube*).

Quantification of the faunal and floral record, as well as the domesticates, has revealed a trend from predominance to decline associated with culture change from Malwa to Jorwe (Early to Late). The decline in the Late Jorwe is attributed to climate change, which allowed a shift during the Savalda phase to hunting and wild food gathering, while the Malwa and Early Jorwe phases witnessed a prosperous phase of the agropastoral economy (Dhavalikar 1984; also see Schug 2011). Between Early and Late Jorwe, as revealed by the Inamgaon bioarchaeological data, one observes a fundamental shift in the floral and faunal remains. The Late Jorwe saw a focus on more lentils (a saline-tolerant crop) and gathered vegetal foods, like jujube and an increasing proportion of sheep, goat, antelope, and deer remains (Schug 2011).

Mid-Deccan: The Ashmound Tradition – An Independent Center of Millet Agriculture

The South Deccan is predominantly semi-arid, occupying the middle portion between the relatively humid Western and Eastern Ghats (Figure 28.6). Several hundred Neolithic sites in the southern states of undivided Andhra Pradesh, Karnataka, and Tamil Nadu have been documented (Korisetar, Venkatasubbaiah, and Fuller 2002; Fuller 2008). Recent archaeological research on the Southern Neolithic has identified three distinctive traditions in the developmental sequence of agropastoral economies between 3000 and 1200 BCE. They are (1) the Ashmound tradition, the earliest among them, (2) the Kunderu tradition, and (3) the Hallur tradition (Fuller, Venkatasubbaiah, and Korisettar 2001). These three traditions are chronologically well constrained by a suite of AMS radiocarbon dates (Fuller, Boivin, and Korisettar 2007). The Ashmound tradition began earlier than the other two and survived for almost two millennia. These three traditions reveal successful adaptation to the largely semi-arid environments of the Late Mid- and Early Late Holocene fluctuating monsoon regimes. A systematic archaeobotanical sampling and laboratory identification of a suite of food crops, both native and introduced, have been identified from a series of Neolithic sites along an east–west transect between the Western and Eastern Ghats. This has considerably enhanced our understanding of the origins of agriculture as well as documenting evidence for identifying the Ashmound tradition as an independent center of agricultural evolution during the period between the early 3rd and mid-2nd millennium BCE (Fuller et al. 2004). These ashmounds are large heaped accumulations of cattle dung that were burned, often at high temperatures. Recent analysis suggests that at a number of sites the ashmounds (which were not uniform deposits) predate the establishment of regular villages (Korisettar et al. 2002; Boivin et al. 2005; Boivin, Korisettar, and Fuller 2008).

Radiocarbon data from Watgal, Sanganakallu, Tekkalakota, Budihal, and Kodekal have considerably helped in extending the beginnings of the Southern Neolithic culture to the beginning of the 3rd millennium BCE. On the basis of the Watgal excavations, the Neolithic

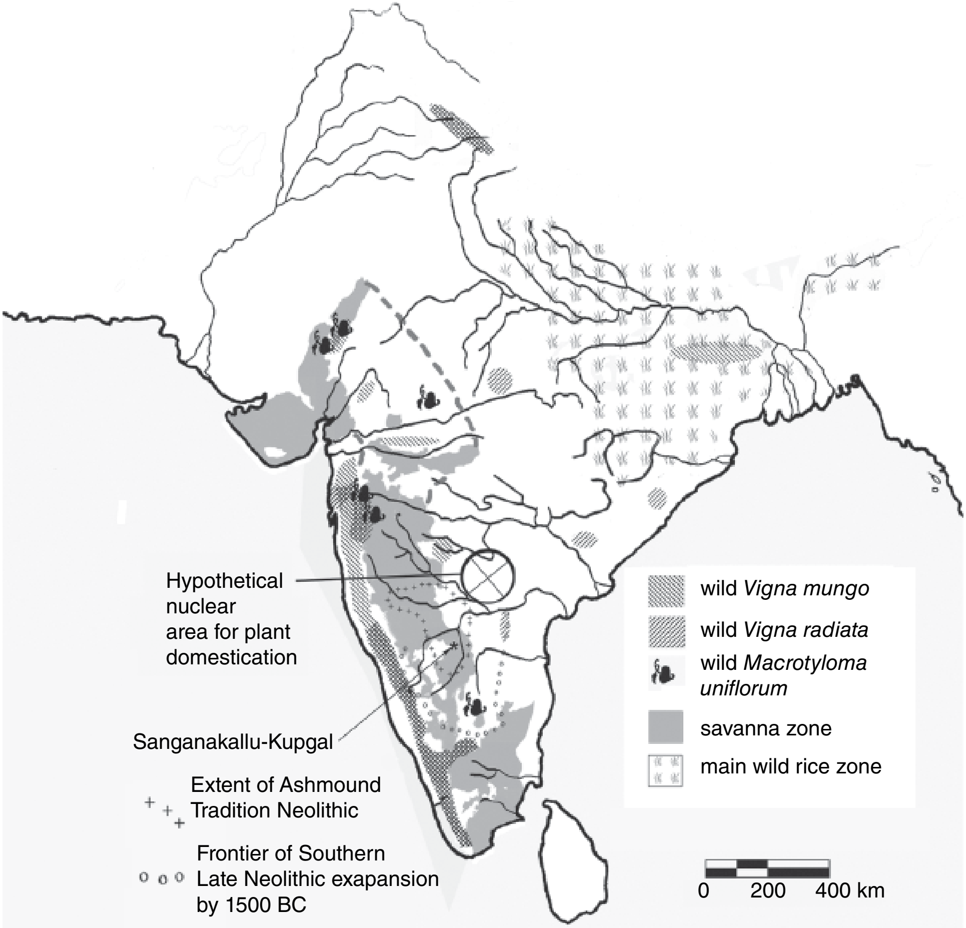

Figure 28.6 Map of selected wild crop progenitors in India in relation to the hypothetical south Indian center of plant domestication and the Southern Neolithic. Indicated is the savanna-scrub vegetation zone showing distributions of wild horse gram, wild millets, and pulses. After Boivin et al. 2008. Source: Illustration by Ravi Korisettar

has been divided into four occupational periods: Periods II to IV represent the continuous development of the Neolithic occupational sequence, starting around 2700 BCE and ending around 1500 BCE, with Period II consisting of two sub-phases that provide clear evidence of Neolithic occupation at Watgal (Devaraj et al. 1995).

Cattle bones are dominant in both the habitation and ash mound sites. Two breeds of cattle have been identified: (1) longhorned (*acutifrons*), slender-bodied and humped (the zebu) and (2) massive and relatively short. Because of the importance of cattle, sheep and goat were relegated to a secondary position (Korisettar et al. 2001).

Of the vegetal remains, pulses were clearly the most prevalent. The most widespread pulse on Southern Neolithic sites is horse gram/kulthi (*Macrotyloma uniflorum* (Lam.) Verdc., synonym *Dolichos uniflorum* Lam.). Horse gram occurs in the earliest samples, such as the lowest level at Sanganakallu, and it has also been recovered from the all regions of the Neolithic thus far sampled. The green gram/mung (*Vigna radiata* (L.) Wilczek, syn.

Phaseolus radiatus L.) is also widespread through the middle and later periods of the Southern Neolithic. The closely related black gram/urid (*Vigna mungo* (L.) Hepper) is less widely represented in Neolithic samples, although it has been found from the Late (?) Neolithic of Hallur and from the Iron Age (1st millennium BCE) at Veerapuram, Kurnool district (see Fuller and Murphy 2017). Two other pulses that were probably later additions have been recovered from Southern Neolithic sites, one of which may have originated in Africa. Pigeon pea/Tuvar/Arhar (*Cajanus cajan* (L.) Millsp.) was derived from the wild *Cajanus cajanifolia* (formerly considered a separate genus, Atylosia) which is restricted to southern Orissa and Bastar. Archaeobotanical finds are few but suggest that the domesticate was diffusing on the peninsula in the mid-second millennium BCE, i.e. the Late Neolithic/Early Jorwe, including Sanganakallu, Peddamudiyam, and Tuljapur Garhi (Maharashtra). Another pulse widely recovered from 2nd millennium BCE sites on the peninsula is hyacinth bean/sem (*Lablab purpureus* (L.) Sweet).

The staple crops of the Southern Neolithic were millets, dominated by a foxtail millet (*Setaria* sp.), in some cases to be identified with the bristly foxtail (*S. verticillata*), although the yellow foxtail may also have been present. It is also possible that sawa millet (*Echinochloa colona*), another grass that is a natural constituent of the peninsular grasslands, is present. Present in the Iron Age, and perhaps coming into cultivation during the later 2nd millenium BCE, was Kodo millet (*Paspalum scrobiculatum*), which has been found further north from Jorwe period Daimabad and from the Iron Age site of Veerapuram in Kurnool district. The ubiquity and quantity of millets from recently studied sites strongly suggests their use as staple grains, especially *Setaria* sp., although it remains ambiguous as to whether these were actually domesticated or extensively gathered in the wild. The high level of purity of the samples, with relatively few other grasses present, argues for cultivation (Fuller et al. 2004).

Northeastern Region: The Brahmaputra Tradition

Northeastern India, comprising Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, and Mizoram, is one of the least explored regions of the subcontinent, mainly because of the torrential rain and impenetrable jungles. The northeastern Neolithic culture zone includes the Cachar, Garo, and Naga Hills containing the excavated sites of Daojali Hading and Salbalgiri (Garo Hills) and Sarutaru and Marakdola (Shillong plateau). However, keeping in view the geographical vastness of this area, the data are admittedly inadequate. Further, even the documented excavations are mostly of a vertical nature, and we still do not have either a detailed picture of the lifestyle and economic background or a firm chronological base for most of these cultures.

The Neolithic culture seems to have penetrated in the hilly tract in the Himalayan foothills, and Neolithic stone implements have been reported from north Sikkim as well as neighboring Nepal. Explorations conducted along the Tista River and its tributaries in the Djangu area of north Sikkim have brought to light no fewer than 11 sites, i.e. Lingthen, Lingdon, Barpak, Saukalan, Lingden, Gytong, Sangdeng, Guon, Torang, Gor-Taranol, and Linkyong. The tool types comprised harvesters, knives, axes, adzes, and single- and double-perforated celts mostly made of schist shale and basalt. Some of these types, like the double-perforated celts, are typical of this region and have affinities with the Indian Neolithic assemblage. The adzes, Honan knives, perforated celts, and harvesters are typical of the South Chinese Neolithic assemblage. A similar assemblage was also reported from Nepal by the Institute of Archaeology of Leningrad.

It is postulated that this region might hold the key to understanding an independent development of rice cultivation or spread of rice from the east into the subcontinent (Bellwood 2005, p. 87), probably very early in the Mid-Holocene.

Discussion: The Role of Water in Sedentation and Adoption of Agriculture

The two millennia between 3000 and 1000 BCE witnessed the rise and fall of a series of regional Neolithic/Chalcolithic cultures; some reached the level of state society (Harappan Civilization) and yet waned; clusters of settlements were abandoned, and some were transformed. Archaeologists therefore have had compelling reasons to design research questions that address these issues as well as formulate theories and models to be able to explain the causes for "rise, development and decline." To date there are a number of such theoretical models about the "decline" of the Harappan Civilization, and not surprisingly similar attempts are made to explain either the end or transformation of Neolithic/Chalcolithic cultures or settlement desertion during the close of the 2nd millennium BCE in the diverse culture-historic divisions that have been identified above.

Origin, development, and decline are the triple aspects of this culture-historic study of early agricultural societies or early urban societies, and of the three, explanations for the development of a particular culture are not as complex as the other two: origins and decline. Many theoretical and empirical models exist in the archaeological literature of Indian Protohistory (Harappan Civilization) and later prehistory (Neolithic/Chalcolithic cultures) (the studies of Schug 2011 and Roberts et al. 2015 are recent examples; see also Sinha et al. 2011; Spielmann et al. 2011; Staubwasser et al. 2003, 2006). However, I do not intend either to critique or to go into the merits of each of these models but would like to add a further dimension to the study of early agricultural settlement history with reference to sites in the Mid-Deccan Neolithic province.

Ecological Stability and the Role of High Water Table: Observations from the Deccan

The subcontinent's ecological diversity is governed by the spatial variation in the summer and winter monsoon precipitation, and their resource stability is maintained by groundwater movement and high water tables, which are in turn maintained by monsoon recharge. For example, the evergreen character of the Western Ghats and the so-called perennial drainage network of the Indo-Ganga basin are primarily maintained by groundwater movement from the Himalayas and adjacent uplands. Short-term variations in the monsoon circulation no doubt affect the discharge regimes, but the impact on the carrying capacity of the ecosystems and the dependent human communities would have been of a degree but not of a magnitude comparable to the Younger Dryas event of the Early Holocene. It has been suggested that moisture regimes over the subcontinent during even-numbered oxygen isotopic stages (see above) experienced reversal only in the intensity of summer and winter monsoons over the subcontinent (Prasad, Phartiyal, and Sharma 2007; Prasad et al. 2014), thus maintaining a stable supply of meteoric waters. Given the low demographic pressure during the Mid-Holocene, one is not convinced of the impact of "aridification" causing transition to agriculture. In support of this statement, I would like to describe the perennial nature of water resources for the early agricultural communities in the Mid-Deccan region, which is coterminous with the Southern Neolithic Province, a largely semi-arid environment since the Mid-Holocene, or even throughout the Holocene.

The Mid-Deccan region is largely a tor-inselberg granitic landscape surrounded by pediplains and peneplains. The terrain is potentially low in groundwater with poor and shallow surface water resources and low plant animal food resources. These factors may explain the late transition to subsistence production. Surface runoff of monsoon precipitation results in sheetwash flow, leading to the accumulation of rainwater in topographic lows and consequently the formation of swamps and ponds on the surface. Further perennial spring activity contributed to gently flowing hanging streamlets (spring discharge from the hillsides) that eventually terminated in the topographic lows in the largely semi-arid environments of the Mid- and Late Holocene, and even earlier. Under low demographic pressure, the Mid- and Early Late Holocene geomorphic environments were much more well watered than now, a landscape situation almost perfect for raising summer millet and pulse crops, some which were natural grasses endemic to the region.

Similarly, the drainage network with low banks facilitated inundation of the flood plains and formation of thickets and galleria forests. Post-monsoon spring activity emanating from the inselbergs provided for yearlong flow of surface runoff that could support initiation of cultivation of summer crops. Despite contemporary population stress, water resources through spring activity in the inselbergs were active until recently, and some of them still are active for a couple of months in the post-monsoon season. Such ecological conditions ensured that the small-scale societies could sustain their subsistence production during the Mid- to Late Holocene period, despite abrupt changes in the precipitation regimes of the summer monsoon. The most important factor governing the sustainability of the food economy was the low demographic stress on the spring water resources in the inland regions – a mosaic of erosional and gently undulating topography. Denudational activity was characterized by sheetwash flow of surface water emerging from springs in the inselberg hills. Despite the low groundwater potential of the gneissic landscape, springs in the hills were ideal places for locating early agricultural settlements during the Late Holocene. Active springs continued to feed the low-lying ponds and pools during historical times and the drainage organization as we see it today evolved during post Neolithic times, with increasing preference for summer crops, hardy millets, and expansion of arable land.

Natural gravity flow of water from the inselberg heights facilitated the irrigation of the slopes and foothill regions. High water tables released fresh water and dampened the pediments, causing swamps during the post-monsoon months, until the onset of winter. Water fowl and water buffalo habitats were associated with these swamps, besides supporting cultivation of summer crops and a little further irrigation, and winter crops could be introduced and cultivated, despite the fact that this region is not covered by winter monsoon. The existence of palaeo-ponds and pools is evidenced by the patches of black brown ponded soils, with adequate fertility, in the largely granitic calcic soils. Freshwater fish remains recovered from excavations (e.g. at Sanganakallu) attest to the presence of ponded environments in the neighborhood of Neolithic sites, the source of which was not necessarily river drainage networks charged by monsoon circulation.

Shallow ponds and seasonal streams that expand during summer monsoon months and shrink in the winter months were not ideal locales for fixing the settlements. Hence, hilltops and foothill regions around granite inselbergs were preferred for as long as the water tables remained high, maintaining perennial wetlands. Furthermore, these locales assured yearlong availability of fresh water to the communities. Crops could have been planted to take advantage of surface runoff at the base of hills. Though a general trend toward lowered monsoon between 4000 and 2000 BCE (Ponton et al. 2012; Prasad et al. 2014) has been recorded, its impact on spring-fed pools and swamps inhabited by spatially dispersed agropastoral settlements deserves to be considered critically.

Late Holocene monsoon fluctuations reconstructed from the sediment cores of Konkan estuaries, Maharashtra, show a decreasing trend during the 2nd millennium BCE, whereas palynological and isotope studies of the Ganga Basin sediments indicate a lowering of monsoon regimes as early as the 3rd millennium BCE that persisted for two millennia. Similarly, deep sea cores from the Arabian Sea and lake sediment cores, including varve analysis from the Himalayan region, also attest to the onset of lowered monsoon regimes during the 2nd millennium BCE. This spatial variation in monsoon fluctuation is in conformity with the spatial variation in monsoon regimes between proximal (peninsular south) and distal (northern Ganga and the Himalayan foothills) regions across the subcontinent. Obviously the onset of "aridity" during the Late Holocene is not uniform all over the subcontinent, while optimum monsoon conditions prevailed in the Deccan the northern Ganga basin experienced drier conditions during the 3rd millennium BCE. Owing to spatial variation in the intensity of monsoon variation, high-precipitation regimes were largely confined to the Western and Eastern Ghats and northeastern uplands, and a major part of the inland regions experienced semi-arid savanna conditions to which all early agricultural settlements were well adapted. The interregional temporal variation in the start of subsistence production is also in conformity with the pattern of monsoon variation.

There is an interesting coincidence in the onset of lowered monsoon and the domestication of rice, a wetland crop in the Ganga valley. This clearly supports my argument that fluctuations in monsoon regimes were not controlling the adoption or cultivation of subsistence crops. The Ganga basin has a network of oxbow lakes that carried fresh water perennially and facilitated the cultivation of crops on the shores and fishing for aquatic food resources. The mixed crop package of wet cereals and dry millets appears to have supported adaptation to changing monsoon regimes, consequent fluctuations in water levels, and a stable subsistence economy. That is the advantage of having a mixed package of cereals and millets. Although numerous studies on archaeobotanical remains have been carried out, none of the studies have attempted to identify the arable locales on the larger landscape. Transitions to subsistence production in any ecosystem occurred only after acquiring adequate knowledge of the environmental conditions and after acquiring a package of crops that facilitated adaptation to the vagaries of climate change. Even in the hyper-arid conditions of north Gujarat, the Anarta subsistence economy was well settled with a subsistence economy based on native millet crops (Garcia-Garner et al. 2016). The regional Neolithic and Chalcolithic cultures that originated from the mid-3rd millennium BCE, including the Indus Civilization, were all semi-arid cultures. The reasons for their development lie in the regional geographical and micro-environments rather than in high-amplitude fluctuations in the monsoon regimes.

The climate (and high-amplitude monsoon fluctuations) and culture change (prosperity or decline of agriculture) relationship has been overemphasized in the vast majority of studies in India, but unfortunately there are few critical studies. Robbin Schug's important study of the relation between lowering of monsoon and the transition from Early Jorwe to Late Jorwe is relevant here. She observes that the rise of north Deccan Chalcolithic (like the Anarta culture) cultures (Malwa to Late Jorwe), which resulted from expansion of populations from outside, occurred in an already "arid" environment, which has been revealed by multiple proxy records. This region is not known for native cereals or millets, but for a couple of pulses. She argues that in such a situation, further reduction in rainfall over the region at the start of 1st millennium BCE would not have made a dramatic impact on subsistence production and the switchover to an alternative mode of subsistence (Schug 2011).

Discrepancy in the monsoon precipitation regimes over the Ganga valley and western Deccan around 1000 BCE is a clear sign that a weak summer monsoon is unable to penetrate deep into north India, causing peak aridity in the Ganga Plain. I would like to attribute this to spatial variation of the monsoon rather than identifying climate change in the Ganga valley. The monsoon data presented in Table 28.1 do not help identify a standard monsoon profile that could be applicable to the entire subcontinent uniformly. Monsoon distribution is a complex phenomenon. While monsoon upwelling data recorded from sea sediment cores indicates high-amplitude fluctuation in the monsoon in response to forcing factors, they do not seem to have had an impact on sea level strand lines. There are, as of now, no records of fluctuating sea levels along the peninsular coast coinciding either with weak or strong monsoons. The lack of evidence for such dramatic impact on sea levels suggests that fluctuations were of a degree and not of a magnitude indicating climate change followed by culture change.

It has been documented that in the culture-historic divisions of the West and Mid-Deccan, the early agricultural communities were equipped with diverse varieties of crops, including drought-resistant barley and millets, and may have had incipient irrigation facilities providing a means for them to cultivate pulses and vegetable crops. The mixed economy also meant that agricultural activities were supplemented by animal husbandry (cattle, buffalo, sheep, and goat), hunting, fishing, and harvesting wild resources as well. Such adaptive diversity must have provided them with stability and security. Given these conditions, short-term fluctuations in the monsoon regimes would not have caused either culture change or abandonment of settlements. Therefore, I strongly believe ecological factors were less important than cultural factors, which need to be identified in the bio-anthropological record.

Conclusion

Ancient agriculture is relatively late in the Indian subcontinent as both archaeological and radiocarbon dating suggest. The Indian subcontinent could never have been an agricultural hotspot. It lies between two major primary areas of cereal cultivation, Southwest Asia on the west and East Asia on the east. The Indo-Iranian borderlands on the western frontiers of the subcontinent and the northeastern humid landforms on the east are critical geographical areas that appear to have been passages for dispersal of crops and movement of peoples from outside. The Indian Ocean maritime links further added to the exchange of food crops and horticultural commodities in and out of the subcontinent.

The subcontinent lies between these two major agricultural regions that have preserved evidence for the transition from hunting-gathering to subsistence production marked by cultivation and domestication of cereal crops and animals such as goats, sheep, and cattle. The Indo-Iranian border lands and maritime links appear to have played a pivotal role in the dispersal and introduction of food crops and agricultural technologies between Africa, southwest Asia, eastern Asia, and the Indian subcontinent and vice versa during the course of Early and Mid-Holocene times. The crops involved in the Neolithic economies of the Indian subcontinent fall into four groups in terms of ultimate origin: Southwest Asia, Africa, Central Asia/China, and native South Asia.

A combination of pastoral and agricultural economies probably contributed to a successful agricultural way of life in the diverse ecosystems across the subcontinent. Both sedentism and cultivation of food crops appear to have started simultaneously in the region. Early farming communities are generally referred to as Neolithic; however, such is not the case in some regions, particularly in western India, where early agriculture is associated with advanced agropastoral communities generally referred to as Chalcolithic.

The subcontinent transition from hunting-gathering to subsistence production does not coincide with glacial to post glacial, or the onset of the Younger Dryas event, or for that matter even with the climatic events of the Holocene. Early farming communities adopted various combinations of crops and animals in different parts of the subcontinent at different times. Village life based on the complete package of Southwest Asian, East Asian, and indigenous domesticates (both plants and animals) took several thousands of years to develop. Several crops have different ecological adaptations and distinct geographical distribution, and their introduction into new areas necessitated adaptive measures to ensure productivity.

Ancient agriculture in the Indian subcontinent, as elsewhere, was the result of a mixed economy that incorporated cultivation of staple crops and herding. These two components appear to have emerged simultaneously, though one observes spatial variation in the timing of their emergence in the distinctive Neolithic/Chalcolithic provinces across the region. This mixed economy also meant that agricultural activities were supplemented by herding cattle/buffalo, stock raising, gathering wild plant foods, hunting, fishing, and harvesting mollusks (Schug 2011). This adaptive diversity would have ensured the stability and prosperity of the early agricultural societies. Chronologically, the Indian subcontinent presents itself as an area of secondary agricultural origins as compared with the early centers of Southwest Asia and Eastern Asia. The temporal span of ancient agriculture in the subcontinent falls between the 7th and 1st millennium BCE, as contrasted with 12th millennium BCE developments in Southwest Asia and East Asia.

With the exception of the inter-montane Kashmir Valley in northern India, archaeobotanical research on early agriculture is either negligible or sporadic, especially in the montane valleys of Nepal, Bhutan, Sikkim, and the northeastern humid landforms. A similar dearth of information is exhibited by the sub-Himalayan province. Outside these regions, distinctive Neolithic provinces were identified early on, based on material culture evidence and routine radiocarbon dating (see Allchin and Allchin 1982). The last three decades have witnessed increasing intensity of bioarchaeological research contributing to reconstruction of early agricultural economies aided by AMS radiocarbon dating with implications for the existence of independent centers of agricultural origins with unique packages of food crops, combinations of introduced and local domesticates. In some geographical regions, subsistence production coincided with the emergence of the Neolithic, and in some other areas, this was associated with the Chalcolithic, particularly in the semi-arid tracts of the northern Deccan, Gujarat, and Rajasthan (Bellwood 2005; Fuller 2006a,b).

Coexistence of hunter-gatherers and early agriculturists is evident. In this study, adoption of subsistence production is discussed in the context of resource availability and the beginnings of sedentism. One is, however, not certain of delineating the threshold events leading to full-scale subsistence production that was governed by spatial variation in monsoon precipitation (intensity of seasonality) and the availability of suitable seed corps. Further, both millet and cereal cultivation were prerequisites for animal husbandry. A large suite of AMS radiocarbon dates has facilitated the tracing of the origins and spread of cultivation among the early agricultural communities inhabiting a diverse network of geographical environments across the subcontinent. AMS dating and the application of modern field and laboratory techniques to recover and identify microbotanical remains have strengthened the confidence levels for the history of ancient agriculture in the subcontinent.

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FURTHER READING

Archaeobotanical reconstruction of ancient agriculture in the Indian subcontinent has gained momentum during the last five decades with greater intensity and in step with advances in laboratory techniques and broader issues of domestication morphology, transition to agriculture, and mapping of wild progenitors of domesticated crops. Periodic progress in these investigations has shed fresh light on identification of independent centers of agricultural origins, diffusion, and introduction of crops and expansion of language families. Liversage 1989; Vishnu-Mittre 1989; Kajale 1991, 1998; Fuller 2002, 2006a, 2007, 2008, 2009; 2011a,b; Garcia-Garnero et al. 2016, to name a few have dealt with these issues authoritatively. The intensity of archaeobotanical research has grown under the leadership of Fuller, helping to update our understanding of ancient agriculture in early India and Pakistan (Costantini 2008; Fuller 2003a, 2007; Fuller and Madella 2002; Murphy and Fuller 2016). Archaeobotanical research with specific reference to cereals and pulses has also been carried out (Fuller 2011b, Fuller and Qin 2009; Fuller and Harvey 2006; Harvey and Fuller 2005; Fuller and Murphy 2017; Fuller et al. 2010). Dispersal of crops from Africa, Southwest Asia, and East Asia is an important and major task of archaeobotanists (Fuller 2003a,b, 2006b; Fuller and Allaby 2009). The existence of independent centers of agricultural origins within the subcontinent has received particular attention (e.g. Garcia-Granero et al. 2016; Fuller and Murphy 2014). The presence of wild rice through a phytolith analysis from Paleolithic contexts along the southeast coast of India has been documented by Prematilake et al. (2017). Fuller has attempted an integration of archaeobotanical research with historical linguistics to trace the introduction of exotic crops through the dispersal and expansion of language families (Fuller 2003a,b,c, 2007), the hunter-gatherer transition to agriculture, and the importance of cash crops and early political economies (Fuller 2009; Murphy and Fuller 2016). The nature of Holocene monsoon variation and its relation to the early agricultural societies in different parts of the subcontinent has been discussed by various scholars (e.g. Sharma S., et al. 2004, 2006; Singh, Prasad, and Chakraborty 2007; Sinha R. et al. 2006; Sinha A. et al. 2011; Spielmann et al. 2011; Staubwasser et al. 2003; Staubwasser and Weiss 2006; Singh I.B. 2004, 2005; Srivastava 2008).

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CHAPTER TWENTY-NINE

Trajectories of Agricultural Development in Prehistoric China: From the Beginning of Crop Cultivation to the Period of Agricultural Intensification (c. 10 000–3000 BP)

Yijie Zhuang

Introduction

Fast-accumulating archaeobotanical remains in China have shed new light on prehistoric subsistence not only inside China but beyond its borders in Central and East Asia. Examining the most recent archaeobotanical and archaeological evidence, this chapter delineates trajectories of agricultural development in prehistoric China. It focuses on the periods when initial farming began, when agriculture with year-round sedentism was established during the Middle Neolithic, and when agriculture was gradually intensified due to dramatic social, economic, and cultural changes from the Late Neolithic onward.

Debate on the origins of agriculture in China has focused on whether farming started in one center and spread to other regions or whether there were multiple centers (Zhao 2011; Qin 2012). The former viewpoint often fails to consider the importance of ecological and cultural diversity, which accounts for the diverse pathways to agriculture in different regions across time (cf. Fuller, Willcox, and Allaby 2012). Of particular importance are the environmental, ecological, and cultural differences between the Yangtze and the Yellow Rivers, which define the fundamental difference in agricultural practices and food consumption patterns in these two regions. However, these regions were not isolated; rather, they were increasingly interwoven by long-distance interactions.

Therefore, in addition to the ecological and environmental diversity and its relationship with agricultural development, this chapter also focuses on the following two issues. First is

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the close entanglement between food production and formation of cuisines. As illustrated by some scholars, there is a long-standing tradition of boiling grains (rice and millets) in East Asia, which demarcates a profound departure from the bread-making tradition in West Asia from the very beginning of agricultural production (Fuller and Rowlands 2011). Within the broad context of agricultural development through time, this chapter will investigate the formation of food traditions and how it was closely intertwined with agricultural production and social changes (cf. Barker 2006; Haaland, 2007; Jones 2007; Sherratt 1999 for related theories on food production and social organizational changes in different parts of the world). The second important issue to be explored is the increasing movement of cultivars that continuously shaped the agrarian landscapes of different regions. Related to these two perspectives are the recent theoretical developments that consider domestication and other food exploitation strategies a "cultural and ecological entanglement" underlying human behaviors, including technological innovations and cultural adaptations, and genetic selections that were closely woven together (Fuller et al. 2010, 2016). These theories contribute to a comparison and contrast of cultural choices and food systems in a broader perspective.

Origins of and Transitions to Agriculture: Protracted Process and Remaining Mysteries

Similar to the trend observed in the Fertile Crescent (Savard, Nesbitt, and Jones 2006), the transition from the Terminal Pleistocene to the Early Holocene in China also ushered in the beginning of a fundamental shift in plant food exploitation strategies, that is, the consumption of small-seeded grasses, which eventually led to the cultivation and domestication of some of the grasses. Not only did millet and rice begin to be consumed, other small-seeded plants such as barnyard grasses were also eaten (Yang, Fuller et al. 2015a). Such a shift resulted from dramatic environmental and ecological changes in the Pleistocene-Holocene transitional period. One of the most significant changes was the increase of atmospheric CO_2 levels due to temperature increase, which would have been favorable for the growth of C_4 plants (Sage and Monson 1999). C_4 plants, such as millets and maize, have a special photosynthetic mechanism allowing them to fix carbon more effectively, especially in dry and warm conditions. The dietary shift was also related to a revolution in food processing techniques. The invention of ceramics (with the earliest ceramics occurring around 20 000 cal. BP (Wu et al. 2012)), for instance, triggered the unprecedented development of grain boiling, which would have potentially further emphasized the importance of small-seeded grains in the palaeo-diet. However, how and when exactly this transition of food processing occurred and the specific roles of early ceramic containers in this change remain controversial.

Millets in the North

Figure 29.1 shows sites containing early millet remains. They are located in different environments. This suggests that, despite their small percentage in the archaeobotanical assemblages, millets were becoming a common plant food among these communities (Yang et al. 2015b). Consumption of millets lasted for almost 2000 years before millets were domesticated (Yang et al. 2012). Lack of archaeological discoveries in this prolonged period hinders our understanding of the domestication process of millets.

Although Cishan (ca. 8000–7000 BP) in the Taihang-Yan Mountain region has long been considered as a place for early millet cultivation and domestication due to the discovery of

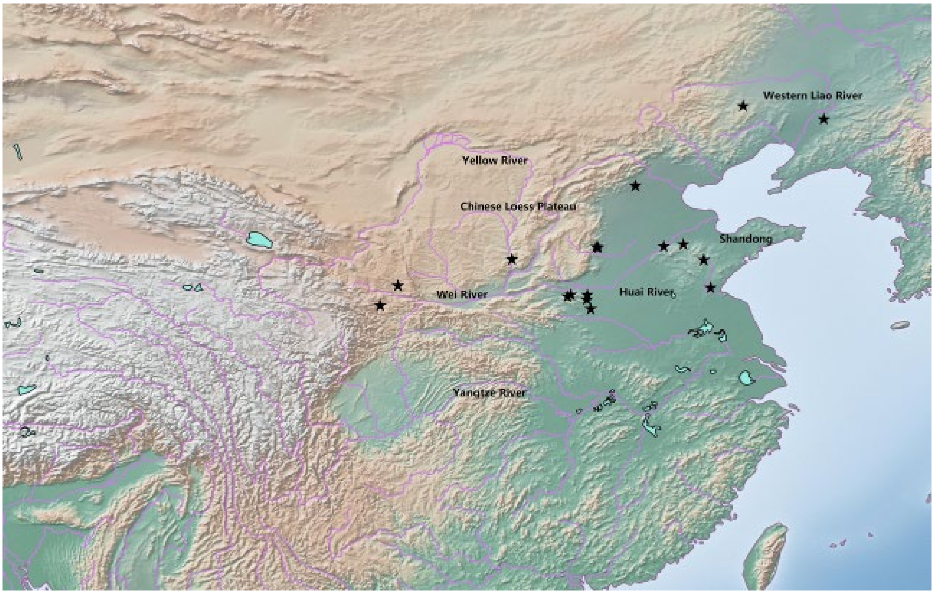

Figure 29.1 Sites containing early millet remains in China and important geographic areas mentioned in the text. Source: Illustration by Yijie Zhuang.

tens (88) of large storage pits that might have been used to store millet grains (Tong 1984), detailed information concerning how millets were cultivated remains unknown. On the basis of their pioneering research on the morphology of millet phytoliths, Lu et al. (2009) suggest that it was broomcorn millet rather than foxtail millet that was first cultivated and largely consumed. The earliest unambiguous evidence of millet cultivation comes from the archaeobotanical research at Xinglonggou (c. 8200–7400 BP) in the Western Liao River (Figure 29.1), another potential area for independent domestication. Here, broomcorn millets overwhelmingly predominate over foxtail millets (Zhao 2006, 2011). The abundance of weedy seeds (*Cerastium glomeratum*, *Astragalus* sp., etc.) suggests that millet farming was practiced but still at an initial stage. Indeed, characteristics derived from wild progenitors are still observable (e.g. the grain sizes are small and close to those of wild grains) (Zhao 2006).

The absolute number of sites that contain millet remains increases dramatically during this period (8500–7000 cal. BP). Broomcorn millet indeed was a more important cultivar than other crops. There is a popular opinion suggesting that this is related to the physiological advantage of broomcorn millet being able to adapt better to water stress (Dong and Zheng 2006), but how this coevolved with environmental change and cultural selection remains to be demonstrated. Other plants, primarily different kinds of nuts, still accounted for the large majority of plant foods consumed.

Rice in the South

Compared to the myth concerning the domestication process and wild progenitor of millets, the story of the beginning of rice consumption, cultivation, and domestication is relatively clear. Rice was consumed at the beginning of the Holocene (Liu et al. 2007). Rice had to be boiled before being eaten. By the Early Holocene, pottery technology reached a peak, with the appearance of large-sized ceramic vessels and sophisticated production technology (Jiang 2013). Also very highly developed was the lithic industry, characterized especially by the production of very large-sized grinding stones (Jiang 2013) (Figure 29.2). Such technological breakthroughs must have been associated with fundamental changes in food processing and indicate an initial stage of food production intensification. The latter would have involved management of wild habitats of rice and other grasses, paving the way for rice domestication.

The timing of rice domestication is, however, controversial. Some scholars, while acknowledging that it was a "long, non-linear" process, suggest an early cultivation of rice during the "Late Pleistocene/Early Holocene," mainly on the basis of the measurement of many individual grains from a series of Early Holocene sites. Others advocate that the domestication of crops was a truly prolonged process with increasing labor input and intensifying management of landscapes, which has been contested in the research of agricultural origins in the Near East (Fuller, Asouti, and Purugganan 2012). Fuller and colleagues, in their examination of the archaeobotanical remains recovered at Tianluoshan, fully and convincingly demonstrate that while the "non-shattering domesticated rice (Oryza sativa)" occurred very early (8000–7700 BP), the cultivation of rice took more than 1000 years before reaching full domestication. This is characterized by the predominance of non-shattering rice spikelet bases in the floral assemblage (Fuller et al. 2009). In line with this dramatic increase was the decrease of wild gathered plant foods consumed at Tianluoshan, pointing to a heavier reliance on cultivated crops. These early rice farmers, deploying a range of methods such as land clearance and burning, were transforming "coastal wetlands" into early paddy fields (Zong et al. 2007), but the function of these fields remains to be further demonstrated.

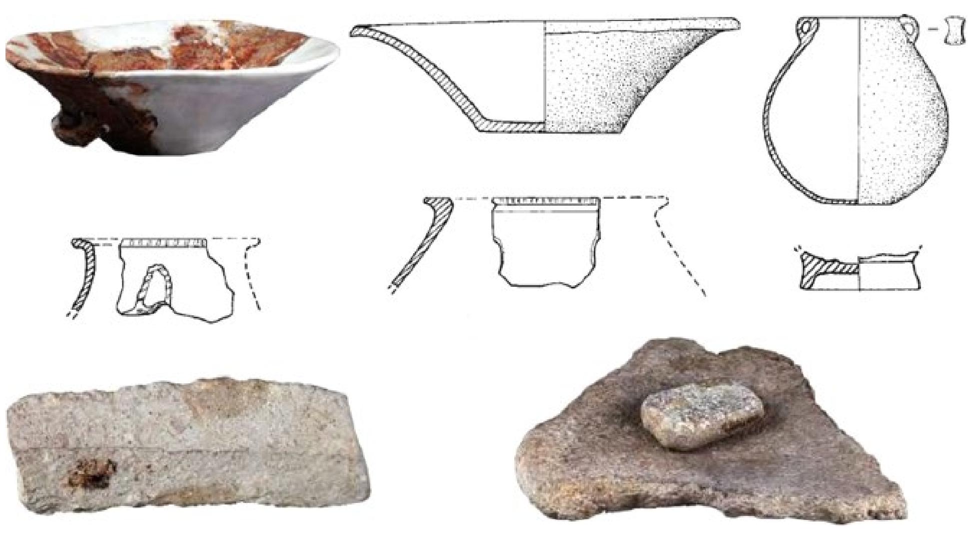

Figure 29.2 Pottery and stone tools discovered at the Shanshang site, Zhejiang Province. The pottery types include basins, jars, and other types of vessels, while the stone tools include chipped stone tools and grounded grinding stones. Source: From Jiang, L.P. (2013). The early Neolithic age of the Qiantangjiang Basin and its cultural lineage (in Chinese with English abstract) (Qiantangjiang liuyu de zaoqi xinshiqi shidai ji wenhua puxi yanjiu). *Southeast Culture (Dongnan Wenhua)* (4): 44–53.

Multiple Centers and Dead Ends?

Recent archaeobotanical research at a number of sites located in other regions than the Lower Yangtze River has provided new insight into the exploitation and cultivation history of rice and other crops. Rice was also consumed very early in the Middle Yangtze River. By around 8000 BP at Bashidang, abundant rice grains were recovered along with wild nuts, fruits, and aquatic plants (HPICRA 2006, pp. 544–562). The shapes of these grains vary greatly. The rice remains at Shunshanji located in the Huai River are directly dated to around 8400 cal. BP (IANM and SM 2014). In addition, excavations at the contemporary Hanjing site reveal structures and soils that resemble those discovered at several later-period rice paddy fields. There is a possibility that the Hanjing residents had already started changing water and soil conditions in the habitats of wild rice for initial farming.

The rice remains at Jiahu and Baligang (8700–8300 BP) belong to similarly early periods (Deng et al. 2015; Zhang 2011). Even though the grain size continued to change, non-shattering rice spikelet bases were already abundant at Baligang, making the area another candidate for independent rice domestication. Moving further north in the Lower Yellow River, rice was also consumed at Yuezhuang (8000–7800 cal. BP (Crawford, Chen, and Wang 2006)) and Xihe (8070–7900 cal. BP (Jin et al. 2014)). However, the percentages of rice in these early archaeobotanical assemblages remain low, and non-shattering rice spikelet bases are rare. More dramatically, it seems that the rice, whether cultivated or domesticated, disappeared, before it reappeared around 6000 cal. BP in the region (Jin et al. 2016). This prompts speculation that this early rice encountered environmental and/or biological bottlenecks, which led to a dead end in its development (Fuller et al. 2010). Although this is a compelling case in the study of rice ecology and is supported by genetic evidence (cf. Fuller et al. 2010), it is still too early to conclude that there was definitely a dead end. Other possibilities such as migration or long-distance exchange of crops should be taken into account.

Beginning of Animal Husbandry

Dogs were domesticated in the Early Holocene. During 8500–7000 BP, evidence of pig husbandry and domestication emerges in both North and South China, where archaeogenetic research has confirmed them as independent domestication centers (Larson et al. 2010). At Jiahu, interdisciplinary studies, which examine geometric morphometric (Cucchi et al. 2011), mortality patterns (Yuan and Flad 2002), and palaeo-diet (Luo 2007), have confirmed that some pigs have a similar diet to humans, and most of them were culled under 2 years (81.4%) (Luo 2007), making Jiahu one of the earliest places for pig domestication in China. At Dadiwan, most of the pigs were culled at the age of 1–1.5 years. This suggests strong human intervention in the reproduction cycle of pigs as the age profile of pigs that were not managed by people would have been more scattered rather than being concentrated on 1–1.5 years. But this contradicts the results of isotopic research, which points to the opposite scenario in which the diet of the pigs was different from that of the residents. In other words, the pigs were not fed leftover food from human consumption (Barton et al. 2009). Other possible centers for early pig husbandry include Cishan, Xinglongwa (Liu et al. 2012), and Xihe (Song 2012), but none of the sites has unambiguous evidence for pig domestication yet. At Kuahuqiao and Tianluoshan in the Lower Yangtze River, the debate on when and how pigs were domesticated is also ongoing, with recent evidence tending to support they were still wild or at least only at the initial stage of herding. The lack of consensus in these studies might also indicate that interbreeding between domesticated and wild boars was common in the early stage of pig husbandry, rendering it hard to pinpoint a clear baseline for domestication.

Meat consumption in this period, however, still largely relied on hunting wild animals, especially different kinds of deer (e.g. SPIA and ATBC 2007).

Middle Neolithic Agricultural Villages: Yangshao and Majiabang

Agriculture in Yangshao and Its Contemporaries

In the Yangshao (c. 7000–5000 BP) period, agricultural villages, occupied by millet farmers and craftsmen all year around, were established. The Yangshao farmers built settlements in various types of environments. Representative examples include Banpo, Jiangzhai, Dahecun, Xiawanggang (Figure 29.3), to name just a few (Underhill 2013). Located on river terraces or alluvial plains, these settlements are often very well planned, with buildings clustering as groups surrounding a central public space or forming a row of long houses (Institute of Archaeology 1963; XBM, SPIACR, and MLC, 1988). Close to these buildings were kilns, lithic workshops, and other economic production units as well as cemeteries. This new economic development was supported by and further stimulated agricultural production.

The Early and Late Yangshao horizons at Dadiwan contain abundant millet remains, including grains and chaffs, with more broomcorn millets in the early phase (GPICRA 2006, pp. 914–916) and more foxtail millets in the later phase. Millet remains have been found in a much wider geographic area during the Yangshao period (Liu, Jin, and Kong 2008, p. 165). Isotopic research provides semiquantitative evidence for the increasingly important role of millet consumption in the palaeo-diet of Yangshao (Barton et al. 2009). The $\delta^{13}C$ values of human remains at many sites indicate "a staple role for millets" (Pechenkina et al. 2005). At the Xipo cemetery, though there was emerging evidence for social stratification as demonstrated by the different quantities and qualities of burial goods among the burials, the generally high $\delta^{13}C$ values of the human remains show that these people, potentially of different social status (Institute of Archaeology and HPICRA 2010), had equal access to the crop (but perhaps differential access to meat). Other indirect evidence for developed millet farming includes the pronounced increase in agricultural tools, especially ceramic and stone knives and sickles used for harvesting (Zhu 2013; Wang 2013) and bone and stone spades or shovels and hoes used for land clearance and plowing (SPIA and ATBC 2007, pp. 400–401; Wang 2013). These activities would have promoted the gradual expansion of arable lands that were occupied by crops and their wild relatives surrounding the settlements.

Benefiting from the much improved temperature and humidity conditions during this period (An et al. 2000), rice, which requires a significant amount of water to grow, was also cultivated in many regions of the Yangshao culture, notably the Guanzhong Plain in Shaanxi and the Central North China Plain, which are presently relatively dry (Liu, Jin, and Kong 2008), according to recent archaeobotanical evidence. Phytolith studies suggest that rice was likely cultivated on river floodplains that had better hydrological conditions (Zhang, Lu et al. 2010). But the importance of rice in local subsistence remains unclear. There is also evidence of vegeculture at some Yangshao period sites. A whole jar of vegetable seeds (species not identified), for instance, was found on the house floor at Banpo (Institute of Archaeology 1963). Other plants likely cultivated include *Brassica campestris* L., rape seed (Brassica), *Perilla frutescens* (Linn.) Britt, etc. (GPICRA 2006; Kong, Liu, and Zhang 1999). All are plants often grown in gardens or near settlements.

In the Lower Yellow River, judging from the limited archaeobotanical evidence, millet farming was further developed in the Beixin (7000–6100 BP) and Dawenkou (6100–4600 BP)

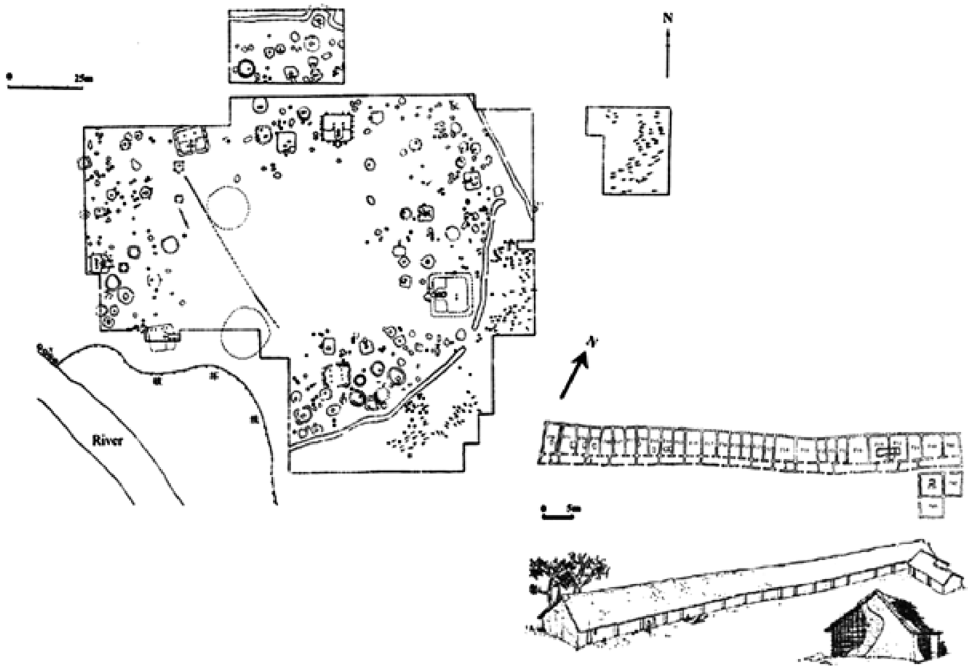

Figure 29.3 Settlement plans during the Yangshao period. Left: Settlement pattern revealed at the Jiangzhai site, Shaanxi Province. Several rectangular houses were grouped around smaller circular houses and other features for economic activities (e.g. kilns). The settlement is encircled by a moat. Right: Plan and reconstruction of the long houses discovered at the Xiawanggang site, Henan Province. Source: After XBM, SPIA, and MLC (1988) and HPICR and HTACYRPO (1989). Xi'an Banpo Museum (XBM), Shaanxi Provincial Institute of Archaeology (SPIA) and Museum of Lintong County (MLC). (1988). *Jiangzhai: Excavation Report of the Neolithic Site (in Chinese with English abstract) (Jiangzhai: Xinshiqi Shidai Yizhi Fajue Baogao)*. Beijing: Cultural Relics Press. Henan Provincial Institute of Cultural Relics (HPICR) and Henan Team of the Archaeological Commission of the Yangtze River Planning Office (HTACYRPO). (1989). *Xichuan Xiawanggang (in Chinese with English abstract)*. Beijing: Cultural Relics Press.

cultures. Foxtail millet grains have been recovered from a number of sites (Wang 2013; Liu, Jin, and Kong 2008). Similar to the trend seen in the Yangshao culture, the abundance and styles of agricultural tools at Beixin culture sites also increased significantly, with spades, sickles, and knives, as well as grinding stones, becoming a common set of food production and processing tools in society (Wang 2013, p. 400). This implies that farming had now become a common practice in the "villages."

Rice disappeared after the Houli culture period, and a new rice species was reintroduced to Shandong during the Middle Neolithic period, as evidenced by the discoveries of rice remains in the coastal areas of Shandong and Jiangsu provinces (Jin et al. 2016; Qin 2012, p. 275), pointing to a possible coastal route for the spread of rice. The role of rice in society varies. While isotopic studies at some sites show that millets were a predominant source for food consumption (Zhang, Qiu et al. 2010), by the late Dawenkou period, $\delta^{13}C$ values of some "high-ranking individuals" suggest that they were consuming more C_3-based plants such as rice, compared to other members of the society, who mainly consumed C_4-based plants including foxtail and broomcorn millets (Luan 2013, p. 414).

Animal Husbandry

While the relationship between pigs and humans was already becoming closer during the previous period, by the Yangshao period, pigs were definitely domesticated. Most pigs were culled before 2 years of age. There is also a consistent decrease in the M3 (teeth) length (cf. Wang 2011) through time. Isotopic evidence shows that pigs were fed with food left over from human consumption. Along with this new tendency were the steady increase in pig meat consumption and the corresponding decrease of wild animals (e.g. GPICRA 2006). The social role of pigs also changed dramatically. Not only were pigs, along with other animals such as dogs, buried in sacrificial pits in cemeteries, pig mandibles were often collected and buried in graves too. The latter has been found at sites such as Diaolongbei and Baligang (Zhang 2012). In one burial (no. M13) at Baligang, 90 human skulls were buried, with more than 120 pig mandibles being placed on the platforms in the burial. The consumption of these pigs would have been a collective activity; the mandibles were likely kept as a symbol of assets and/or social status. The socioeconomic role of pigs became more prominent in Dawenkou society. Burials enriched with elaborate goods would often contain one or several pig mandibles or whole piglets (Luan 2013).

Agriculture in Hemudu and Majiabang in the Yangtze River

At Chengtoushan (6500–5500 BP) in the Middle Yangtze River, rice became an important crop (70%); foxtail millet was also cultivated, but only in small proportions. The cultivation of rice and millet is corroborated by the presence of weed seeds. These weedy plants grew in both dry uplands and paddy fields during cultivation and were brought to the site together with crops when being harvested (Nasu et al. 2012). Wild plants, however, continued to be consumed in large quantities. Except for the cultivation of millet, the plant food exploitation strategies in the Lower Yangtze River are similar to the ones at Chengtoushan. At Longqiuzhuang (7000–5500 BP), for example, there is a general trend that saw the increase of rice in the floral assemblage, gradually replacing water chestnut and Euryale (ATLS 1999). This trend can be seen at Luojiajiao around the Taihu Lake (Zheng, Sun, and Chen 2007) and at Tianluoshan. From the huge number of plant remains recovered at Tianluoshan, Fuller and colleagues found that 6900–6600 BP was the critical period for rice domestication, which saw increased domesticated rice spikelet bases from 27% to 39% and rice remains as a whole from 8% to 24% (Fuller et al. 2009). This culminated in the domestication of rice after 6500 BP.

Along with this clear shift were changes in settlement plans, the development of farming tools, and the appearance of paddy fields. The last was particularly significant. One of the earliest rice fields was found at Chengtoushan. Located on an alluvial plain, the fields were continuously used, with simple irrigation and drainage features being gradually built (Pei 2008, cited from Qin 2012, p. 269). Slightly later, more paddy fields were found at more places. In this early stage of rice farming, draining during harvesting would have been very important. Great effort was made in micro-scale management of in-field ecology such as building embankments and digging small ditches and water outlets. These early farmers were managing different types of landscapes for rice farming. At Tianluoshan, early rice fields were built between 6650 and 6490 BP by opening up "marshes of dense reeds with fire and wooden or bone spades" (Zheng et al. 2009). In contrast to this, at Caoxieshan and Chuodun (c. 6200–6000 BP) located around the Taihu Lake, paddy fields were built directly on top of relatively higher grounds. Here more labor was invested for digging well-connected water outlets and ditches.

Movements of Cultivars and Formation of Agrarian Landscapes

The Yangshao and Majiabang period witnessed large-scale human migration, which fundamentally transformed agrarian landscapes across China. First, millet farming was introduced to different parts of China by farmers from Central China (Guedes 2011; Qin 2012). As new crops in South China, local residents cultivated millets on the margin of their landscapes, as a supplement to rice farming such as at Chengtoushan and other sites (Nasu et al. 2012). Second, rice, potentially of new species, was introduced to North China by migrants from the south. Indeed, the favorable environmental conditions during the Middle Holocene were conducive to the growth of rice in areas as far northwest as the Upper Yellow River. Despite the controversy regarding their discovery contexts (Qin 2012, p. 273), direct AMS dating of carbonized rice grains and abundant rice phytoliths from Xishanping in Northwest China suggest that rice farming was an important agricultural development in the area around 5000 BP (Li et al. 2007a,b).

From the Middle-Late Yangshao period, rice and millets appeared together in archaeobotanical assemblages recovered in areas such as the Nanyang Basin in the intermediate area between the Yellow and Yangtze rivers (Deng et al. 2015) and at Nanjiaokou in the Middle Yellow River (Qin 2012). Such a new phenomenon became more common during the Late Yangshao period. In addition to the Yellow River, where rice was becoming a more important crop, in central Henan, Fuller and Zhang find that rice and millets appeared together and had high ubiquities (Fuller and Zhang 2007). The formation of such a mixed farming regime profoundly changed the seasonality of farming in these regions, and its potential was further enhanced in the succeeding Longshan period.

Domesticated animals such as pigs would have been moved around by the migrants, and so would technology, exotic goods, and ideology. But it is hard to track down the movement of pigs due to the lack of archaeogenetic and other evidence. By the Middle Holocene, agriculture, along with craft production, had become the primary economic activity in the farming villages across vast areas of the Yellow and Yangtze rivers. This established, village-based economy paved a solid foundation for the social and economic "taking off" in the following period.

Agricultural Intensification and Emergence of Early Complex Societies during the Late Neolithic

The Late Neolithic saw dramatic social, economic, and cultural changes across China, characterized by the emergence of walled sites of enormous scale, advancement in technologies, and the introduction of new cultivars to China such as wheat, and domesticated sheep and goat, to name just a few. This led to the formation of early complex societies or states, which in turn further changed the organization of agricultural production. During this period, agricultural production was intensified, which took the form of crop diversification in some areas, whereas in other areas, it was the loss of crop diversity.

Agriculture of the Longshan Period (c. 5000–4000 BP)

While climate as a whole was deteriorating during this time (Dong et al. 2010), rice was becoming a more common cultivar across North China. This was significant as it indicates that a more diverse and wider range of niches suitable for rice farming in the otherwise semi-arid environment began to be cultivated due to population growth, as attested by changes in settlement patterns (Wagner et al. 2013). In Shandong, the Lower Yellow River, not only were the quantity and ubiquity of rice becoming higher than previously, but rice fields were also built for rice farming. The latter is confirmed by a phytolith study at Zhaojiazhuang (Jin et al. 2007) in the coastal area. Similarly, rice appeared in many archaeobotanical assemblages examined in Henan province, also with high ubiquities (Zhong et al. 2016). This rice was cultivated in wet fields, as suggested by phytolith studies (Weisskopf et al. 2014). The appearance of rice was more scattered in westward areas, as precipitation reduced. This created a distinctive difference between the eastern and western parts of North China in terms of crop choices, which was even more pronounced in the Bronze Age.

Millet farming was further intensified during this period. Foxtail and broomcorn millets were predominant (often more than 70%) in most archaeobotanical assemblages recovered from both large walled and small sites. The majority of these millet grains were full with a smooth surface. Broomcorn millet grains, though in smaller quantities, were on average larger (2 mm) than foxtail millets (1.2–1.5 mm) in length. Carbonized weed seeds accounted for only a small proportion (Zhao and He 2006; Zhong et al. 2016; Zhao and Xu 2004), which implies changes in crop processing and/or intensified farming practices in fields, such as more weeding during farming, which would have eliminated many weedy plants.

Another important agricultural development in this period was the domestication of soybean. Recent research has confirmed the very evident size increase of carbonized soybeans at a number of Late Neolithic sites in North China (D. Fuller, personal communication). Although the study of soybean domestication is intrinsically difficult due to the lack of unambiguous evidence such as the non-shattering trait of seeds, size increase could be considered as a sign of human intervention in the biological properties of legumes. Well known for their ability to fix nitrogen (Postgate 1998), legumes would have been cultivated to compensate for the potential loss of nitrogen levels of soils. Legumes were consumed from a very early period, with the earliest remains discovered between 8000 and 7000 BP (Kong, Liu, and Zhang 1999; Zhao and Zhang 2009), but the evident size increase seemed to become widespread only during this period. This prompts speculation that (1) the intensified consumption of soybean resulted in its "secondary domestication" and/or (2) some of the legume species were actually domesticated outside China and introduced to China (see below).

Abundant charcoal has been commonly found among archaeobotanical assemblages, some of which are believed to be from tubers and other starch-rich plants such as roots. But without the help of other analytical means such as starch grain analysis, it is hard to ascertain what plants were actually consumed.

Though the main types of farming tools used in this period remain roughly the same, including "shovels for digging, knives, and *lian* sickles for harvesting, and grinding stones and slabs for processing millet" (Zhao 2013, p. 249), the production of these tools were organized in a dramatically different way. The scale of production increased significantly. At Taosi, for example, a huge amount of sandstone flakes (20 930) were discovered in just one pit. According to Liu et al. (2013), 53.7 hours would have been needed to produce these from around 268 blanks. Related to this was the abundance of finished products discovered at large sites. The occupants at these large walled sites had control of raw material available in their vicinity. The Dagudui Mount near (7.4 km) Taosi was providing three main types of stones for Taosi. Similarly, the Wadian walled site was also directly controlling stone mines located in the nearby mountains. Raw material from these mines was mainly used for producing agricultural tools such as spades and axes, a kind of "loose specialization" of production during the Longshan period, according to Pang and colleagues (2013). Agricultural tools produced at these sites might be then redistributed to smaller sites, some of which might have specialized in agricultural production.

Animal Husbandry and "Secondary Product Intensification"?

Not only were pigs widely raised during this time, newly introduced domesticated animals, mainly sheep and cattle, were herded at some sites. At Taosi, for example, isotopic studies show that not only were pigs and dogs fed by food leftover from humans, which was C_4-based, but C_4 plants also partly contributed to the diet of domesticated cattle (Chen et al. 2012). This suggests that millet agriculture was further intensified due to animal husbandry as, at least at some key sites, millets were increasingly fed to animals.

Domesticated sheep appeared in around 5300–5000 BP in the Hexi Corridor of Northwest China (Cai et al. 2010). There is a growing consensus that the Hexi Corridor was one of the most important geographic areas where domesticated sheep, along with many other cultivars and new technology such as metallurgy, was introduced into Central China. They arrived at Taosi around 4300 BP, and their percentages in the faunal assemblage continued to grow, from 3.57% (MNI) in the early phase to 9.18% in the late phase (Li, Brunson, and Dai 2014). Although sheep were raised, fed by C_3 grasses, and consumed as meat at many Late Neolithic sites of North China, recent evidence suggests that, at some key sites, they were kept for other economic purposes. At Taosi and Xinzhai, patterns in the culling age of the sheep were quite similar: at Taosi, 40% of them were killed at 4 years of age (Brunson 2011; Li, Brunson, and Dai 2014); 25% of adult sheep were killed at 6 years of age; and more than 50% of sheep were killed at 4–6 or >6 years of age in both phases 2 and 3 at Xinzhai. This lends some support to the hypothesis that the sheep were kept for wool production, though more study is desirable.

Like domesticated sheep, domesticated cattle were introduced to China around the same time. Cattle bones frequently appeared at sites in middle and eastern Inner Mongolia, with their percentages sometimes higher than 15% of the mammals (Yuan et al. 2007). Unambiguous evidence for domesticated cattle again comes from the Neolithic Hexi Corridor. At least around 4500 BP, domesticated cattle were found at sites in Central China, with a pronounced increase in percentages through time (Yuan et al. 2007). Other domesticated animals introduced into China via the Hexi Corridor or other routes include camels and horses, although the timing of their domestication and spread remains highly controversial (Flad, Yuan, and Li 2009).

Liangzhu and Shijiahe Agriculture in the Yangtze River

The areas around the Taihu Lake and the Jianghan Plain were densely populated by the Liangzhu and Shijiahe people, respectively. Among the increasingly concentrated settlements around the Taihu Lake, smaller sites appeared to play a more important role in agricultural production. Plant remains recovered through flotation are predominantly rice, including seeds, chaff, stalks, and other parts of rice plants from different archaeological contexts with high ubiquity. Future research needs to unpack crop processing and the different consumption patterns at these sites. There is also clear evidence of agricultural intensification from the early to late Liangzhu period. This can be best seen in excavation of the well-preserved paddy field site at Maoshan. The size of the paddy fields increased significantly from the early (around 30–40 m^2) to the late period (up to 2000 m^2). Along with this size increase was intensified water management through time as evidenced by greater control and management of ditches and water outlets, more careful management of in-field ecology, and the beginning of soil amendment in the late period (Zhuang, Ding, and French 2014). In addition, ongoing research on agricultural tools also shows parallel changes in them through time (L. Qin, personal communication). A huge hydraulic engineering project was built in the early Liangzhu period, situated to the north of the ancient Liangzhu City. It consists of low and high dams and covers a huge area (13 km^2). These dams were mainly used for flood protection, but irrigation would have also been one of the main functions, though how and where it was supplying water to have not yet been investigated in great detail.

A large number of huge walled settlements were built in the Jianghan Plain during this time (Zhang 2013), forming a very distinctive regional characteristic. The Shijiahe people were rice farmers too. Rice remains were the overall majority in the archaeobotanical assemblages examined (Deng, Liu, and Meng 2013). Weedy plants only accounted for a small proportion, which must have been an outcome of increased weeding in the field, but there is no physical evidence of paddy fields in the Shijiahe culture yet. Despite their small percentages, millets commonly appeared in the flotation samples at many sites (Deng, Liu, and Meng 2013; Wu, Liu, and Zhao 2010; Tang et al. 2014). These millet remains were sometimes found together with rice spikelet bases rather than rice seeds. Some think they were used to feed animals (Wu, Liu, and Zhao 2010). More in-depth surveys are required to understand the dynamics between rice farming and dryland farming in the Jianghan Plain and how they adapted to local environmental conditions.

Expansion of the Interactive Circle and Consolidation of Distinctive Chinese Cuisine

The interactive circle for the movement of cultivars and technological transmission expanded significantly during this time. The two ends of the Eurasian continent were closely interweaved and saw constant movements of goods, cultivars, and ideas (Sherratt 2006; Jones et al. 2011). Millets traveled westward, reaching central Asia and further west (Hunt et al. 2008; Frachetti et al. 2010; Miller, Spengler, and Frachetti 2016). Along the eastern coast, millet agriculture spread southward to places such as Taiwan and northward to Northeast China and Korea (Crawford and Lee 2003), but the timing of these processes remains unclear. For those that were introduced to China, apart from the ones discussed above, the arrival of wheat and the introduction of metallurgy were most significant. Though it is still unclear how and through what routes wheat was introduced to China, it appears that the Hexi Corridor was again important for this process, where wheat remains and evidence of metallurgical activities have been found at sites such as Donghuishan and Ganggangwa (Flad et al. 2010; Dodson et al. 2009). These new cultivars and the associated changes (e.g. modifying local environments for wheat farming and animal husbandry) drastically changed the agrarian landscape across China, almost to a point of no return that set the scene for the economic activities during the Bronze Age.

This agricultural development also revolutionized food processing and consumption in society. Already in the Yangshao period, a whole set of ceramic cooking vessels appeared in houses and burials. At the aforementioned cemetery of Xipo, for instance, regardless of the wealthy status of the burials, each one would contain a whole cooking set including a stove and several bowls, potentially for boiling grains (Figure 29.4). This method of food processing,

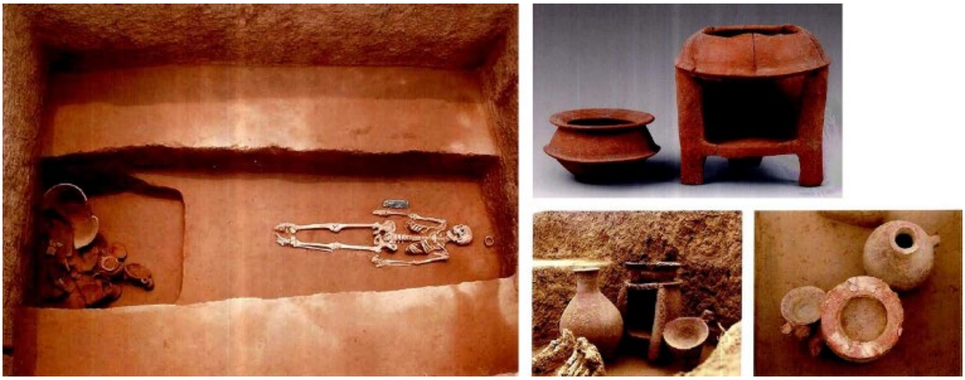

Figure 29.4 Ceramic cooking vessels discovered at the Xipo site. Left: Burial number M8 with a whole set of ceramic vessels (mainly for cooking and eating) situated in the pit at one end of the burial chamber. Also note the jade axe and ivory item placed next to the body. Upper right: The cooking set discovered in burial M8. Lower right: Another set of cooking and eating vessels discovered in burial M13, which lacks the elaborate jade and ivory items. Source: Courtesy of Institute of Archaeology, CASS, and Henan Provincial Institute of Cultural Relics and Archaeology (HPICRA).

mainly relying on boiling grains, according to some scholars, derived from a long-lasting tradition of boiling cereals (Fuller and Rowlands 2011), and by the Yangshao period, benefiting from the agricultural development (millet farming), this culinary tradition was further emphasized. In addition to boiling, some recent research suggests that the Yangshao people might have already started making alcoholic beverages (Wang et al. 2016). Although this is controversial, there is increasing evidence of alcoholic consumption during the Dawenkou period. This is supported by (1) the pronounced increase of pottery drinking vessels and (2) scientific analysis of food residue discovered in such vessels. The latter finds that alcoholic beverages made from crops and other plants were consumed (McGovern et al. 2005). Indeed, by the Dawenkou period, fixed sets of cooking and drinking vessels became very common in burials. This led to the formation of a very salient ancient Chinese mortuary tradition, that is, the enhanced role of food and drink in mortuary practices. This reached a peak during the Late Neolithic when agricultural production grew, and there is accelerating development of social stratification (Luan 2013). Elaborate eggshell like goblets with high stem and very thin sections were produced and appeared to be used by elites. A large burial at Zhufeng contained many black-colored pots, along with a large number of elaborate items such as jade, some of which would have been used as drinking vessels (Luan 2015) (Figure 29.5). Such an emphasis on drinking is also seen in ordinary burials. At Dafanzhuang, nearly 100 ceramic vessels, most of average or poor quality, were placed in a single burial (Underhill 2002) (Figure 29.6).

Bronze Age Agriculture: A Short Summary

A full appreciation of Bronze Age agriculture in China suffers from the lack of archaeobotanical data derived from systematic investigations and a pronounced bias of archaeological research that is too heavily focused on pottery typology and city planning. It is not our intension to discuss these problems; rather, we will draw out a few observations based on the

Figure 29.5 Burial and grave goods discovered at the Zhufeng site, Shandong Province. Upper left: Plan of the burial number M202. The human skeleton was placed in the middle of a two-layered wooden coffin. Lower left: Jade hair pin discovered in the burial. Right: Black-colored pottery vessels discovered from another burial (M203). Source: After SWTIA (1990). Shandong Working Team of Institute of Archaeology (SWTIA), CASS. (1990). The Longshan culture burials discovered at Zhufeng, Linju, Shandong (in Chinese) (Shandong linju zhufeng longshan wenhua muzang). *Archaeology (Kaogu)* (7): 587–594 and 674–675.

emerging data. First, large-scale irrigation projects were constructed and maintained by the states. Structures of large-scale water management facilities are revealed in some recent archaeological surveys. At the late Shang capital Yinxu in Central China (c. 1300–1050 BC), Tang and colleagues have found a tree-like, highly organized water system, which was connected not only to palaces but to all kinds of workshops and economic areas. Some of the canals were 2.8–4 m in depth, 6 m in width, and 2500 m long in total (Tang et al. 2016). The actual functioning and maintenance of these irrigation projects are subject to further research, but it is undoubtedly true that the Bronze Age communities were radically transforming their landscape at an unprecedented scale for farming and other economic activities. This further stimulated agricultural intensification. Second, this increased capability in land-

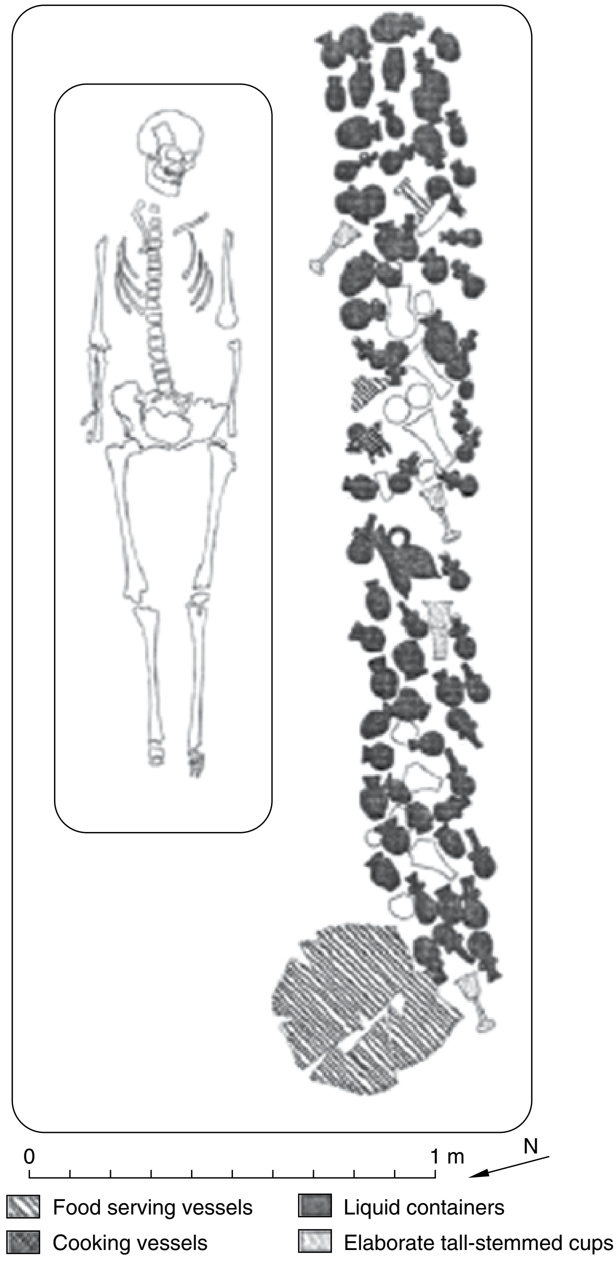

Figure 29.6 Burial with many ceramic drinking vessels discovered at the Dafanzhuang site, Shandong Province. Source: From Underhill (2002). Reproduced with permission of Springer Nature.

scape transformation also meant that the farmers were able to engineer local environments and provide growing conditions for different types of crops, even though climate as a whole was deteriorating during this time (Dong et al. 2010). Zhao and Xu (2004)'s recent archaeobotanical work at the Western Zhou (c. 1050–771 BCE) capital Zhouyuan in the Western Loess Plateau suggests that even though domesticated wheat was already introduced to this area during the Late Neolithic, it was not until the early Bronze Age that wheat farming of a proper scale began to take shape, which must have benefited from the construction of large-scale irrigation facilities consisting of a large pond and several ditches (Song and Xu 2016). Third, the elites continued to enjoy certain crops and animal products during the Bronze Age. In addition, there is clear evidence, such as that recorded in oracle bone inscriptions, that food played a central role in ritual activities (Chang 1977; Song 1994).

Conclusions

It is clear that from a very early period onward, there is a distinctive difference in subsistence between the Yellow and the Yangtze rivers, mainly due to their intrinsic differences in environmental and ecological conditions. Despite the chronological gap between the earliest millet remains and the cultivated/domesticated ones, the former area witnessed the early domestication of millets and pigs and their increasing importance in food production. In the latter, although the consumption of rice also began early, there was a long period in which the consumption of wild plants and animals remained predominant. Between 7000 and 5000 BP, full domestication of cultivars was completed, and agricultural "villages" with year-round sedentism were established in both areas. It is also a period with growing regional interactions, characterized by the introduction of different cultivars to different regions, which profoundly transformed agrarian landscapes in these regions.

The production and consumption of food were closely related to social development. Boiling and steaming have been a salient culinary characteristic in prehistoric China. With the rapid accumulation of agricultural surpluses from 7000 BP onward, this tradition also became an important part of mortuary practices with fixed sets of cooking vessels gradually becoming a norm in burials. By 5000 BP, such pottery sets were augmented by the addition of drinking vessels. Drinks made of crops and herbs were enjoyed by the elites and possibly other classes of the society. Indeed, the differential access to food was one of the stimuli for the socioeconomic evolution in the Late Neolithic (cf. Liu 2003). The elites were controlling raw materials for the production of agricultural tools, food, and "secondary products." Prestige goods and special foods were consumed by the elites on important occasions, through which they further enhanced their social status. Rites involving the consumption of all kinds of foods contained in special food vessels were gradually developed and became a very distinctive characteristic of ancient China. This indeed defined the Chinese trajectory of agricultural and economic intensification, which is driven by the endless demand of the elite. However, trajectories to intensification vary greatly from region to region due to the elites' different tastes in both prestige goods and foods. This is the question that requires further research.

FURTHER READING

Half a century ago, the prominent Chinese historian, Ho Ping Ti, published his influential book, *Loess and the Origin of Chinese Agriculture* (1969). Though it was criticized for the lack of a full assessment of archaeological evidence, this book still serves as a good guide to understanding the nature of the debate over where and how agriculture developed in China. An updated view on the ecology of the beginning of farming in China can be seen in Liu et al. (2009). For the fast-accumulating archaeobotanical data, Zhao's 2011 article provides a good overview of several independent centers for domestication of plants and some unsolved problems. The multiple centers of agricultural origins are further unpacked by several articles synthesizing the most recent archaeological and archaeobotanical evidence (e.g. Fuller et al. 2012; Zhuang 2015). An excellent summary of currently available archaeobotanical data on the beginning, development, and intensification of rice and millet farming is Qin (2012; but in Chinese). This is then complemented by Liu, Fuller, and Jones (2015). For a huge region like China, the best method to acquire an in-depth understanding of agricultural development would be to break it down into different regions. The volume edited by Underhill (2013) serves a good purpose for this task. Though not specifically focused on prehistoric agriculture, each chapter discusses subsistence developments in each region within their wider socioeconomic backgrounds in the light of recent archaeological discoveries. There have been many new discoveries, especially with respect to the archaeobotanical data, since this chapter was written in 2017. While more recent data have been published in a wide range of journals, English-speaking readers should start by consulting *Holocene, Archaeological and Anthropological Science*, and *PlosOne*.

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CHAPTER THIRTY

Late Antique Farming

Michael J. Decker

Introduction

The Roman world occupied an astonishing array of communities and landscapes stretching from the north of Britain to North Africa in the south and east across central and southeast Europe to Mesopotamia, northern Arabia, and Egypt. This vast swathe of territory included numerous environments characterized by great regional and local variation. The Romans themselves maintained political hegemony over Romanized groups from Britain to Gaul to the Black Sea, though the degree of adoption of Roman customs and Roman cultural expression varied considerably. The Romans also inherited prior farming practices from Celtic and Germanic groups, as well as a rich Punic-Berber North African tradition (Shaw 1984). Due to the nature of the Mediterranean and Black Sea landscape, one could traverse a number of microclimate zones by simply traveling a few miles inland, where narrow coastal lowlands, as around Sinop in northern Asia Minor, were backed by mountains that experienced vastly different levels of precipitation and temperature. During late antiquity, mountainous landscapes were increasingly exploited. Upland environments, which historically have been difficult to farm and if exploited at all were usually the preserve of forestry and herding, were farmed to an unprecedented extent in late antiquity. In the Mediterranean, areas of broad, open, rain-fed farmlands were rare. The Po Valley in northern Italy (Sereni 2014) and the rolling hills of Africa Proconsularis (roughly corresponding to modern Tunisia) (Mattingly 1996) offered rare exceptions. While Africa was the granary of the western Roman Empire, even it could not compare with the grain-growing capacity of the Nile Valley; in the sixth century, Egypt shipped some 24 million metric tons of surplus grain to Constantinople, where it fed the citizens of the capital, the bureaucracy, and the imperial army (Sarris 2006, p. 4). Egypt's fertility was ensured by the annual flooding of the river Nile, which typically began in Upper Egypt in June and peaked in October, tapering off once more until the following June. The Nile flood carried rich plant nutrients and soil and deposited these, along with millions of cubic meters of water, over the floor of the Nile Valley.

In the late Roman west, the fertile river valleys of Spain, along the Guadalquivir River in Baetica (Haley 2003), the Rhone in France (Van der Leeuw 2005), and the Rhineland in

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present-day Germany (Shaw 2013), to name but a few, were heavily exploited. Throughout northern Gaul into Belgium, the presence of large estates, often specialized in growing one of the three major crops of the late antique world, indicate the spread of intensive farming. In rolling or open country, such as in portions of present-day Belgium, the inhabitants employed advanced plows and harvesting machines that were matched in few regions prior to the modern era (Shaw 2013, pp. 93–149). Lowland Britain was intensively occupied and farmed during late antiquity, and though there are some exceptions, forests never made a dramatic return to most regions of England (Fulford 1990). The record of forest recovery in western Europe is mixed, and settlement remained relatively high in many areas. In northern Gaul, however, there is evidence that suggests a decline in population and the area of cultivation in the fourth and fifth centuries, but a rather swift recovery thereafter in the Merovingian period. The northern Balkans seem exceptional, as they suffered a severe settlement drop in the fifth century from which it took most places several centuries to fully recover (Curta 2013).

Considerable landscape change, some of its sudden, occurred over parts of the late antique world. In the Friuli in northern Italy, Sicily, and elsewhere, pollen records indicate a slight decrease in human activity that may relate to the shift of population from lowlands to uplands (Mercuri et al. 2013). Heavy erosion events due to violent precipitation characterized the period from about 350 to 800. These probably combined with the collapse of Roman irrigation and drainage networks to create marshlands and instability in some lowlands. Expanding marshland and waterlogged lowlands silted up by alluvium led to more frequent flooding and a rise in malaria and other insect-vectored diseases. These environmental realities often led to further degradation of farmland and forced settlements to move to more stable environments. Accompanying these alluvial episodes was an overall expansion of forest, as along the Biferno in Italy (Barker 1995), and major landscape change in southern Spain (Carr 2002), where the collapse of Roman authority was accompanied by increasing scrub vegetation. Many of these landscape shifts are indicative of intensive farming and herding regimes supported by large rural populations; the abandonment of these systems therefore seems to indicate demographic decline or displacement.

A period of high seismic activity globally can be detected both in the geological record and in the textual and archaeological record of late antiquity. The high frequency of earthquakes reported from the fourth–sixth centuries belong to the so-called "Early Byzantine Tectonic Paroxysm," which proved damaging to regional agriculture. Earthquakes disrupted the late antique farming regime through local landscape change, such as coastal uplift, the destruction of wells, and damage to terracing and other installations. Massive damage from tsunamis as that of AD 365, which affected large areas in the eastern Mediterranean, included losses to ports and cities that served as export and receiving centers for agrarian surpluses (Figure 30.1; Leroy et al. 2010).

Climate events played a major role in late antique agriculture. The period of warm weather known as the Roman Warm Period (RWP), or Roman Climatic Optimum, allowed longer growing seasons in northern latitudes and aided the spread of warm weather plants over temperate Europe in the wake of Roman colonization (Brooke 2014). By late antiquity, a millennial shift in precipitation was underway, with Iberia and the southeast Mediterranean experiencing drier weather, while the central Mediterranean and Anatolia was wetter. By 500, the RWP had ended, and global temperatures dropped precipitously in the era termed the "Migration Period Pessimum," in which annual averages were as much as 0.5 C° lower than today. More extreme short-term weather events devastated crops on a local or regional scale, as during the so-called Dust Veil Event of AD 536, which was likely caused by the massive volcanic eruption of Ilopango (El Salvador), proto-Krakatoa (Indonesia), or both (Gräslund

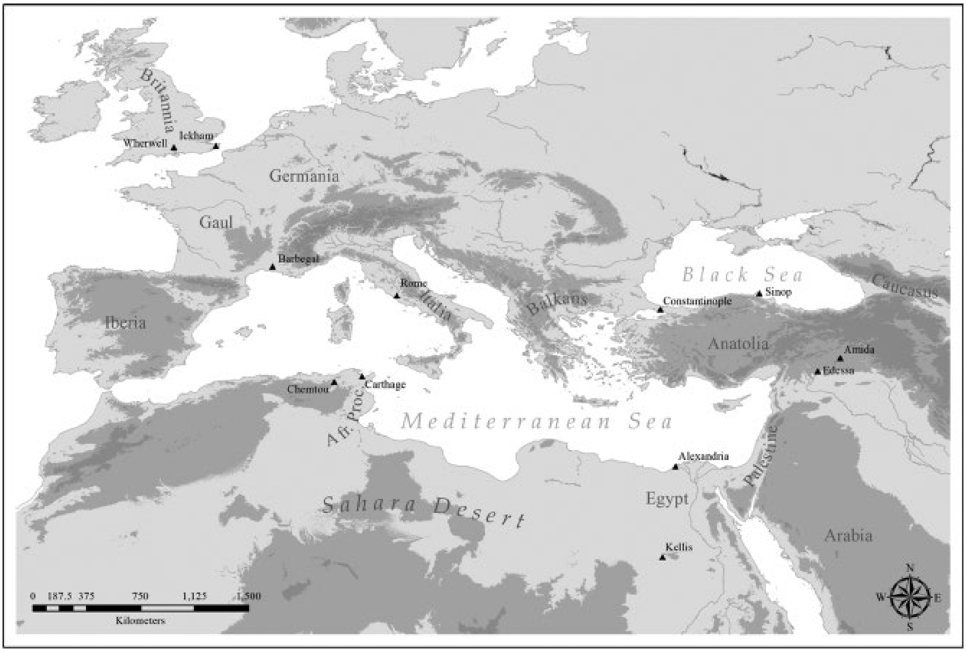

Figure 30.1 The Mediterranean Basin. Source: Courtesy of John Northrop.

and Price 2012). Whatever the cause, the Dust Veil Event led to a decrease in solar radiation, the sun was darkened, and days were cold; crops failed in many places, and famine ensued. Cold summers and the attendant bad harvests may have resulted from the Dust Veil Event as late as 545–550.

Evidence

The evidence for late antique farming comes from two major sources: textual and material. Textual evidence comes in many forms. There is limited evidence to be gleaned from law codes. The bulk of our information comes from farming handbooks in Latin and Greek, although there are some relevant texts in Syriac, Armenian, and Arabic. It seems that the majority of Hellenistic agricultural farming technique, to which much of this literature owes its genesis, has been preserved across these traditions. Papyri account registers as that from Kellis in Egypt and the receipt books such as that of the fifth-century traveler Theophanes (Matthews 2006) provide important sources, and Coptic almanacs also provide some information regarding planting and work cycles (Wilfong 1999). Incidental references in various literary genres, such as hagiography, inscriptions, and legal codes, allow for glimpses into local farming practices. A great deal of information about the kinds of plants that were widely grown and readily available is found in the writings of late Latin and Greek medical authors.

The most important technical treatises are the handbooks of Palladius' *Opus Agriculturae* and the *Geoponica*, a Byzantine Greek farming encyclopedia compiled in the tenth century but largely comprised of late antique material (Decker 2007a). Agricultural handbooks were not merely academic, but used by literate estate owners and perhaps also by estate managers. These handbooks often derive from earlier Latin and Greek writers, but they contain observations of contemporary practice. They generally cover estate management and the agricultural calendar, and detail the planting, care, and harvesting of cereal and tree crops. Special attention is generally devoted to olive and grape production, as these were both staples and also rendered marketable commodities in the highly connected economy of much of the late antique Mediterranean and beyond. In addition, the handbooks deal with animal husbandry, including the feeding and care of animals, and the treatment of diseases. Veterinary manuals also survive, and these provide us with a good deal of knowledge about large animals, primarily equids (horses, donkeys, and mules) and cattle (*Bos taurus*). Inscriptions and art also offer glimpses into farming and rural life. In the case of meat supplies to Rome, Constantinople, and other great imperial cities, stock were clearly moved over considerable distances. We see this through documents like the famous "pig stele of Edessa" (Daux 1970), which shows animals being driven for sacrifice or to the market.

Archaeological remains include traces of farms, tools, fields and field boundaries, canals, and other irrigation systems such as underground drainage galleries (qanats) or waterwheel installations (Decker 2009). Tree pits in former plantations have also been recovered archaeologically, though these are uncommon, as are plant nurseries, which have been recovered from late antique Egypt and which shed some light on botanical production and propagation. Wine and oil presses, often comprising stone components or cut into the rock, are also major indicators in the Mediterranean of ancient production, but press finds are uncommon in places like Egypt and the western provinces and beyond the olive-growing belt (Decker 2001). A common archaeological proxy for agriculture is amphorae, the best preserved of which are usually recovered from shipwrecks (Ward 2004). Numerous different types of amphorae exist, but these can usually be linked to specific regions or locales, and if subjected to chemical analysis, their precise origin can usually be determined. Jar morphology often provides clues about what the vessel may have carried. For example, carrot-shaped amphorae from Egypt, with their tapering bodies and long foot, are good for pouring and therefore were ideal for liquid; the fact that many remains of these are coated with pitch is another strong indicator that they carried fluid, most likely wine, which was often resonated with pine pitch. Small boreholes sometimes appearing in the shoulder offer more evidence of what these amphorae contained, as these holes were drilled in order to allow wine to ferment without the jar bursting from the pressure of trapped gases. Visual and chemical content analysis has allowed some jars to be linked with a product or, more commonly, a variety of products. Plant remains, in the form of desiccated, waterlogged, or carbonized seed or stalk fragments, or from those incorporated into mudbrick, provide an additional window into late antique farming. Pollen and tree ring data are increasingly valuable in reconstructing past climate and the plant regime on a regional basis.

Though they were for decades largely ignored in historical archaeological investigations, animal skeletal material found in excavation are now often studied to determine not only the type of animal to which the remains belong, but also its sex and age. Skeletal remains also help shed light on the size of livestock (MacKinnon 2010). While advanced faunal study, including DNA study, is only getting underway for plant and animal evidence, there is little doubt that this type of analysis will be an important part of future work. In addition, isotope analysis of human skeletal material can allow the reconstruction of local diet and provide a fairly granular picture of past environmental conditions.

Plants Cultivated

The peoples of late antiquity generally relied on a much broader spectrum of plants than is now common. However, as is the case today, grain was the usual staple of the diet. Among settled peoples, grain provided as much as 70% of consumed calories, and even nomadic groups, while they relied on animal products for a sizable portion of their caloric intake, typically consumed grain and other plant foods for which they traded. Wheat was the most important crop in the Roman Mediterranean, and many varieties were cultivated. By late antiquity – and in apparent contrast to the Classical period – bread wheat (*Triticum aestivum*) was the staple over much of the empire. Bread wheat produced good-quality loaves that were both nutritious and palatable. While bread wheat was also relatively adaptable, other, more primitive types, such as emmer and einkorn, were more resilient and continued to be grown. Macaroni wheat (*Triticum durum*) was a major Mediterranean variety, especially in Egypt and the Levant (Jasny 1944). Naked grains like bread- and macaroni wheat as well as hulless barley were easier to process than hulled types, though they were less resistant to disease and did not store as well. Barley (usually hulled varieties) was the second most important grain and provided the main cereal for the poor in many regions, especially in parts of Gaul and Spain, but the general trend was more often toward wheats of various kinds, a pattern that would continue into the medieval period. Although minor crops such as rye and oats are often overlooked, in many instances these could be quite important depending on the place and circumstances. Millet, another minor grain, was often a summer crop and important in the multi-cropping rotation systems that characterized many agricultural regimes in late antiquity. Millet's relatively short growing cycle meant that it could be planted in some places after the wheat or barley harvest and mature before the onset of frosts.

The most important tree crop in the Mediterranean world was the olive, the "queen of all trees," which provided edible oil that was excellent for cooking but was mostly used as a condiment. Olive oil was used as a preservative, in cosmetics manufacture, in medicine, as a general-purpose lubricant, and as fuel for lamps. The Mediterranean economy thus required vast quantities of oil and the slow-growing tree required significant capital investment to establish, as trees do not reach peak fruiting until decades after seedlings are planted. Roman tastes required olive oil in the diet, and Roman colonists encouraged vast plantations in Spain, North Africa, Cilicia, and Syria (Mattingly 1988). By late antiquity, these regions were home to millions of trees that produced oil for export on a grand scale, supplying major urban areas like Rome, Constantinople, and Carthage. Olives have specific sunlight and temperature requirements that largely confine them to regions with classical Mediterranean climate, and even within the Mediterranean they rarely thrive over 1000 m elevation. In areas where olives did not grow, oil was either imported or, in the case of the poor, pressed from other seed crops. In warm areas, like Mesopotamia, sesame was a major oil seed, while in Egypt radish seed oil was commonly consumed, along with oil from tree nuts such as almond.

The third part of the Mediterranean triad, wine, was also consumed heavily, as much as 20 liters of wine per capita annually, and much more among those who could afford it. Wine offers numerous advantages, including the capacity to be stored over long periods of time and thus preserve a source of calories and vitamin C in which the ancient diet was otherwise poor. Although the European wine grape (*Vitis vinifera*) was first domesticated in the subtropical climes of the Caucasus region, the plant is exceptionally adaptive, and by the end of late antiquity, grapes were grown and pressed for wine in the Sudan, south of the Tropic of Cancer (Decker 2013). The spread of the grape northward, into central Europe and among Germanic groups established along the imperial frontiers, was due to a combination of increasing Romanization among local elites and the spread of Christianity among groups like the Goths and Franks.

Next to the crops of the Mediterranean triad, legumes were the most important class of plants in the ancient diet. Various kinds of beans, peas, and lupines provided B vitamins, carbohydrates, and relatively rich sources of protein. For most peasants, meat was consumed rarely, and protein was obtained through grains, nuts, legumes, and seeds. Vegetable greens, including types common today, such as brassicas like cabbages and kale as well as leaf vegetables like lettuce and chard, and some less common types, such as orach were quite prevalent in the late antique farming regime. Root crops, including beets, leeks, and onions, were ubiquitous, especially in kitchen gardens or in intensively farmed fields near urban and suburban areas. Carrot and parsnip were also planted; the former, despite claims to the contrary, was not an Islamic introduction into Europe, as orange carrots are illustrated in the herbal of Dioscorides dated to AD 512 (Dioscorides, Goodyer, and Gunther 1934). Melons, including watermelon, cucumber, and gourds, were common garden crops and had spread over much of the Mediterranean and were known as imports or as local, experimental crops in northwest Europe.

Animals

Cattle of various types, including large cattle (cows; *Bos taurus*) were the most important domestic animal in the late antique world and were an important source of power, meat, milk, and hides (McInerney 2010; Kroll 2012; Ryder 1983). Like other large livestock, cattle also provided useful secondary products, such as bone, tallow, and sinew used in manufacture of a large array of domestic items. Oxen (castrated males) provided the bulk of transport and traction capabilities over large portions of the empire, especially in places like Anatolia, where the road network was relatively well developed and where substantial rangelands existed for their support. Beef was a popular food, but has always been expensive to produce, as cattle need plenty of high-quality forage and access to ample fresh water if they are to thrive. Stabling and stall feeding of cattle was common in many regions, in Syria and the south of Gaul, for example, where the practice returned only in the modern period, or not at all. Stabling of large livestock indicates a heavy reliance on arable farming, restricted pasture, and the need to monitor food intake and protect the animals from predators, thieves, and exposure to environmental danger. With large cattle, the practice also underscores the working nature of the animals; range-fed cattle were not readily available for work, as they had to be transported from pasture to working farms, sometimes over considerable distances. The Roman animal economy was therefore first and foremost a cattle economy, and a cattle economy predominantly in service of arable agriculture. Evidence from Roman Italy indicates late antique producers intensively selected cattle for particular heritable traits that served the aims of individual farmers or communities of farmers on a regional basis, and it is the late antique period where the notion of "breeds" of cattle, familiar to us today, might be reasonably applied as a useful category (MacKinnon 2010).

In areas with adequate water resources and particularly those with high concentrations of urban settlements, pigs were raised in large numbers. The main use of pigs was for meat, though hides were an important secondary product. Swine were frequently herded in forest pannage areas where they were fattened on acorn mast and other forest resources and then herded to market in cities like Rome. Pigs, while prone to infection with parasites that can be deadly for humans (for example, Trichinosis from the roundworm Trichinella), are able to thrive and add weight efficiently in a variety of conditions as well as exploit forest landscapes and human waste. This made them attractive animals throughout much of late antiquity. In areas where urbanism faltered, as in the northern provinces of Gaul, Britain, and the Danube, pigs seem to have declined in importance relative to other large, meat-bearing livestock, especially sheep and goat.

Sheep and goat (ovicaprids) were always major parts of the late antique agrarian landscape (Hongo 1996). Unlike pigs, sheep and goat were multipurpose animals, offering not only meat, but wool or hair, milk and hides, bone and sinew. As urban communities shrank and population dispersed or declined over various regions, the role of sheep and goat seems have risen in importance (Kroll 2012). Ovicaprids possessed certain advantages over pigs, which they tended to displace, not least of which are generally requiring less water and being more heat and drought tolerant, easier to herd, and offering raw materials vital in cloth manufacture. Dietary taboos against swine also helped the expansion of caprine herding, especially in the Levant, though there were apparently similar cultural restrictions in place in places like Asia Minor long before the Roman era.

Equids were raised throughout western Eurasia, North Africa, and temperate Europe. In ascending order of importance were the horse, mule, and donkey, or ass (*equus africanus asinus*). Donkeys enabled farmers to travel and transport goods. Asses are hardy creatures, can thrive even on poor-quality provender, and are reliable workers. Mules are derived from crossbreeding horses and asses, and they have many of the characteristics of both, being larger, faster, and able to bear larger burdens than asses, but being less fleet of foot or of refined appearance than horses. The general competition from other animals for the limited grazing lands available limited the number of horses and their importance. Horses were used mostly by elites and by the state; they were less rugged than their other equid relatives, required finer food and better care generally, and were limited to specialist roles, primarily as transportation or as military mounts (Kelekna 2009).

Other animals were of some importance in the late antique agricultural economy. Among these were fowl, which were raised in limited numbers and mostly confined to small peasant flocks. Pigeons were the most important fowl – they were grown by the hundreds of thousands throughout the empire, as evidence from texts and finds of dovecotes inform us. Pigeons reproduce rapidly and are generally easy to keep; they forage readily and provided critical protein in the form of meat and eggs. In addition, pigeon guano was one of the most useful fertilizers available to farmers in the pre-industrial world (Decker 2007b).

Dogs were kept mainly as working animals, to aid in herding or in hunting. Dogs also had an important role as guard animals. Domestic cats were relative latecomers to the Mediterranean basin, but by the late antique era their range had expanded considerably, probably in large part due to the spread of the black rat over much of the landscape.

Agricultural Calendar

Palladius's handbook (*Opus Agriculturae*) (Rodgers 1975; Fitch 2013) is arranged as a farming almanac, and his offerings generally parallel those found in the *Geoponica* (Dalby 2011; Beckh 1895). Since Palladius was writing primarily from an Italian perspective, the arrangement of the planting and harvesting cycle he presents holds for much of the Mediterranean coastlands, but less so for upland or northern climates. In these colder regions, the planting and harvest cycle lagged somewhat behind the Palladian ideal. In January, laborers dug the roots of vines and trees; cold-tolerant plants like lettuce were sown, the winter-planted grain crops were weeded, and new vines were planted. Other activities like mending tools and utensils also occupied the winter months while the grain crop was growing. Plowing and preparations for spring-sown crops began in warmer areas in February; for example, flax was sown at this time, gardens were started in warm regions, and fruit trees were planted and grafted. In March, these activities continued; millet and chickpeas were sown, gardens established, and fruit trees planted. The spring marked the season when animals were acquired, and, for stall-fed animals, these might be pastured or prepared for work. Throughout April and May, hay was tended, vines were shaped and supported, bees tended, and cattle and lambs birthed. June and July were hot months in the Mediterranean and an agricultural peak – with the harvest of grain being the major activity spread out over the period. Following this, toward the end of summer, crops like legumes were typically sown – where sufficient water was available, these were planted in fields where grain was harvested. September marked the early portion of the grape harvest and pressing that continued through October in most places. Bringing in the grape harvest, treading the grapes, and racking the vintage represented one of the busiest parts of the calendar, with large numbers of laborers having to be mobilized if good quality was to be ensured. Some grapes were dried or pressed into inferior wine long past their peak. Fruit harvests from major trees like pear, peach, and apple would have occurred in the last quarter of the year. During the late autumn and through the winter months, the olive crop was brought in and oil pressed. The olive harvest usually overlapped with the sowing of wheat and barley, which put labor at a premium.

Tools and Technology

Since grain was the most prominent food crop, equipment for cereal culture was ubiquitous in the late antique world. The plow, most often the simple, light Mediterranean scratch plow (ard) that etched shallow furrows in the soil, was the commonest basic farming tool. The plow required oxen to pull it, and thus tack and harness were also necessary. Poor farmers often owned a plow, but they often lacked an ox; these they had to borrow or rent from their neighbors. It was in northern Gaul that a special harvesting machine was also in use during the fifth century, as Palladius noted; this simple reaping device, called *vallus*, was pushed by a mule while at the front of the machine a worker fed stalks of grain into a scoop-like opening with sharp serrations at the bottom which cut the heads (Decker 2009, pp. 90–97). Nearly everywhere, though, the simple curved metal sickle was the main grain harvesting tool. Threshing sledges, pulled by people or animals in the circular pounded earth or stone threshing floors, were also common. These were usually made of boards studded with sharpened flints. Simple storage technology, such as large sunken earthenware jars (*dolia*), lined storage pits, or built granaries were used to store the crop through the autumn and winter months. These store centers were highly prone to spoilage and infestation by vermin.

Other common tools included various hoes, spades, and digging forks (White 1975) used mostly in tending trees and vines whose roots were frequently dug in order to ensure water and nutrient absorption. Vines were tended and pruned using pruning knives (*falx*), and grafting cuts were made with knives and saws. Baskets made from reeds and osier were used in many farm chores. Ceramic vessels were also important, especially for storage of fruits, vegetables, and pickles of various kinds. They were also apparently used to transport waste from houses to the fields immediately surrounding the village: the high density of ceramic sherd scatters have been understood to represent manuring, especially using human waste (night-soiling) (Wilkinson 1990).

Metal was costly, and many poorer farmers owned only basic items; a few knives, a spade or fork for digging, a pruning knife, and a sickle were the most commonly held. Needles and awls for making and repairing leather and cloth items were also ubiquitous and important; items like pack saddles and blankets were made from wool and leather, and since donkeys provided most of the transport capacity in the countryside, such baggage was in constant demand around the farm. Great estates had a much wider array of tools and specialist equipment. The well-equipped estate included blacksmiths tools like tongs, bellows, and forges, and anvils. Based on the quantities of slag found on archaeological sites throughout the world of late antiquity, rural metalworking was common. Textual sources, such as the *Life* of the seventh-century Anatolian hermit St. Theodore of Sykeon, indicate that metal was available in rural Galatia where the holy man preached, but it was never cheap and abundant (Dawes 1977).

Carts and wagons represented substantial capital investment and were of limited utility due to the need for good roads and for animals to pull them. By the fourth century, the Roman road network had degraded over large areas of the empire, and maintenance of the vast overland transportation network was always a struggle. While mosaics and relief panels depict carts, wagons, and even liquid tankers for items like wine and olive oil to carry bulk commodities to other transport and market nodes, these items were typically owned by the great landlords who could afford them and the harness teams and teamsters required to operate them. Most agricultural produce moved, when possible, by water transport. On the Rhone and Moselle, small barges and boats were used to shift large quantities of foodstuffs from villages and estates to the cities and military units stationed throughout Gaul (West 1935). In Spain, the Guadalquivir was the vital artery that helped to shift Spanish oil from the remaining Baetican estates, which were apparently fading from the fourth century, though villa sites along the rivers of Spain continued to thrive in the fourth century and later (Chavarria Arnau 2004). The Nile allowed the "happy shipment" of grain to be carried to the harbor at Alexandria. While water transport was preferred, the vastness of inland areas of Roman late antiquity in the interior of Gaul, Anatolia, Spain, and North Africa meant that thousands of tons of agricultural produce were shifted by pack animals, mostly donkey and mule trains, but also by cart and wagon. Camels were increasingly important from the Levant through North Africa and Spain – and possibly even further north.

Social Changes and Agriculture

As with other facets of late antiquity, the breakdown of imperial authority was a major driver of change (Dossey 2010; Conant 2012). However, one has to be cautious about such generalizations, as the expression of state authority and influence in the countryside was uneven when the empire was at its most powerful. Peasant access to justice or opportunity other than via their master (if slaves) or their landlord (if legally free) was slight in the extreme, as was peasant access to the levers of elite power through literacy and ideas. One disruptive force in rural life was Christianity. Indeed the role of the church in all its forms has yet to be fully explored through the lens of rural action and change, though a recent study on North African peasants and Christianity (Dossey 2010) indicates that some established norms were being corroded during the late empire and that one of the most acidic social and cultural streams was Christianity and the reception and use of public sermons. However uneven in its teachings and practices and however slowly the countryside succumbed to its message, Christianity eventually came to largely supplant the patchwork of local religious cult. This fact has great implications beyond the mechanics of farming. The promulgation of Christian notions of the poor and sermons which railed against worldly vanities were like sand rubbing on the soft stone edifice of elite identity and notions of the state.

Classical large estates of the late Republic and early imperial eras were centralized, large-scale affairs whose labor force was dominated by slaves. In late antiquity, great estates of the classical type, mainly staffed by slave labor, continued to exist. But it is uncertain what portion of landed domains these types of estate comprised, and such large centralized entities were probably becoming increasingly rare even in the west, where they were always proportionally more important than in the eastern half of the Roman world. The existence of bipartite estates, in which the landlord has his or her private land farmed separately from tenant lands through various labor instruments, were hardly universal in late antiquity, and we need not look to these systems as engendering the serf-driven feudalism of the medieval period, as has so often been the case. In some form, bipartite estates appear in papyri documents from late antique Egypt, and they were also apparently known in North Africa, if the term *pars dominica* can be correctly interpreted (Sarris 2004). Political stability and expansion favored the growth and expansion of elite landed wealth, but there were numerous other elements that affected the social landscape. While the greatest families of the late Roman west exceeded the emperor in wealth, post-Roman elites were not as rich. The estates of the stupendously wealthy were large and geographically spread out in order to minimize risk. Estates spread across provinces were somewhat insulated from the raiding and large-scale influx of barbarian settlement, but they could hardly be immune to damage from these events. Indeed, by the fifth century, most of Gaul was dominated by Germanic groups, nearly all of Spain was taken by the Visigoths, and North Africa formed a new Vandal kingdom. Estate owners adapted and made accommodation with the new arrivals, but these were seldom without cost. As the basis of elite wealth was always land, the new elites required an abundance of this which, as we have noted, was already occupied. The rundown of imperial power furthermore meant the end of large-scale central government demand for agricultural surpluses to feed the soldiers and bureaucracy and an end to urban food subsidies that helped fuel a market for commodities and reduced transport costs by creating economies of scale. Local disruptions in the fourth and fifth centuries occurred due to raiding and invasion, but more likely the kind of farming being done, the types of crops being grown, and animals raised look much the same in the sixth century as it did in the fifth.

While the general categories of landholding – small-free peasant farmer with a freehold, dependent tenants of one kind of another (whether free or unfree and sharecropping or paid a wage did not make much difference), and wealthier landlord, late antiquity resembled the Classical period in many ways. However, as with other major pieces of Roman life, the reconfiguration of political relationships reflected some serious structural changes (Banaji 2001). These included the prominence and power of the imperial service elite, the rise of the church as a major landowner (even, it would seem beyond the considerable reach of the old temple estates of late antiquity), and the increasing militarization of the provinces, both as arenas of military conflict and as billeting spaces for the settlement of soldiers whose presence changed power dynamics in the countryside. This is seen not only in the western and northern portions of the empire, but quite early even in the eastern provinces. Alongside this, the influx of new settlers who brought with them new agricultural practices and different cultural preferences are detectable in the material record, for example, in the proportion of rye that appears on some sites in western Europe, or in the expansion of runoff farms on the desert fringes of Roman Arabia and Palestine.

Changes in the Practice of Agriculture During Late Antiquity

Some of the changes in the practice of agriculture that occurred during late antiquity have been noted above. Among the most important of these were the spread of irrigation methods, especially in the eastern Mediterranean. Most important of these was the diffusion of the qanat through the semi-desert fringes of the imperial landscape, most notably in Syria and Egypt. The spread of the saqiya-driven water-lifting gear throughout the eastern provinces is another major change which occurred in late antique farming. Saqiyas were an important part of the transformation of the Egyptian landscape, where their widespread use allowed the growth of irrigated garden spaces well beyond the limits of the Nile flood; the machines were thus an important component of the massive growth of wine production in the eastern Mediterranean (Decker 2007c). The strengthening of Mediterranean wine culture was largely the result of Christianity, which required wine for the Eucharist; consumption of the beverage thus was spread far beyond its traditional boundaries in the Mediterranean and Mesopotamia to the Horn of Africa, the Gulf, and beyond. The prominence of wine also meant that other alcoholic beverages, most notably beer, often declined. Though culturally driven in most instances, the spread of vine cultivation also benefited from the fact that *Vitis vinifera* does not generally compete in the same ecological niche with beer. Vines could grow on steep hillsides and in more difficult-to-work, more marginal areas not suitable for cereal cultivation.

New crops also circulated and were adopted by farmers during late antiquity. Wheat made steady progress in the diet on its way to supplanting barley in most regions as the main staple; the selection of wheat seems to have been embedded within cultural as well as ecological concerns. Crops like bottle gourd (calabash, *Lagenaria vulgaris*) were at least grown experimentally by farmers during the Roman period, and trials like these apparently continued, if only on a limited basis. Apricot was also introduced by the Romans into temperate Europe, but due to its climatic needs could never have been widely grown in the north. Perhaps the most widely adapted exotic fruit disseminated into the Roman world (though arriving earlier) was peach (*Prunus persica*), which continued to be commonly grown in the post-Roman world. Sorghum, first domesticated in sub-Saharan Africa, arrived in the Mediterranean region sometime during the Roman period. Sorghum yields a nutritious grain and is drought tolerant, which made it an ideal crop in many southern regions of the Roman world. The grain does not seem to have been widely grown, however. Other grains like rice, a Hellenistic-era introduction, were spread as far west as Gaul. Rice requires a high amount of water and typically requires substantial artificial irrigation. While well known to medical writers, Roman authors exhibit some prejudice against the plant which was nonetheless important in areas to which its growth was suited. Cotton was also grown in lowland Palestine, around Jericho, where abundant water and high temperatures suited it, as well as in the larger oases of Egypt. Archaeological finds of cotton cloth produced within the borders of the late Roman East are known, but these are found in much lower quantity than wool, from which most clothing was made.

New basic technologies were refined and spread, at least on a regional basis, during late antiquity. Most of these, such as the watermill, were earlier inventions. But the archaeological evidence for late Roman watermills is growing and impressive; a great number are known from places as disparate as southern Gaul at Barbegal, where the famous and truly massive installation was capable of supplying the needs of a substantial urban community, but also on a much smaller and more local scale at Ickham and Wherwell in Roman Britain, Chemtou in Tunisia, Amida in Anatolia, and Spain (Wilson 2002). It seems that there was a real expansion in water-driven technology. The precise cause for this is unclear, but it should probably be linked not to demographic factors, but to the continuing quest by individual wealthy landowners for efficiencies and intensification. Beyond the *vallus* reaping machine, and possibly the scythe, which seem to have been radical leaps in technology but regional in their reach, there were other smaller technological changes, including the use of the hinged flail for processing cereal grains. The screw press for processing grapes, olives, and other oleaginous plants, while a Hellenistic invention, seems to have gained wider currency only during the later empire. The screw press required specialist skills to construct (namely, screw cutters), but it required fewer materials to build and is generally more efficient than older press types.

Important Debates and Avenues for Future Investigation

There are many debates regarding agricultural practice and rural life in late antiquity. Among the most important is the issue of rural living standards. One component of the debate is the problem of fecundity of the landscape and the physical potential of ancient farming to produce regular surpluses, often in the face of environmental adversity. Grain yields, on which the bulk of the population depended, have not been adequately understood, and there is still a wide range of scholarly disagreement, with pessimists assuming a threefold return as normal. Another key element of the debate about rural living standards is the social situation of late antique landscapes. Once more, there seems to have been considerable variation in the ability of local wealthy landowners to exploit and control their peasants. Labor mobility and management has been studied in light of perceived imperial crisis and political collapse, but fresh perspectives are needed, beginning with a thorough study of demography now possible at a regional level in some areas especially rich in archaeological and epigraphic remains.

Banal objects like tools receive scholarly attention very infrequently, and although museums typically possess numerous specimens recovered in local excavations, there has been no attempt to catalog and classify these implements. Such an effort would repay scholars by offering views into pathways of technological diffusion, shared technical vocabularies, and local adaptation.

Understanding the diffusion and role of common late antique water technologies, such as the saqiya, noria water-lifting wheel, and the qanat, to places in the former Roman provinces of Spain and North Africa will help advance the debate about whether these technologies were ever utilized extensively in these regions prior to the arrival of Islam and shed additional light on local practice. Moreover, they offer sustainable possibilities and could be studied in order to be adapted to present-day circumstances. A more utilitarian approach would rely on DNA analysis of archaeological samples and subsequent identification of relict ancient crop varieties. Their discovery offers the potential to diversify our dangerously shallow genetic pools of many traditional crop plants. At the same time, the revival of ancient cultivars has potential benefits to both producers and consumers.

The ways in which new crops circulated around the late antique world and the reasons for their adoption are also important, providing possible avenues of exploration into wider social networks and questions of culture. While the Roman world was responsible for a transferal of agricultural knowledge and crops within Europe and western Eurasia that was unrivaled until the Columbian Exchange, much more work needs to be done to understand the full extent and drivers of this movement. Many ancient landscapes are under critical threat from environmental degradation and modern development; most have already been irrecoverably damaged. Those that remain need to be mapped and studied and, where possible, preserved to offer us a glimpse into the ways in which human beings attempted to tease their living from the earth.

FURTHER READING

K.D. White did pioneering work on Roman agriculture in his work, *Roman Farming* (1970); his work focuses mainly on the Republic and central period of the empire and relies on the classical Roman agronomists. The most important agronomic texts are those of Palladius, whose *Opus*

Agriculturae is accessible in a modern scholarly edition by Rodgers (1975) and in English translation by Fitch (2013). The *Geoponika*, a collection of Greek texts mostly from the sixth century, is currently available in the outdated edition of Beckh (1895); general audiences may access the recent translation of Dalby (2011). Agriculture and economy in the western empire is explored by Fowler in Britain (2002), in Gaul by Durand and Leveau (2004), in Spain by Martinez (1990) and Bowes (2013), in Italy by Lewit (1991), and regionally in Germany by Heimberg (2011) and Seiler (2015). Dossey (2010) provides a good introduction to intersections of rural life and social change in late antique North Africa. For the late Roman East, Safrai (1994), Sarris (2006), and Decker (2009) provide entry points.

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PART VI

CONCLUSION

CHAPTER THIRTY-ONE

Common Ground: Understanding Ancient Agriculture from the Perspective of the Modern

Pamela Riney-Kehrberg

When David Hollander approached me with the idea of writing the conclusion for this collection, I was skeptical. I had no idea what a historian of modern American rural and agricultural history could possibly have to say about the history of agriculture in the ancient world. The people I study lived in a modern world. They bought tractors and combines. They used a variety of chemical agents, such as herbicides, pesticides, and fertilizer. They read bulletins from agricultural colleges and discussed their problems with agricultural extension agents. They relied on federal farm programs. The agriculture these farmers practiced was extensive, expensive, and resulted in enormous surpluses, well beyond what their families, communities, and nation could absorb. On the surface, there would appear to be no points of similarity between agriculture in the ancient world, and the world within which twentieth-century American farmers operated.

Diving below the surface, however, reveals that the agricultural world has not changed as much as we might think. While ancient farmers operated on a smaller scale, with different tools, and without the chemicals modern farmers generally take for granted, farming is farming. It is the process by which human beings have most altered their world, stripping it of what would have grown naturally, and substituting that which they would prefer to grow, either for subsistence or profit. It is the process of cultivating flora and fauna with a purpose, and all of the steps involved in bringing those plans to fruition. Ancient farmers worked with far different tools than those of the modern era, but they had the same desire to wrestle a living out of the land on which they worked.

When a scholar involved in the study of modern agriculture begins to read the literature of ancient agriculture, that scholar discovers many points of similarity, and far more than she might have expected. Take, for example, animal husbandry. Even historians sometimes have unrealistically romantic views of how animals and humans lived together in past time, imagining that cattle and pigs were ranging freely across open pastures, without being subject to any of the kind of confinement and manipulation that marks modern animal agriculture. Reading this volume, however, I discovered that animals in the distant past, too, were subject to

A Companion to Ancient Agriculture, First Edition. Edited by David Hollander and Timothy Howe.

human whims, although perhaps, not on the same scale as one would find in post–World War II America. The essays tell us that in Syria and the south of Gaul, stabling large livestock was common, in an attempt to both control and protect the animals. We find swine being confined in stalls as well, particularly in urban areas with their high demand for meat. Even their genes were being shaped for human benefit. Michael MacKinnon tells us that "studies of livestock 'breeds' for antiquity … reveal targeted, shrewd, and dynamic manipulations of animals," an assertion that calls into question any vision we might have of idyllic domestic animal life in a far distant past.

The available ancient texts can tell us, to some degree, about the more subjective part of the human–livestock relationship. Human beings had a relationship with animals, or at least particular animals, which went beyond their mere utility as providers of milk, meat, and hides. In some societies, animal ownership was a sign of prestige and wealth. Some domesticated animals, such as cattle in ancient Egypt, were sacred. Animals also died as objects of ritual sacrifice. What did this mean, however, to their well-being and care, if anything? Did the reverential feelings some ancient peoples had for animals translate into more humane treatment? That is something that we cannot know, given the source base. In turn, if modern Americans saw cattle as objects of worship, would it have prevented the development of feedlots, and the use of modern slaughter and packing facilities? Although historians usually avoid dealing in counterfactuals, it is an interesting question to contemplate. According to historians, there is a distinct lack of reverence in the way that farmers have approached the care, feeding, and processing of animals for the modern American plate (Brown 2016).

Other descriptions appearing in this volume remind us that it was not only animal life that was being manipulated. The struggle to subdue the land was ongoing. Intensive agriculture resulted in significant deforestation, and in some locations, such as Britain, the vegetation has never recovered. More natural events, such as heavy precipitation, combined with human interventions, such as collapsing drainage networks, resulting in erosion, silting, flooding, and the spread of malaria. These farmers had discovered something that American farmers in Idaho's Snake River Valley would also discover more than a millennium later: that nature could be manipulated, but that it could also bite back, asserting itself in interesting and uncomfortable ways in response to people's efforts (Fiege 1999). Ancient farmers further tinkered with their environments, developing irrigation systems, and other means of controlling water. They clearly changed the landscape within which they worked. As a result, we find that environmental degradation is not an invention of modern agriculture, nor is it an invention of the modern capitalist system. Soil conservation, in turn, is not the product of modern agricultural science. In some areas, such as Republican Italy, with its limited arable lands, farmers approached problems in soil fertility with innovations such as crop rotation and intercropping. They also managed their cattle in such a way that their animal husbandry – particularly the use of manure – complemented their cropping system, maintaining the health of their fields. In the ancient world, as in the modern, farmers fell across a broad spectrum of environmental practices, some of which were more damaging than others.

Any occupation involving control over land involves power relationships between people as well. As these essays show us, these power relationships were very visible in the ancient world. Wealthy landholders in places such as the Bagradas Valley of North Africa gathered up an enormous amount of land, and may have experienced the wrath of Nero as a result. In some communities, landholders exercised power over slave laborers, in order to till their lands. Others collected rent from tenants. Peasants worked much of the land, but held little of the power, and small farmers were particularly vulnerable to economic competition. Itinerant laborers moved from location to location, following the harvest, and sometimes taking part in local conflicts. Because of its need to provision those in its employ, either as government officials or soldiers, the state, in its many forms and locations, maintained an interest in agriculture. Agriculture had political purposes, as well as economic purposes. In the case of Alexander, the state may have applied pressure on pastoralists to become farmers, in hope of rendering them less potentially harmful to their sedentary neighbors. The degree to which this happened and its degree of success are subjects of debate among ancient historians.

All of these themes resonate throughout agricultural history. Struggles between small and large landholders are too numerous to mention, and power struggles between large landholders and the state have led to many a conflict, up to and including the American Civil War. Pastoral tribal peoples found themselves on the losing end of a process of forced sedentarization, as a result of the agricultural development of the American West by settlers of European extraction. The sufferings of small farmers, caught in the turmoil caused by technological and political change, are well documented. Greta De Jong (2016) ably told the tale of one of the most poignant of these battles, between southern African American tenant farmers, displaced by technology in the 1950s and 1960s, and the local and state governmental officials who wanted to be rid of them. Large landowners in the southern states had been slow to mechanize their cotton agriculture, given the availability of inexpensive, politically marginalized African American labor, largely in the form of tenant farmers. When those tenants were the beneficiaries of voting rights acts in the 1950s and 1960s, landlords replaced their labor with machines as quickly as possible, hoping to remove African American voters from their midst. Jobs were scarce, and local and state governments denied them access to new federal food programs, hoping to force them, by way of starvation, to migrate out of the region. It was only through their concerted effort, and the intervention of the United States Department of Agriculture, that these displaced farmers were able to get access to food programs created by the War on Poverty. Holding land, and holding power, were one and the same in many times and places in American history.

The topic of power leads me to an aside that I cannot help mentioning, given its salience to the differences in the way that ancient historians and modern historians go about their craft. The ancient historian suffers from a dearth of resources, whereas the modern historian suffers from an excess. Various authors of these essays have expressed a desire to know more. They have wished, if not in explicit terms, for the kinds of sources that would allow them to know just what the people they are writing about *thought* about the situations they were experiencing. What did farmers *feel* when the state forced them to relinquish the products of their labor in order to feed the emperor's soldiers, occupying far distant lands? Did they meet this situation with anger, resignation, or respond with some other emotion we cannot even conjure up, from a distance of two thousand odd years? The study of ancient history requires a degree of historical imagination that the historian of the modern is rarely – if ever – forced to muster, given the plethora of materials (sometimes too many) available on so many topics. We can know the anguish with which Southern tenant farmers faced the loss of their land, and the frustration and anger they felt when confronting a recalcitrant state. We can only wish to know the inner conversations of the Roman slave, working another man's land, or the itinerant, Punic-speaking laborer, in a land ruled by the Latin-speaking.

As I mulled over this set of essays, another topic struck me forcefully, and that topic is usefulness. Agricultural history seems, in many ways, to be a peculiarly useful subject, whether in its ancient or modern form. At its most basic level, it tells us how people have done the most essential of all human tasks, feeding themselves and others. Writing a recent review of the historiography of American agriculture, I was impressed by the degree to which much of the first and second generations of agricultural historians were not writing from a distant and theoretical understanding of the craft. They had grown up tending cows and chickens, and walking behind horse-drawn plows or riding tractors. They had an intimate understanding of their chosen field of study. Their detailed descriptions of an agricultural world and processes now long gone satisfy the curiosity of city-raised and relatively clueless historians (I count myself in this group), while filling in the blanks for museum professionals who have inherited collections of centuries' old implements that leave everything to the interpreter's imagination (Reid 2017). They also provide us with important information about how, under often adverse conditions and with very few resources, families and communities fed themselves for generations. The same type of information is embedded in these narratives of ancient agriculture. As Michael Decker noted in his discussion of late Antique farming, these are not just stories about the distant past, but information with possible present utility. These ancient farmers produced surpluses in spite of significant environmental stress, a fact that suggests that their techniques "offer sustainable possibilities and could be studied in order to be adapted to present-day circumstances." They tended ancient and long-lost varieties of crops, the DNA of which might be recovered in the interest of deepening the genetic pool of the foods we eat. In other words, the ancient agricultural past is not just history, but also potentially useful information that could be used to address modern crises in agriculture.

Scholars are beginning to discuss the ways in which the work of agricultural historians is applicable to the problems of the early twenty-first century. In September of 2017, Olivier De Schutter, a Belgian legal scholar specializing in economic and social rights and former United Nations Special Rapporteur on the right to food, provided the keynote address at the European Rural Historical Organisation meeting in Leuven, Belgium. His talk, "Memories of Hunger," detailed among other subjects the problematic relationship between economic development, agricultural change, and the export of Western agricultural technology and systems throughout the world. Among the consequences of the green revolution, De Schutter noted, has been an increase in the size and capital intensity of agriculture around the globe, to the detriment of many of the small farmers who lacked the resources to compete in that kind of a market. The legacies of the Green Revolution include an increase in rural to urban migration, and a resulting "planet of slums" (De Schutter 2017).

We also live in a world that is environmentally stressed, and that stress is pushing farmers to the brink. One of the most painful examples of this is the Indian state of Maharashtra, where a severe drought has forced farmers to drastically change the way in which they farm. Farmers who once raised sugarcane have been required to find alternatives because of the very high water demands of that crop. Many now raise cotton, a somewhat more drought-resistant crop, but cannot raise enough to pay their debts, given low yields. The despair is palpable. In 2015, as many as 3228 farmers in this state committed suicide, faced with debt and crop failures. Those left behind will have no choice but to adapt, changing their choice of crop yet again, but most are uncertain how to do so. Their options are grim: adapt, but with insufficient resources; migrate to cities that are already overpopulated; or join those who have made the most drastic responses to their suffering (McCarthy 2016).

In the face of developments like these, historical knowledge of alternatives and the ways of the past remain particularly salient, whether those were the ways of ancient Egyptian tillers or nineteenth-century yeoman farmers in North America. Given situations such as that in Maharashtra, De Schutter argued that it was incumbent upon historians to help to shape the future. The "task of rural historians," he argued, was to address the problem of food insecurity around the globe with the tools provided by historical understanding. "There is no script. The fight against hunger is a political matter … Each context is specific, calling for flexibility and warning against ideology." His address was a challenge, and he concluded with what he called "The Historian's Herodotus oath," which began with these words: "What happened in the past can inspire our actions in the future without restricting them." While there are no guarantees that historical knowledge will provide any sort of direct aid to suffering people in economically or environmentally stressed communities, the possibility remains, and so should drive historians to encourage policy makers to interrogate the past, both distant and recent, when grappling with the questions of the present.

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