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PREHISTORIC DESERT FARMERS OF THE SOUTHWEST

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INTRODUCTION

The fact and intensity of their commitment to agriculture is a foremost characteristic that distinguished the prehistoric farmers of the Greater Southwest (82) from their contemporaries to the east, north, and west. As the ultimate members of a continuum of agricultural peoples stretching north from Mesoamerica, pottery-making cultivators in the southwestern United States and adjacent northwestern Mexico (see Figure 1) formed an agricultural peninsula with constantly shifting boundaries among North American groups who were predominantly hunters and gatherers. To understand the environmental context and social role of agriculture, then, is to understand the most essential factors that differentiated the Southwest as a culture area and distinctively shaped the lifeways of its inhabitants. This review explores recent advances in the effort to understand the relationship between society and agriculture in southwestern archaeology.

To those whose perceptions are conditioned by temperate climates and technology of the industrial era, the original occupants of arid southwestern basins, plateaus, and mountains faced daunting challenges to an agricultural lifestyle. Concepts concerning agricultural marginality have played a central role in the study of societal forms and dynamics, as can be seen in current analytical approaches and interpretive frameworks favored by southwestern archaeologists. As Kohler observes (85), "the effectiveness of various ecologi-

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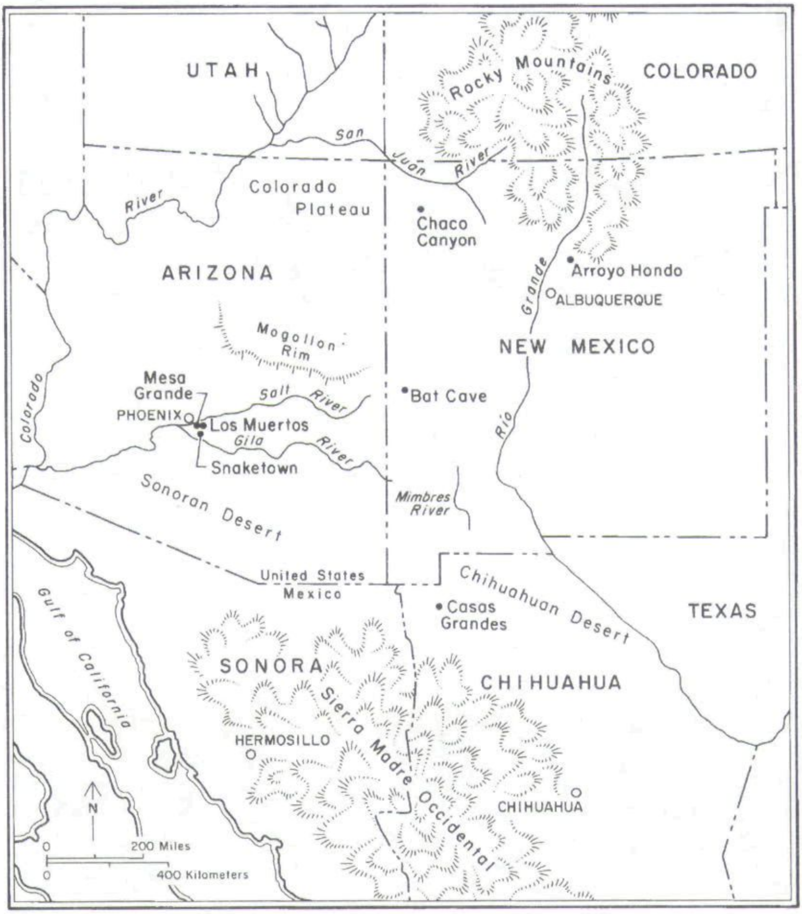

Figure 1 The southwest region with important geographical and archaeological terms used in the text.

cal approaches for understanding culture change in these environments (which, on a large scale of comparison, are marginal for agriculture and sensitive to climatically induced change and human impact) has allowed these positions to remain more dominant than they are, for example, in Europe."

FIRST FARMERS

New findings about initial transitions to agriculture have led to dramatic reformulations of southwestern culture history. An erroneous age of 5000 years for corn at Bat Cave in west-central New Mexico created the impression that there had been a lapse of 3000 years before cultigens began to support instances of village life and farming economies. Agricultural marginality was implicated in the apparent delay between the appearance of cultigens and visible effects on regional societies. Proposed deterrents to an immediate impact included low yielding types of early corn, the lack of varieties adapted to conditions outside the presumed locale of entry in the relatively cool and moist Mogollon highlands, and the mobility of populations in the Late Archaic period between approximately 2000 B.C. and A.D. 1 (68, 107). According to Wills (173), Late Archaic planting was pursued despite very modest returns because small, predictable harvests allowed activities that in turn improved foraging success.

Re-dating of the earliest Mesoamerican corn from the Tehuacan Valley (95) within a few centuries of the original dates from Bat Cave reveals a new timing of northward transmittal. However, skepticism regarding the existing set of earliest southwestern corn dates (9), and the re-study of Bat Cave (173) had already laid the groundwork for revised models of the southwestern transition. A proliferation of evidence for Late Archaic cultigens has provided further impetus for currently changing ideas.

Late Archaic Cultivators

The widespread distribution of Late Archaic farmers in the Southwest is now supported by the recovery of corn in unexpected locations (e.g. 34, 44, 145, 172) as well as through focused Archaic investigations (e.g. 76, 146, 163) and comprehensive regional sampling (e.g. 64:109–113, 99, 147). Site types yielding these materials range from isolated features to rock shelters to small pithouse villages with substantial middens and numerous burials. Early dates on corn at about 3000 B.P. occur in widely separated locales in the Mogollon highlands, Sonoran and Chihuahuan desert basins, and the Colorado plateaus (176). The early corn is usually described, if at all, as resembling modern Chapalote, although a second variety has been reported in one case (163).

One of the largest and most coherent bodies of information pertaining to Late Archaic farmers comes from the Tucson Basin and adjoining areas in southeastern Arizona (48, 76, 176). Extensive excavations over the last ten years have documented cultigens dated between 3000 and 2000 B.P. at more than fifteen widespread locations. In well studied village sites among these, flotation analyses reveal a ubiquity of corn in the range of later Hohokam settlements (76), and settlement patterns also appear to parallel those of ceramic times (48).

Based on evidence for a pre-ceramic Basketmaker II reliance on crops and close stylistic similarities in projectile points and a few other elements of material culture with Late Archaic manifestations in southern Arizona, Matson (98, see also 9) favors a northward migration of southern cultivators to the

Colorado plateaus. His model posits an initial suitability of the low elevation desert basins for the biological requisites of corn and farming techniques originating in Mexico, followed by a further transmission after the development of adaptations to northern conditions. Equally early dates for corn of similar morphology in a variety of southwestern locations and environments (see 76, 146, 147, 163, 173) brings this scheme into question, however.

Alternative models for the adoption of cultigens, emphasizing evidence from other southwestern regions, feature longer periods of minor incorporation into primarily foraging orientations (e.g. 110, 145, 146, 173). The degree of dietary reliance and commitment to agriculture are difficult to determine even with the fuller record of ceramic times, but secure storage of seed in addition to consumable supplies is mandatory at any level of cropping. Pre-ceramic technology for storage in the form of large, often bell-shaped pits is common at sites yielding cultigens, both with and without indications of extended residence (e.g. 76, 98, 145, 146, 173).

It is doubtful that any single model of transition will prove adequate, given the environmental and probable Archaic cultural diversity of the Southwest. Indeed, the historic period, harboring contemporary groups whose practices ranged from mobile foraging to intensive irrigation, is a reminder that the transition was never geographically uniform, completed, or irreversible. The notably low visibility of Late Archaic populations before the appearance of cultigens and the virtual absence of knowledge about their modes of subsistence are major obstacles to reconstructing processes and rates of incorporation. The influence of cultigen donor groups is also unknown in the absence of archaeological investigations in northern Mexico for the period when domesticates first appeared in the Southwest.

The recent demonstration of extensive manipulation and unequivocal cultivation of local species in the eastern United States long before the advent of Mesoamerican crops (148) should serve as a caution against the automatic assumption that a residentially mobile seasonal round of hunting and gathering constituted the sole Late Archaic strategy throughout the west. Ethnographically recorded practices provide possible analogs for similar, pre-agricultural interventions to increase the yields from wild plants. Groups on the southwestern fringes such as the Paiute, Cahuilla, and Washoe used a variety of techniques for sowing, transplanting, tending, irrigating, and otherwise heightening the productivity and predictability of native species (e.g. 6, 38, 144, 151). A few sites with pit house structures (e.g. 122) predate the known entry of Mesoamerican cultigens by many centuries, and village settlements in southern Arizona are approximately as old as the oldest well-replicated dates for southwestern corn. Determining the combinations of environmental, demographic, cultural, and economic factors that would have facilitated or inhibited the adoption of farming lifestyles in different sectors of the Southwest (47,

175) and identifying their consequences in the archaeological record are priorities for future research on the transition to agriculture.

Early Ceramic Farmers

Differential rates and mechanisms of cultigen incorporation in Late Archaic times involve many of the same issues of current interest in the archaeology of ensuing ceramic sequences (e.g. the degree of dietary reliance on crops and residential mobility). It is now apparent that residential sites associated with the earliest regional ceramics (by about A.D. 200 to 300) in many parts of the Southwest are not the first farming villages, but this temporal threshold marks a change in the visibility of cultivators and undoubtedly in key aspects of behavior other than pottery use. For the first time, data are sufficient to address effectively the relationships between organization and subsistence. However, as with Late Archaic methods of agriculture, the technologies that supported these settlements are still inferred exclusively from locational correlates. In terms of developmental timespans, the interval between the earliest record of dietary importance for cultigens (e.g. as early as 800 B.C. in southern Arizona) and the appearance of pottery in the same southwestern region is almost as long as the ensuing ceramic sequence.

Estimates of agricultural commitment figure prominently in interpretations of cultural variability in Basketmaker and earliest Mogollon sequences. Both weak and strong commitments are suggested on the basis of site types and the distribution of cultigen remains within settlement patterns (64, 145, 147), organization of architecture and storage (128:185, 174:173), groundstone attributes (66), and the regional availability of natural resources (9, 55, 98, 146, 177). A limited number of studies that attempt quantitative assessment of subsistence for the Four Corners area (the intersection of Arizona, New Mexico, Utah, and Colorado) show high proportions of cultigens (e.g. 31, 99, 109).

Many archaeologists see an increase in regional differentiation across the upland Southwest within several hundred years of the earliest plain ceramics, although prior to the adoption of pottery, broad Basketmaker II divisions are also defined on nonceramic stylistic grounds (e.g. 98, 165). More geographically limited stylistic zones are linked to a decreasing scale of routine interaction and to the adoption of designs that signal social identities (14, 128:189), processes stemming from increasing sedentism and territorial delimitation among agriculturalists.

A more unified pattern emerges for Hohokam and nearby portions of the southern Southwest during early ceramic times. A widespread horizon of brownwares similar to initial northern and eastern ceramics has been identified recently as preceding decorated styles (e.g. 18, 40, 77, 93). Analyses of subsistence remains for most well-sampled early ceramic occupations reveal almost every cultigen in quantities comparable to representation in later prehistoric times (e.g. 8, 20, 49, 65). The array of settlement locations strongly suggests a variety of surface runoff, floodwater, and irrigation strategies, and large Phoenix canals can be dated as early as A.D. 450 (2). Although these findings indicate that sedentism and agricultural commitment should have been relatively strong and pervasive in the southern Southwest, regional differentiation in early decorated ceramics and architectural styles has not been as readily distinguished as it has been in the north.

ENVIRONMENT, AGRICULTURE, AND CULTURE CHANGE

Environmental variables critical for agricultural success are regionally and topographically diverse. Separate weather systems produce winter dominant precipitation to the west and summer dominant moisture to the east. The timing of adequate rainfall is balanced against spring and fall frosts at upper elevations and withering summer heat in low basins. Average precipitation ranges from barely sufficient amounts for rain-fed farming at upper elevations in some regions to several orders of magnitude less than is necessary for direct rainfall agriculture in the hottest, driest sectors. All regions are subject to significant seasonal and annual variability. The consequences of marginality, a unifying theme throughout southwestern archaeology, are most commonly conceptualized as a dependent relationship between culture change and climatic trends of regional or subregional extent.

Response to Climate

The ability to rigorously examine climate and, in the broader sense, environment as a causal force in southwestern prehistory is largely attributable to the quantity and precision of combined climatic and chronological information from tree-ring studies. Plog (128:194) notes that when this information is compared to temporally coarser reconstructions of culture history, it will always be possible to find climatic fluctuations that are roughly contemporaneous with episodes of culture change. Although a response to climate is one of the most common explanations for cultural change in the southwestern archaeological literature, an explicit or well-supported linking argument is not always supplied.

Archaeologists of the upland Southwest have also produced highly refined and sophisticated treatments of relationships between environment and culture, as reflected in the exigencies of arid land farming. A series of multidisciplinary studies of the western Anasazi in northeastern Arizona is a prime example (29, 63, 64). Environmental processes are analyzed in terms of low frequency (periodicities of more than 25 years or one generation) and high frequency (periodicities less than 25 years) categories that are meaningful in terms of human perception and response. A long-term developmental scheme for the region is developed through correlations between multiple measures of environment and changing cultural patterns (summarized in 41, 64). A plausible and painstakingly documented connection is formulated between climatic events, corresponding hydrological and geomorphological effects on agricultural locations and production, and the implications for settlement and other societal patterns. A second set of exemplary multidisciplinary studies used a similar framework of low and high frequency periodicity with tree-ring and pollen data for the Anasazi of the Mesa Verde region in the Four Corners area. Investigators examined linkages among the movements of farmers, the form of successive dispersed or aggregated settlement patterns at varying scales, and climatic fluctuations in precipitation and temperature (125, 141). Values for intermediary variables such as agricultural yields, costs, and surpluses were also considered in determining whether aggregation, complexity, conflict, or other societal processes tended to occur in conjunction with particular kinds of climatic trends (16, 124).

Two recent versions of the developmental trajectory for Chaco Canyon in northwestern New Mexico illustrate the point that the juxtaposition of precise climatic measures and intensively studied archaeological remains does not guarantee consensus on the manner in which agricultural response to climate operated as a contributing factor. R. Vivian (165) sees an expansion of agriculturally-based settlements by the aggregated builders of great houses within the Chacoan core and then outward during favorable climatic episodes, thus accounting for their culturally distinctive sites connected by roads among surrounding dispersed populations of different origin. Deteriorating conditions later forced the carriers of the great house tradition from the core and truncated development there. In L. Sebastian's (142) reconstruction, early great houses are associated with favored agricultural locations near Chaco side canyons at a time when corn production would have been low elsewhere. When climate and productivity improved, now-established leaders in the canyon controlled greater surpluses with which they underwrote competitive construction, both internally and among more distant client groups. A final climatic downturn again figures in the ultimate collapse outward from Chaco Canyon.

The ability to evaluate climatic influence in the low southern deserts by methods other than long-range projection (e.g. 97:215, 216; 167) is constrained by the rarity in structures of conifer beams suitable for tree-ring analysis. Graybill overcame this limitation in a pioneering interpolation with explicit consequences for the study of Hohokam irrigators in the Phoenix Basin (59). Using modern calibrations, he reconstructed annual streamflow, including disruptive floods, from tree-ring records in the upland watersheds of the Salt and Gila Rivers that flow into the deserts. Archaeologists have also applied this reconstruction in the Tonto Basin, another region supplied by the Salt River system (5, 22:27).

Two floods of maximal scale coincided with an earlier interval of significant culture change in the Hohokam sequence near A.D. 900 and a subsequent interval of transition between early and late divisions of the Classic period, respectively (59). Erosion following the later flood may have precluded repairs of canal intakes in a locality where several lines headed (61:184–186), although canals headed there again historically. The timing of this second flood at A.D. 1358 and the presumed agricultural crisis that it generated fits what some scholars see as the approximate onset of collapse of the first Classic peak in organizational complexity. This catastrophic flood fed by winter precipitation might be implicated in downturns in Phoenix or Tonto Basin trajectories. The summer rainfall critical for agriculture along the hydrologically dissimilar Hohokam drainages to the south, however, varied little during the same years (60:12). Thus, the same climatic phenomenon cannot be directly invoked to account for generally synchronous expressions of cultural trend in these parts of the Hohokam tradition that would not experience flooding or be affected agriculturally in an equivalent manner.

Calculation and Quantification of Agricultural Variables

Climatic data in combination with other factors influencing agricultural production and consumption provide a means for deriving measures of variables immediately affecting human behavior. In a pioneering example of such quantification, Wetterstrom (168) considered climatic fluctuations, amounts of arable land and crop harvests, yields from wild plants and animals, and satisfaction of nutritional requirements in her investigation of demographic and subsistence stress at Arroyo Hondo in north-central New Mexico. Other studies in the Four Corners area build upon annual climate and yields from carefully specified acreage to reconstruct storage values, capacities for population support in relation to demographic change, and the interplay between risks, costs, and production in land-extensive agricultural systems (16, 87, 164). Hegmon (70) drew upon coordinated historic values for Hopi climate, fields, and yields to simulate different patterns of household sharing and the implications of these patterns for optimal organization and behavior in counteracting agricultural risks.

AGRICULTURAL LANDSCAPES

Non-climatic elements figure in the basic relationships between environment and agriculture that underlie the broadest southwestern cultural divisions. A dichotomy can be drawn between plateaus of the north and southern desert basins, a contrast that holds to a lesser degree between upper and lower elevation landforms throughout. Higher upland precipitation and greater numbers of mountain-fed drainages in the north, coupled with relatively widespread domestic water sources, imparted greater flexibility in field location. Where agriculture was supplied by direct rainfall or clear mountain streams, fertility sometimes may have declined with continued use (140), but cultivation required minor ancillary effort. Settlements could be readily relocated, a factor in land tenure and territoriality. Farming locations in the low deserts of the south, on the other hand, were more restricted by the scarcity of seasonally prolonged domestic water and situations that insured supplemental moisture for fields. Structural improvements for water delivery required investment by cultivators, after which plentiful suspended nutrients in soil-laden flows repetitively renewed the fields (113). Options and agricultural inducements for relocation were correspondingly few.

Resource Depletion

North-south contrasts for prehistoric agriculturalists are reflected in the analytical interests of regional archaeologists. The issue of depletion of critical resources has drawn most attention in the upland Southwest. Retrodicted magnitudes of decline in soil fertility (e.g. 7, 126, 140) remain problematic without supporting observations of decline in different soil types under indigenous cultivation techniques (see 100:258, 86:539 for evidence suggesting persistent fertility); likewise, swidden-like practices in response to this problem (86, 100, 152, 155) are plausible but as yet unconfirmed through archaeological indications such as lenses or pockets of ash in prehistoric fields. Most quantified studies of depletion focus on natural resources consumed by cultivators over time, based on species composition and relative quantities of biological remains and estimated use rates, rather than on the exhaustion of an area by farming per se.

The reduction of woody growth for fuel and construction has been examined on various scales with regard to limits on residential duration, increased costs of supply, and alternative uses. Changes in charcoal of more and less desirable fuel species indicate a resort to alternative trees and woody shrubs over the course of occupations in a number of disparate locales (e.g. 86, 106). Fuel depletion may have been a factor in sequential short-term occupations where cold temperatures created high demands and where alternative arable locations were still plentiful relative to farmers. Simultaneous depletion of pinyon nut sources in these same situations was serious for subsistence systems that depended on substantial increments from gathering (52). In the long-term and densely settled occupation of Chaco Canyon, inhabitants appear to have decimated trees on a regional scale (139) and ultimately recycled structural timbers for fuel (178). Certainly, substantial distances had to be traversed to acquire the many timbers in the unusually elaborate Chacoan edifices (10) and in most similar examples of massive communal constructions elsewhere in the Southwest. Localized depletion of particular kinds of trees probably also resulted from timber consumption in settlement patterns composed of more ordinary modes of Puebloan ceremonial and residential architecture (73).

The extermination of game in the vicinity of agricultural settlements is one form of depletion registered in faunal analyses of both upland plateaus and desert basins. Earlier proportions of large mammals, often deer, gave way to smaller species commonly dominated by rabbits (78, 123, 143, 152, 157). A shift to animals favoring open habitats and secondary vegetation is also a common finding (120, 152, 157) after natural vegetation was progressively cleared. Even farmers in settlements with great time depth may have achieved some degree of compensation in their overall protein supply by the convenient hunting of animals attracted to fields and the other anthropogenic habitats of agrarian landscapes.

Mechanisms for Balance and Sustainability

If recent publications on southwestern archaeology are indicative, it is easier to investigate and reconstruct the mechanisms through which prehistoric agriculturalists depleted their environments than those through which they maintained balances permitting residential stability. Natural resource pressure was undoubtedly greatest in instances of aggregated and persistent settlement patterns in the northern Southwest and in a broader variety of enduring southern occupations tied to circumscribed water sources and investments in delivery structures. However, depletion of soils, native plants, and animals is but one aspect of the culturally modified environments created by prehistoric southwestern farmers.

In an influential articulation of the holistic effects of farming in early agricultural occupations, Ford (55) noted that resource predictability and available edible biomass were enhanced in agricultural contexts through the cumulative productivity of crops, weedy plants, and game drawn to fields. The proliferation and subsistence contribution of successional species is now often treated as a separate interpretive category in archaeobotanical analyses. Carbonized seeds and pollen reveal rich weedy floras in agricultural environs that included abundant resource species (e.g 7, 51, 55, 58, 105, 168:55–60). In seasons lacking sufficient precipitation for successful crops, these hardier southwestern native taxa may have provided the major returns from cultivated land. The management of anthropogenic environments toward greater productivity represents an ancillary subsistence strategy, and probably included an enhanced diversity of harvestable flora and fauna in hedgerows, along canals, and in other differentiated habitats of cultivated landscapes (e.g. 114, 133, 134, 143).

The ethnographic literature of the Greater Southwest records a variety of behaviors aimed at guaranteeing or augmenting densities of resource species in anthropogenic vegetation (e.g. 17, 23, 53:190, 170). Morphological attributes believed to be associated with human selection or manipulation and anomalous archaeological distributions (summaries in 13, 51) suggest active intervention, transplantation, and even cultivation of nondomesticates (e.g. cholla and little barley) that were not formerly thought to be potential cultigens. A significant breakthrough of this sort is the compilation of evidence for agave as a cultigen among the Hohokam and its subsequent documentation as a major crop in southern Arizona (50, 51, 56).

Compensation for some aspects of depletion or scarcity involved long distance solutions. Aquisition methods may be uncertain, as in the case of fuel consumed in firing the impressive quantities of Hohokam pottery at Snaketown (69:192), a relatively large site occupied continuously for more than 700 years in an environment with sparse and highly localized trees. In other cases, as with the timbers in Chacoan edifices and large Hohokam adobe structures, aggregated agriculturalists clearly bore the transport costs of obtaining distant supplies. Other examples of organizational solutions and attendant costs include episodic communal hunting of large game that was depleted in the vicinity of farming settlements (149), regular trade with hunters and gatherers as in eastern Pueblos-Plains exchange (150), and the possible existence of extractive specialists.

MOBILITY, SEDENTISM, AND COMMITMENT

Sedentism, mobility, and agricultural commitment are important, interrelated issues in current southwestern archaeology. Perhaps one of the most important outcomes of re-examining assumptions about these topics is a heightened awareness of the range of potential patterns and combinations of relevant variables. Villages may have been permanent over many years, occupied year-round for a few years, occupied seasonally, reoccupied at intervals in either of the two preceding cases, or may have encompassed different mobility patterns among member households (81, 86, 100, 115).

The manner in which southwestern scholars interpret the duration of residential settlements and reliance on agriculture is undergoing scrutiny. Most archaeologists have advanced arguments in terms of features, structure types, or diversity in residential architecture (e.g. 32, 57, 103, 129, 174), and artifact attributes and assemblages (e.g. 66, 112, 117, 118), rather than by prehistoric evidence for agricultural activities or products. Explicit expectations for distributions or proportions of subsistence remains and their identification in the archaeological record have played a relatively minor part in these discussions.

Agricultural variables and farming behavior enter the equation primarily through ethnographic analogy. The western Apache and a few other comparatively mobile groups such as the Navajo and Tohono O'odham furnish the models for subsistence practices of prehistoric groups with high mobility and low commitment to agriculture (e.g. 18; 88; 110:130–132; 173). In addition to animal transport, herding, armed warfare, and other post-contact factors in mobility options, these southwestern groups maintained strong economic ties with committed neighboring farmers, regularly exchanging for agricultural products and replenishing vital seed after episodes of lapsed planting or crop failure. Thus, these analogies may be misleading unless qualified by similar prehistoric interdependencies. Models featuring mobility during the growing season are also questionable where immediate manipulation of fleeting storm runoff, diversion of channelized flow, or irrigation was critical to crop success.

Interpretations emphasizing appreciable mobility and low commitment tend to be correlated with cases involving little or no archaeological evidence for agricultural locations and techniques. It is probably no coincidence that greater potential for mobility is disproportionately associated with rain-fed cropping and a lack of investment in durable constructions. Earlier records of agricultural features in the southern Southwest support the previously discussed environmental inducements for settlement stability among low basin farmers. Moreover, proposed archaeological signatures for mobility and low commitment such as pithouse residence cannot necessarily be extended to the intensive farmers of the Hohokam tradition, as illustrated by the co-occurrence of pithouses and massive canals used for hundreds of years.

As with most topics in archaeology, a consideration of scale provides alternative perspectives on relationships between agriculture and residential duration. For example, house clusters of Hohokam floodwater farmers might come and go with changes in hydrological processes on individual alluvial fans, while settlement was continuous across the larger topographic zone composed of these landforms. Phase to phase continuity in residence and farming for up to 600 years on an optimal alluvial fan and for more than 1500 years at a zonal scale (from Late Archaic to late ceramic times) can be documented in Hohokam basins (49). In southwestern Colorado prior to A.D. 1000, rain-fed cultivators with land-extensive practices occupied small settlements briefly while slowly regenerating resources were consumed. They resettled successively until entire locales were abandoned. On an expanded temporal and spatial scale, however, these systems were sustained over a prolonged period as this kind of land-use cycled through successive locales across a larger regional segment (83:241).

Wide variability in mobility and agricultural dependence is a characteristic of southwestern agriculturalists at any point in time. In an insightful study of the Tarahumara, Hard & Merrill (67) describe differential residential movement among households in the same settlement, reflecting individual responses to social and economic factors. Simultaneous variation among ethnic groups is illustrated dramatically in the historic period when economic orientations ranged from mobile foraging to fully sedentary and intensive cultivation, often within the same region. Degrees of mobility and agricultural commitment were clearly reversible among historic populations, and some archaeologists see reversals periodically and at regional scales in the past (127, 154, 162). Seasonal and year-round occupations at contemporary small Pueblo II Anasazi sites (81) typify the prehistoric diversity in synchronous patterns that archaeologists are more likely to recognize as the result of recent attention.

FOOD STRESSES AND HEALTH

Food stress resulting from agricultural failure or an imbalance between population and productive limits, particularly under conditions of aggregation and intensification, is an important topic. Although the detection of stress has been the focus of much research (12, 108, 123, 168), unequivocal and replicable criteria for demonstrating its occurrence have seldom been sought through the quantified study of botanical and faunal remains alone. Conclusions from recent, regionally diverse human skeletal studies involving bone chemistry, pathologies, developmental deficiencies, and demographic indices have emphasized dietary stress and low levels of health in the most densely settled areas of the Southwest (e.g. 96, 104, 116, 153). Better nutrition and longer life expectancy among limited social groups at Chaco Canyon and Casas Grandes in northern Chihuahua suggest differential access to food, but such indications are rare in studies of human biology (116). A comprehensive examination of health and nutrition among worldwide Neolithic populations in temperate and tropical as well as arid environments is needed to determine the uniqueness or comparative significance of southwestern dietary stress.

SCALES OF ANALYSIS

Studies at different cultural and geographic scales reveal different facets of the relationship between agriculture and society. Cumulative effects of variables and processes at smaller scales may be inadequate to account for more widespread social responses. Common micro-, meso-, and macro-scales of analysis in southwestern archaeology focus on individual settlements and their components, interrelated settlements in a region, and associated sets of regionally interlinked settlements.

Micro-scale Studies

Southwestern archaeologists have devoted appreciable effort to defining the households or groupings of households that compose individual settlements. In most parts of the Southwest, these are the basic units in what is seen as a modular series. Criteria for discriminating social units involve the function and orientation of rooms and structures and the distribution of shared facilities. Modules of Anasazi and Mogollon affiliation include a structure with communal functions, the kiva, within most multiple household units; the Hohokam lack an equivalent feature. Successively inclusive combinations are often identified as the building blocks of even the largest sites. Village modules are primary objects of investigation for questions concerning social organization and the production and consumption of durable items, but only occasionally are they analyzed in terms of farming requisites and strategies.

With a few exceptions, the occurrence of isolated structures in settlement patterns is attributed to seasonal fieldside residence (e.g. 166). Several authors (84, 131, 156) view these field houses as establishing claims on prime land in addition to reducing travel time to fields distant from a home village. Preucel (130, 131) associates the appearance and proliferation of field houses with population growth and agricultural intensification. Kohler (84:625, 626) outlines linkages with longer term occupations, formalized systems of inheritance, a corresponding potential for inequality in productive access, and heightened agricultural risk in situations of intensified land use. Ownership under intensive practice is illustrated by the apparently contemporary, regular spacing of ephemeral field houses along the canals in a small central Arizona system (42). This example suggests that field houses may have also been convenient residences for timely distribution of water and for assuring fair allotments in irrigation.

A few authors relate household size and composition to agricultural concerns. The appearance of integrated Hohokam households, indicated by groups of structures sharing courtyards, has been correlated with the rise of corporate groups in response to the cooperative demands of irrigated agriculture (71:124–127). The ability of the head of such a household to successfully schedule its labor would add to household size, cohesion, and prestige through the generation of socially manipulable surplus (35). Greater household size in turn increases the possibility for simultaneous tasks and would be beneficial in diversified productive systems. Environmental uncertainty is another proposed factor in large household size because greater risks would inhibit the establishment of independent new households.

Wills' (175) conclusion that production shifted from a communal mode to a household mode during early ceramic times is based on the contrast between publicly visible storage facilities at an earlier Chaco Canyon pithouse village, and storage within structures at a somewhat later village in the Mogollon Highlands. This proposed change to a household mode occurred in conjunction with increasing sedentism and a risk-prone strategy of temporally focused subsistence production, including wild resources and crops, in relatively favorable environments. Hegmon (70) examines the effects of resource sharing and agricultural risk in her simulation of pooling among Hopi households. Heightened survival rates through limited sharing of surplus defined an optimal pooling group of about five households under modern conditions of fluctuation in annual climate and observed field production.

Current attempts to investigate prehistoric land rights coincide with reevaluations of corporate control as the overriding principle in post-contact Puebloan access to productive land (e.g. 90, 169). Furthermore, rules varied historically, as in the different use rights for favorable locales of long-term farming at Zuni and unclaimed land at a distance (27). Reconstructions of corporate tenure have been extended to the Hohokam (e.g. 71), although Piman successors gained access to irrigated land through participation in the original construction of canals rather than through kinship status (19:126, 127; 138:88). Household control of land, intensive practices, and investment in farming improvements tend to be correlated (119). Even in the extensive floodwater systems of northern Sonora, cultivators incrementally established and improved large series of contiguous fields over time (36).

Many researchers see a connection between agricultural conditions and the number of households or multi-household units in a single settlement. The most common and straightforward example is an increase in the number of units per settlement following an environmental deterioration that reduces the overall availability of farmable land (21). This process is the most frequent explanation for late prehistoric aggregation across the Southwest. Variations on the theme include an accretion of units into larger settlements to avoid conflicts over agricultural land that might arise among dispersed populations (124) and the emergence within sites of larger co-residential, land-holding units in tandem with agricultural intensification and greater potential for resource imbalance (4). An alternative relationship between aggregation or settlement size and agriculture is the simple coincidence of larger sites with large expanses of optimal farm land (160).

Meso-scale Studies

The term *community* is often used in southwestern archaeology to denote a configuration of interrelated settlements that includes a central site containing the most elaborated communal architecture and a series of other, usually smaller sites. Such multi-site communites are subjects of meso-scale analysis. Agricultural topics figure broadly in discussions of community form and function, but they are most fully explored in the literature dealing with the Hohokam and Chaco Canyon.

The community concept is particularly prominent in Hohokam archaeology because the well-mapped canal networks along the Salt and Gila Rivers graphically define sets of interconnected sites and simultaneously provide a rationale for cooperation and coordination (39). A single central site with associated lesser settlements occurs along smaller networks, while several such community units occur along larger ones. The fairly regular spacing of central sites and communities along canals and central tendencies in community size and amount of irrigable land probably reflect magnitudes attuned to regular communication concerning irrigation, labor mobilization, and transport of agricultural products (24:155–158; 49:99, 100; 62:383). Integrative mechanisms spanning separate networks after A.D. 1100 have been suggested on the basis of cross cutting canals (121) and the expansion of the total system to the limits of river capacity (75). Communities and sets of communities with primary interconnections ascribed to irrigation are also located in the Tonto Basin (22:29, 30; 180) and possibly in the Mimbres Valley (72) and the southern Tucson Basin (35, 49:101).

Even in the core area of large-scale riverine irrigation, Hohokam communities integrated ancillary environmental zones with different productive potential and agricultural technologies (e.g. 24, 74, 111). Zonally differentiated land-use, however, was at the heart of the territorial and productive organization of Hohokam communities away from the perennial Salt and Gila Rivers. In Hohokam communities elsewhere, canals were constructed along favorable stretches of the intermittent or ephemeral watercourses, but technological mixes in a single community could also include floodwater diversion on alluvial fans, rockpile complexes (stone features supplied by surface runoff) on mid-basin slopes, checkdams, and contour terraces on upper slopes, bottomland farming in large arroyos, and hillside masonry terraces (49). Productive specialization is most clearly illustrated by the localized distribution of rockpile complexes producing agave. The size of the zonally extensive Hohokam communities, up to 150 sq km, was several times the average size of individual Salt and Gila communities with massive irrigation (49:99).

Communities and their environmentally and technologically differentiated territories have been defined in widely separated sectors of the Southwest, including the San Juan Basin in northwestern New Mexico (15), the Casas Grandes region of northern Chihuahua (33), and the Tonto Basin of eastern Arizona (136, 180). Descriptions of such productively diversified entities will be refined and the roster will continue to grow as attention is devoted to recording the impressive variety of prehistoric technologies (45, 97, 101, 179, 181) and specifying their territorial and societal contexts.

Several roles for agriculture are cited with regard to the integrative rationale and structure of productively diversified communities. Reid & Whittlesey (135) observe that differentiated settlement patterns might develop in the absence of overall integration as the result of population growth, when smaller sites are established near limited or marginal acreage following the initial occupation of large sites near prime land. The incorporation and pooling of localized risks is a primary benefit of community organization to the degree that members participate in compensatory exchange. Exchange relationships are likely between sites with complementary patterns of risk (132). Reciprocal elevational and topographic risks are offset where territorial boundaries encompass both settlements near irrigated bottomlands and higher elevation fields; an enlarged labor force is concomitantly achieved for necessarily rapid canal repairs during the agricultural season (1, 94).

Central sites and public architecture are loci of integrative ideologies and processes that foster the circulation of harvests and other subsistence resources among the differentiated sectors of a community in many interpretive schemes. Although not always articulated in detail, these processes are often perceived as involving communal consumption and ritualized exchange among relatively equal social components in the manner of the historic pueblos (3, 11, 54). A major role in the circulation of subsistence goods is also ascribed to central site leaders, particularly in view of evidence for substantial storage and preeminence in other kinds of exchange (e.g. 39, 46, 92, 137). Models highlighting the control of surpluses and their redistribution, including kin-based organizational hierarchies in the manner of a chiefdom (136), are typically associated with Chacoan, Hohokam, and Casas Grandes manifestations that exhibit maximum southwestern complexity.

Macro-scale Studies

Interpretations of the relationship between agriculture and societal organization for Chaco Canyon and its larger regional system span meso- and macro-scales of analysis. The level and significance of subsistence transfer in different schemes reflects differing assessments of whether agricultural production in Chaco Canyon and its surroundings was insufficient for supporting the resident population (80), sufficient during a majority of the occupational interval (165), or at times capable of producing surpluses for exterior expansion and integration (142). Likewise, centralized storage facilities and formal roads enhancing transport might function in the regularized movement of staples (80) or the occasional transfer of emergency supplies to counteract serious agricultural failures (159). Elite exchange and a unifying ideology expressed in the elaborated public architecture of Chacoan centers and outliers maintained connections among these nodes according to various versions of subsistence interdependency (summaries in 26).

Upham (161) formulated a framework for macro-scale subsistence exchange from the clustered distributions of large, fourteenth century western Anasazi pueblos on the southern Colorado Plateau. Average spacing between his clusters converges with the 50 km distance that he identified as the maximum for efficient food transport (91). The 50 km spacing also would have permitted practicable exchange within the clusters. Similar spatial clusterings are suggested to have occurred more widely in the the Southwest (79). The regional system, marked by broadly shared ideology and ceramic and architectural styles that emerged under increasing aggregation and agricultural intensification, represents another model for macro-scale networks of a size sufficient to ameliorate periodic food shortages among members (e.g. 3, 25, 89, 171). Regional inequalities in the environmental potential for agricultural production were the basis for other kinds of subsistence relations between large sectors of prehistoric population. Examples are the exchange of eastern Pueblo crops for Plains buffalo products (150), the exchange of Papaguerian shell for Hohokam crops from the Phoenix Basin (102), and the possible exchange of seasonal agricultural labor by resident Yumans (158:131) for a share of Hohokam irrigated yields in a parallel to historic Tohono O'odham-Pima interchanges.

CONCLUSION: TEMPORAL TRENDS AND TERMINAL SCENARIOS

An integral relationship between regional abandonments and aggregated configurations began to develop before the thirteenth century and then became expressed widely in late prehistoric times. Maps of the Greater Southwest (see Figure 2) illustrate broad-brush patterns of settlement at two successive intervals (43). These distributions contrast with generally uninterrupted occupations across the Southwest at A.D. 1100. Early Pueblo III patterns at approximately A.D. 1275 to 1300 and those of the mid-Pueblo IV period, about A.D. 1400 to 1425, can be compared to locations of historic irrigation in the earliest part of this century, when gravity systems resembling prehistoric technologies were predominant and few dams were in place. A general congruence can be seen between late prehistoric processes of aggregation and irrigable situations (43).

Late prehistoric abandonments have been treated primarily from the point of view of negative climatic conditions (21). However, the timing of agriculturally critical rainfall and other limiting factors are not uniform across southwestern regions and cannot account for all aspects of this phenomenon. By A.D. 1000, agriculturalists were experimenting with denser populations, intensified production, and more integrated territorial units in a few areas such as Chaco Canyon and the Phoenix Basin. Natural or cultural limits that were eventually exceeded may have challenged the stability of aggregated populations in particular times and places. Nevertheless, because organizational modes and structures that facilitated aggregation were cumulative over time, successive entities could build on the organizational innovations and productively intensified techniques of predecessors. Such solutions necessarily included the means to provide the members of increasingly heterogenous populations with access to land and water, to use the expanded labor pool to support

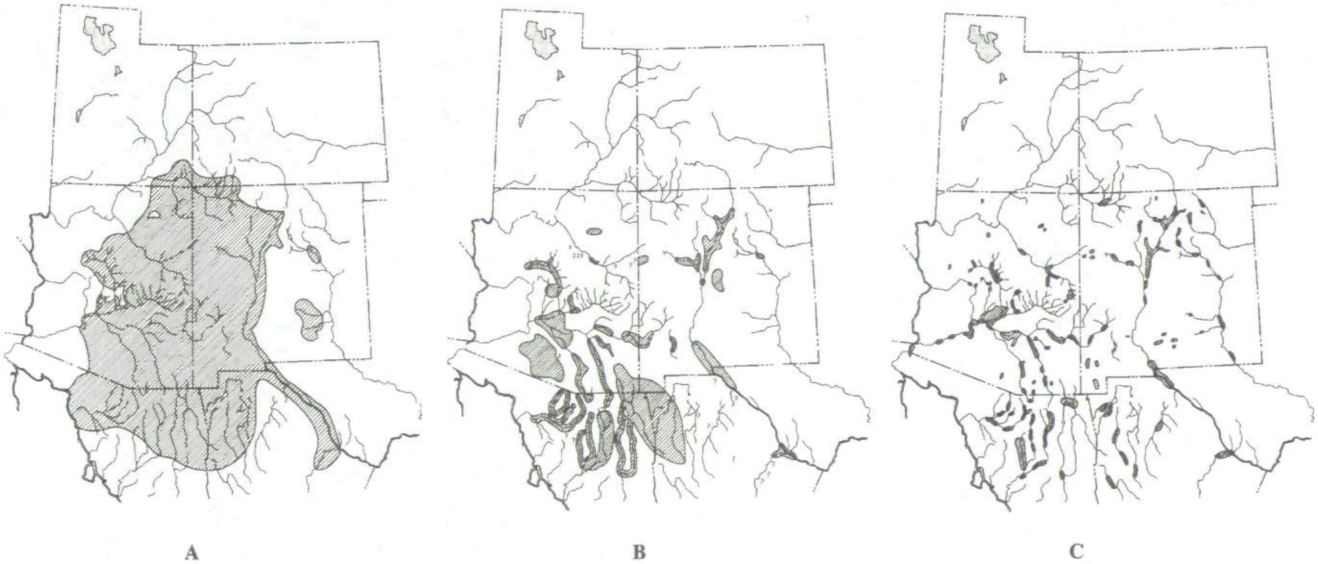

Figure 2 Comparison of prehistoric agricultural occupations during two successive intervals and the distribution of historic gravity irrigation in the Greater Southwest. (Adapted from 43) A. Approximate outlines of southwestern agricultural occupation during the Pueblo III interval between A.D. 1275 and 1300. B. Approximate outlines of southwestern agricultural occupations during the Pueblo IV interval between A.D. 1400 and 1425. C. Distribution of historic gravity irrigation agriculture prior to A.D. 1900.

higher population totals, and to assign and mediate social roles amenable to aggregated modes of interaction.

During the fifteenth century, areas with the densest regional populations, the most interlinked productive technologies, and the strongest evidence for well-integrated territorial configurations (most notably Casas Grandes and sites such as Mesa Grande and Los Muertos in the Phoenix Basin) experienced disruption. However, it is difficult to document end points in these sequences. Recent reanalysis of absolute dates suggests that terminal occupations approaching A.D. 1500 are plausible (28, 30), permitting an increasingly realistic consideration of roles for disease and other vectors of European contact.

The recurrent theme of agricultural marginality plays a central role in scenarios for the terminal era of southwestern prehistory. One polar position advocates absolute environmental constraints on the size and complexity of southwestern societies. A corollary is the notion that the organizational range in the ethnographic record is closely adapted to southwestern limitations, and more hierarchical structures represented inherently unlikely and unsustainable divergences. The opposite view is that European intrusion truncated a still-viable trajectory of cultural evolution that had produced late prehistoric hierarchical societies exceeding the complexity of any found in the historic period.

Concepts of environmental constraint minimally must be tempered for the Hohokam, who constructed more massive irrigation networks than those in Mesoamerica or any other part of North America north of Peru (37). An appreciable if less impressive irrigated core also marks Casas Grandes, another peak of complexity in southwestern cultural expressions. The location of the relatively early Chacoan development in the less hydrologically favored San Juan Basin is instructive by contrast. It is a reminder that, rather than simply being the bearers of a marginal but enduring agrarian tradition, the desert farmers of the Southwest were also the formulators of cultural trajectories that successfully challenged their difficult southwestern environment in accordance with the changing objectives of prehistoric economy and society.

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