Journal of the History of Biology (2011) 44:43–57
DOI 10.1007/s10739-010-9247-3

SPECIAL ISSUE: ENVIRONMENTAL HISTORY

Ancient Deforestation Revisited

J. DONALD HUGHES
Department of History
University of Denver
Denver, CO 80208
USA
E-mail: dhughes@du.edu

Abstract. The image of the classical Mediterranean environment of the Greeks and Romans had a formative influence on the art, literature, and historical perception of modern Europe and America. How closely does is this image congruent with the ancient environment as it in reality existed? In particular, how forested was the ancient Mediterranean world, was there deforestation, and if so, what were its effects? The consensus of historians, geographers, and other scholars from the mid-nineteenth century through the first three quarters of the twentieth century was that human activities had depleted the forests to a major extent and caused severe erosion. My research confirmed this general picture. Since then, revisionist historians have questioned these conclusions, maintaining instead that little environmental damage was done to forests and soils in ancient Greco-Roman times. In a reconsideration of the question, this paper looks at recent scientific work providing proxy evidence for the condition of forests at various times in ancient history. I look at three scientific methodologies, namely anthracology, palynology, and computer modeling. Each of these avenues of research offers support for the concept of forest change, both in abundance and species composition, and episodes of deforestation and erosion, and confirms my earlier work.

Keywords: deforestation, erosion, Mediterranean landscapes, Greco-Roman world, forest history, anthracology, palynology, landscape modeling

Introduction

To visualize the Mediterranean world of the Greeks and Romans, that is, their environment as it was, and as they interacted with it, is a challenge to the intellect and imagination. The classical landscape has exerted a powerful influence on the cultural self-image of Europe and America, and it has been visualized in many ways, but how closely do

Figure 1. Nicolas Poussin, "The Funeral of Phocion," painted in 1648. There are three versions of this painting, one in the Louvre, Paris; one in the Glass House Museum, New Canaan, Connecticut; and one in the National Museum, Cardiff, Wales, on loan from the Earl of Plymouth. This image, which is in the public domain, is taken from the version in the National Museum of Wales

these images resemble the ancient environment as it in fact existed? I tried to answer that question in books published 15 and 30 years ago,[1] and I think it is worth revisiting today, in light of evidence found in the interim, and in response to scholars who have reached conclusions opposed to mine. In particular, I will look at the problem of deforestation. How forested was the Mediterranean world, how much damage was done to forests in classical times, and what effect did deforestation have on ancient societies?

I begin with an image epitomizing the ancient landscape as it appeared in the art of the early modern West, a painting by Nicolas Poussin, "The Funeral of Phocion," painted in 1648[2] (Figure 1).

Phocion was a model Athenian statesman, so the scene is in Attica. Poussin spent most of his working life in Rome and knew the Mediterranean landscape well, if not Greece. This should serve to counter the idea that western European artists were universally unfamiliar with the Mediterranean environment, and when portraying classical themes

[1] Hughes, 1975, 1994.

[2] Nicolas Poussin, "The Funeral of Phocion," painted in 1648. There are three versions of this painting, one in the Louvre, Paris; one in the Glass House Museum, New Canaan, Connecticut; and one in the National Museum, Cardiff, Wales, on loan from the Earl of Plymouth.

presented only idealized settings based on the more northerly landscapes they knew. The image Poussin presents is not wilderness, certainly. Architecture blends pleasantly with topography. Sheep graze in the middle ground, oxen pull a wooden cart, and a horseman rides by. A grove on the left suggests forest, and the landscape is sprinkled with trees. The tree emerging from a ruin on the right has had some branches lopped. This is a humanized landscape, reminding us of Cicero's saying: ''By means of our hands we endeavor to create as it were a second world within the world of nature.''[3] It is a beautiful world where humans inhabit nature, and nature meets human needs.

My research, with observations made during residence in Greece and travels in other Mediterranean countries convinced me that in classical times, harmony with nature was achieved in some cases, but violated in all too many others. Change ruled then as now, and human activities damaged nature, causing deforestation and overgrazing over wide areas, especially near cities and industrial centers. The results included erosion that bled soil down to the sea and impaired agriculture. The depletion of forests was not due to climatic changes, but to removal by human agency through fire, clearing for agriculture, for fuel in industrial processes and heating, timber, and many other uses. Of course forests may regenerate over time, but use of land for other purposes such as grazing and agriculture, and severe erosion, can prevent growth of new trees. I did not find a total deforestation in the Mediterranean basin; in some districts dense forests survived, especially on inland mountain ranges. But many forests were thinned or were replaced by brushlands. The demand for wood as fuel and for use in construction including shipbuilding repeatedly raised its price and stimulated a search for sources accessible by sea and rivers at ever-greater distances. I based my conclusions on those made by many scholars, and I believe that they represented a consensus among those who had studied the subject. But unanimity is a utopia, and utopia means ''nowhere.'' Peregrine Horden and Nicholas Purcell, for example, while admitting that forests were destroyed by factors such as overgrazing and mining, opine that such damage was rare and localized, and that deforestation was seen as a ''Good Thing'' because it improved the landscape for agriculture.[4]

Two prominent skeptics are A.T. Grove and Oliver Rackham, authors of a 2001 book, *The Nature of Mediterranean Europe*.[5] They have an

[3] Cicero, 1880–1885, *De Natura Deorum 2*, p. 60.

[4] Horden and Purcell, 2000, p. 334. The expression, ''a Good Thing,'' is offered in the index, p. 743.

[5] Grove and Rackham, 2001.

unexpected answer to the question of ancient deforestation. The landscape, they assert, is not ruined. Deforestation exists mainly in the imagination of writers who mistakenly assume that cutting down trees destroys forests, whereas trees grow again. Grazing by goats and sheep is not bad, since it renders vegetation less vulnerable to wildfires. But fires do not destroy forests. Deforestation does not make erosion worse. Badlands, where erosional features dominate, are stable landscapes. They see no deserts on the march. The state of the Mediterranean lands in, say, 1950 CE, was little worse than it was at the end of the Bronze Age.

These are conclusions that go against the weight of opinion of students of historical land use who have been investigating these questions since the middle of the nineteenth century. Scholars active today may not be convinced by Grove and Rackham, who, whenever putative evidence arises for deforestation caused by human action, exhaust themselves in a search for ways to explain it away, and demand unassailable proof from those who judge that the evidence shows that humans cause forest removal.

Such proof may very well come from archaeologists who have made exhaustive regional surveys. One of these is Curtis Runnels, whose work in Greece has specialized on the relation between human settlement and landscape through time, using archaeology and geological stratigraphy, and who says, "Recent archaeological work is changing a long-standing view of the impact of agriculture on the land in Greece. The evidence mounts for episodes of deforestation and catastrophic soil erosion over the past 8,000 years. Many scholars believe they resulted from a long history of human land use and abuse."[6]

Others have examined a variety of lines of scientific and written evidence in reconstructing regional ecology. For example, a study by Bruno Pinto and colleagues of northern Portugal over the long term during the Holocene concluded that in a district where the highlands had already suffered from tree removal, Roman agricultural technology along with economic and population relocation cleared the richer valley soils, with "a major impact on the forests."[7]

It is to the evidence, therefore, that I turn in reconsideration. Unfortunately ancient forests are no longer directly observable, so scholars must depend on proxy evidence, including ancient writings, archaeology, anthracology, pollen studies, edaphology, sedimentology, ice cores, and climatic studies including computer modeling. What Fredric Cheyette says of Dark Age studies is true of ancient environmental history

[6] Runnels, 1995, p. 96.

[7] Pinto et al., 2010, p. 17.

generally: "For further progress in refining and correcting the story of this important and still obscure period of European history will demand the communication and cooperation of specialists in all these fields [archaeology, palynology, climatology]. Historians with their traditional tools can no longer go it alone."[8]

The new material available is dauntingly rich, so I will limit myself to a few examples that offer eye-popping insights. Environmental historians must depend on the work of scientists with several forms of proxy evidence for the composition and condition of forests at various times in history. Fortunately, research methods have improved, allowing increased exactitude in conclusions. I will look at three scientific methodologies bearing on the questions I have raised, namely anthracology, palynology, and computer modeling, and give examples in each case of recent published work.

Anthracology

First, anthracology, the analysis of charcoal evidence found in archeological contexts. Charcoal is often used for radiocarbon dating, but anthracology uses microscopic study of charcoal fragments to determine the species of trees or shrubs that were carbonized, and to detect changes in the presence and proportion of various species over time. Explicitly ecological interpretations of carbon analysis appeared around 1940.[9] The methodology has been applied in Mediterranean countries, with a research tradition developed since the 1960s by Jean-Louis Vernet and associates at the University of Montpellier in France[10] and since used in other parts of the region.[11]

In an article surveying the contribution of anthracology to the reconstruction of vegetation and landscapes in the Mediterranean,[12] Vernet cites the work of Lucie Chabal and Fanette Laubenheimer at Sallèles d'Aude, near Narbonne, where a Gallo-Roman potters' workshop with fourteen kilns was active from the first to the fourth century AD.[13] This covers the period from Augustus to Constantine including

[8] Cheyette, 2008.

[9] Salisbury and Jane, 1940; Godwin and Tansley, 1941.

[10] Asouti and Eleni (2009) *Charcoal Analysis Web*, http://pcwww.liv.ac.uk/~easouti/index.htm.

[11] Willcox, 1974; Neumann, 1992.

[12] Vernet, 1999.

[13] Chabal and Laubenheimer, 1994; See also Laubenheimer, 2001.

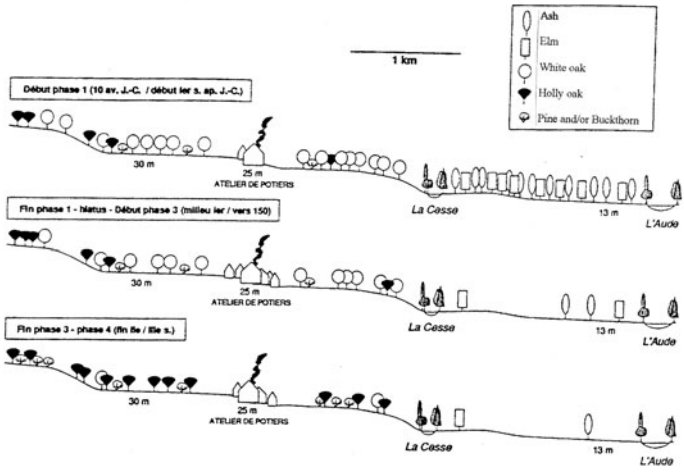

Figure 4.5. Probable sequence of exploitation of local fuelwood sources by the Gallo-Roman pottery at Sallèles d'Aude. (After Chabal and Laubenheimer, 1994)

Figure 2. The probable sequence of exploitation of local fuelwood sources by the Gallo-Roman pottery at Sallèles d'Aude (adapted from Vernet, 1999; and Chabal and Laubenheimer, 1994)

the Golden and Silver Ages of the Roman Empire, and the third century economic crisis. The kilns burnt thousands of cubic meters of wood, at a rate rising to 360 m^3 per year, then declining to 132 m^3 (Figure 2).

The industrial complex was located above a flood-plain at the confluence of the Cesse and Aude rivers, close to the three resources essential to pottery production: clay, water, and wood. Analysis of stratified deposits of charcoal identified at least 25 tree species. Wood from trees was preferred to wood from shrubs, and a few tree species were preferred over others. A sequence of exploitation displayed three periods of species preference. When the kilns began operation, the most common species burnt included deciduous white oak, with moisture-loving trees such as alder, ash and elm, indicating intensive exploitation of the floodplain near the rivers. Relatively soon, the proportion of these moisture-loving trees declined and disappeared. In the second phase, deciduous oaks were the dominant source of fuel-wood, and in the third phase, holm or holly oak, an evergreen species, replaced the deciduous oaks.

The situation this represents in the landscape is, in the first phase, from about 10 BCE to the mid-first century CE, the destruction of the low-lying forest along the riversides. In the second phase, from 50 to

150 CE, the potters exploited a deciduous oak forest beyond the plains, where the removal of that dominant species favored its replacement by evergreen oak, a process noted throughout Mediterranean France.[14] As Vernet notes, "Cutting and repeated fires favor the holm oak more than the white oak, as it is better able to sprout from its stump. The holm oak was able in this way to fill in some of the gaps left by the white oak; deciduous oak practically never reappears."[15] In the third phase, from around 150 to 310 CE, therefore, evergreen holm oak was the dominant species consumed. Where evidence shows replacement of deciduous oaks by evergreen oaks, it is reasonable to suspect anthropogenic disturbance of the local forest ecosystem. Charcoal analysis at the eastern end of the Mediterranean in southern Syria, for example, shows that evergreen oak appeared in the Roman period and gradually supplanted deciduous oak, which now grows only in a very restricted area.[16] This line of evidence shows that it in evaluating deforestation, it is important not simply to establish whether there were still trees in an area, but to note the disappearance of some species and the replacement of some species by others.

The conclusions of Vernet, Chabal, and Laubenheimer merit application more widely in the Mediterranean area in light of the pervasive use of wood and charcoal as fuel in the ceramic industry as well as in metallurgy.

Palynology

The second methodology I will consider is palynology, which is the study of pollen grains in stratified contexts, such as deposits in lake bottoms and caves, for evidence about historical ecosystems. Pollen grains survive well in archaeological and geological situations, and by microscopic study can be differentiated, usually to genus or even species. Analysis of a pollen core, with assistance from radiocarbon dating, can show the changing abundance of the pollen rain and the relative frequency of kinds of pollen over a period of time, often centuries or millennia.

Quantitative pollen analysis began with Lennart von Post in Sweden in 1916,[17] and spread through the rest of Europe and North America in the 1920s. The number of studies has increased exponentially,

[14] Triat-Laval, 1978.

[15] Vernet, *Ibid.*, p. 30.

[16] Willcox, 1999.

[17] Manten, 1967.

so keeping abreast of the information on a regional scale is daunting. Brian Huntley and John Birks published pollen maps for Europe over the past 13,000 years.[18] Valérie Andrieu and associates developed a computerized database covering the Mediterranean Basin, emphasizing palynological evidence for human activity.[19]

As an example, the authors cite the Marsillargues diagram from a core taken from a lagoon site near the French Mediterranean coast.[20] Here, the ''Juglans line'' marks the appearance of walnut pollen associated with the founding of Roman colonies in this area. Afterwards, there was an episode of deforestation with the felling of beech and oak to clear agricultural land. There is an increase of the pollen of cultivated plants. The main sign of the episode of deforestation, a sharp fall in forest tree pollen, is clear.

Diana K. Davis refers to the pollen evidence in her monograph, *Resurrecting the Granary of Rome*.[21] The book is an indictment of the misuse of historical forest data by French colonial administrators of northwest Africa to justify their seizure of land. Evidently the colonialists advanced an environmental story that impugned local people, especially herders, for the degradation of a land that had been the breadbasket of the Roman Empire. I have no argument with her analysis. Part of her argument is based on a report by Henry Lamb and associates analyzing cores taken from Tigalmamine Lakes in the Atlas Mountains of Morocco. She says,

> Since [6,500 BCE], several shifts in tree pollen have occurred, but no significant trend toward either increased or decreased pollen levels is evident, indicating that no major changes in tree populations are likely to have occurred. The most significant decrease in pollen appears to have taken place about 1,600 years ago, well before either of the 'Arab invasions.'

But I am interested in what the diagram says about the Roman period. 1,600 years ago is the time of the fall of the Western Roman Empire, and the chart shows a decline from the time of the Roman Republic to a low in the fifth century. It also shows a decline of oaks, with a disappearance of deciduous oaks, and a sharp rise in grass pollen. Lamb states that this was a severe period of forest degradation, since pollen data show that all tree species declined (Figure 3).

[18] Huntley and Birks, 1983.

[19] Andrieu et al., 1999.

[20] Planchais, 1982; Andrieu et al., *Ibid.*, p. 19, Figure 3.2.

[21] Davis, 2007, p. 11.

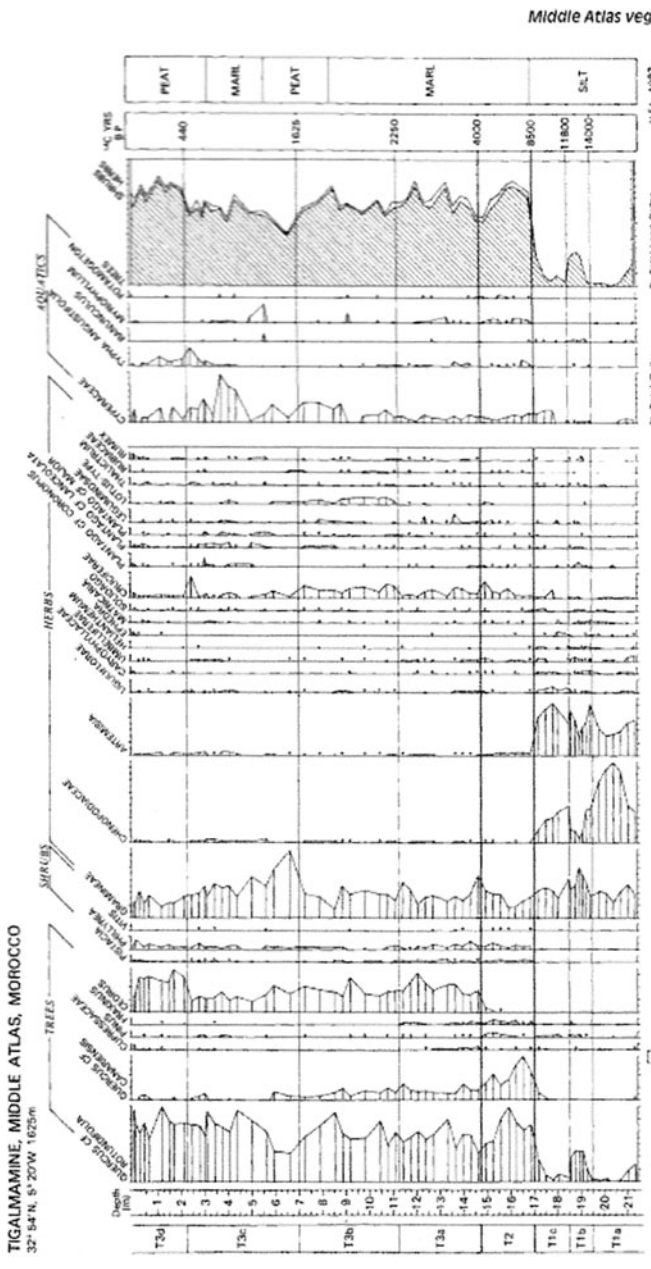

FIG. 6. Tigalmamine: summary relative pollen frequency diagram. The pollen sum is all terrestrial pollen, excluding Cyperaceae and aquatics. Note that Zone T1 occupies half the total time represented, in only 4 m of sediment.

Figure 3. Tigalmamine, Morocco: summary relative pollen frequency diagram. Note that the total tree pollen count (*shaded area*) shows a sharp decline in the Roman period, from before 1625 BP (375 CE) to shortly afterwards (from Lamb et al., 1989)

The Roman writer Lucan tells us that the Romans exploited the forests of Mauretania (approximately the same area as modern Morocco):

> This was a very fertile area which had never been disturbed in the search for metals… The timber of Mauretania was the people's only wealth. They were innocent of its value, it was the leafy shade of the citrus [sandarac[22]] that they enjoyed, and they lived happily. Into the forest hitherto unknown our axes came: we search out tables for our banquets from the end of the earth.[23]

Lamb believes that anthropogenic forest degradation began about 250 BCE, and has continued ever since. Clearance, shredding of trees for animal feed, and grazing of sheep and goats continue to the present day. In fact, goats climb trees in Morocco to get at the argan fruit, whose seeds pass through their digestive tracts and then are pressed for oil. But they also climb trees to eat the foliage, not only in Morocco but in Spain, Greece, and elsewhere, including Montserrat and even Texas, for the latter purpose. Goats are extremely destructive of saplings and small trees. Papanastasis, an FAO expert, avers, ''Domestic goats are blamed for much of the destruction of the Mediterranean forests.… It is not goats per se that are the real culprit but the continuous, uncontrolled overgrazing for which humans are responsible.''[24]

Lamb's chart shows an increase in the pollen of the Atlantic cedar from the sixteenth century, but we cannot ignore the sharp decline at the recent end of the core, from sometime in the nineteenth or early twentieth centuries. Whoever is to blame, over much of North Africa there is a ruined landscape. Abandoned Roman cities present a desolate appearance.

The need for further palynological research, and for integration of the research that has been published in scattered journals, is certainly evident.

Computer Models

The third methodology is computer modeling. Oreste Reale of the Goddard Earth Sciences and Technology Center and associates generated computer models of Mediterranean vegetation and its effects

[22] ''Citrus'' in this case is a somewhat confusing Latin name for the sandarac tree (*Tetraclinis articulata*, formerly designated *Callitris quadrivalva*).

[23] Lucan *Pharsalia* 9, pp. 426–430. Quoted in Meiggs, 1982, p. 288. Lucan lived 39–65 CE, and was referring to the time of Caesar and Cicero.

[24] Papanastasis, 1985.

on climate.[25] Climate studies have used such models since the time that sophisticated computers were developed, and the Reale studies follow that line. Their purpose was "to construct a vegetation map around the Mediterranean Sea that is an accurate representation of conditions two millennia ago, and to use this data in general circulation model experiments to better understand historical climate and climate change."[26] Two models were used, the second with higher resolution than the first, but both provided similar results; that is, that environmental conditions in the Roman Classical Period were moister than at present, and that human modification of the land surface, including deforestation, had produced progressively drier and warmer conditions. Reale points out that before the impact of industrial emissions on global climate, there was a more ancient way in which humans interacted with the climate system: land surface usage, which changed the albedo of the surface (Figure 4).

To develop the model, Reale constructed a vegetation map of Mediterranean lands representing conditions two millennia ago. The vegetation used in the model is taken from pollen maps, but also from classical literature including historians, agriculturalists, and naturalists. Reale also refers to the archaeological evidence of Roman cities such as Timgad, Leptis Magna, and Sabratha, now in desolate environments, aqueducts whose sources have dried up, and bridges across former watercourses now dry. Leptis Magna was assessed a tax of 3 million pounds of olive oil during Caesar's time, but later no olive groves could be seen there. Elephants roamed in the Atlas Mountains, but disappeared in the Roman period.

Reale accepts the prevailing opinion. He says, "There is general agreement that a tremendous amount of deforestation has occurred, and consequently there has been soil erosion – caused by heavy winter rainfall and steep orography."[27] That is, he has not adopted the skepticism of A. T. Grove and Rackham, who think that any evidence of deforestation must be wrong. On the other hand, Reale is in a familiar predicament when deciding what to enter into his model: he, like the rest of us, must use evidence given by written sources, present landscape, forestry, and science.

Reale is a climatologist, and the result of his two experiments showed that the Mediterranean area during the Roman Classical Period, before major deforestation, would have been moister than at present. No information emerged about temperature.

[25] Reale and Dirmeyer, 2000; Reale and Shukla, 2000.

[26] Reale and Dirmeyer, *Ibid.*, p. 163.

[27] *Ibid.*, p. 165.

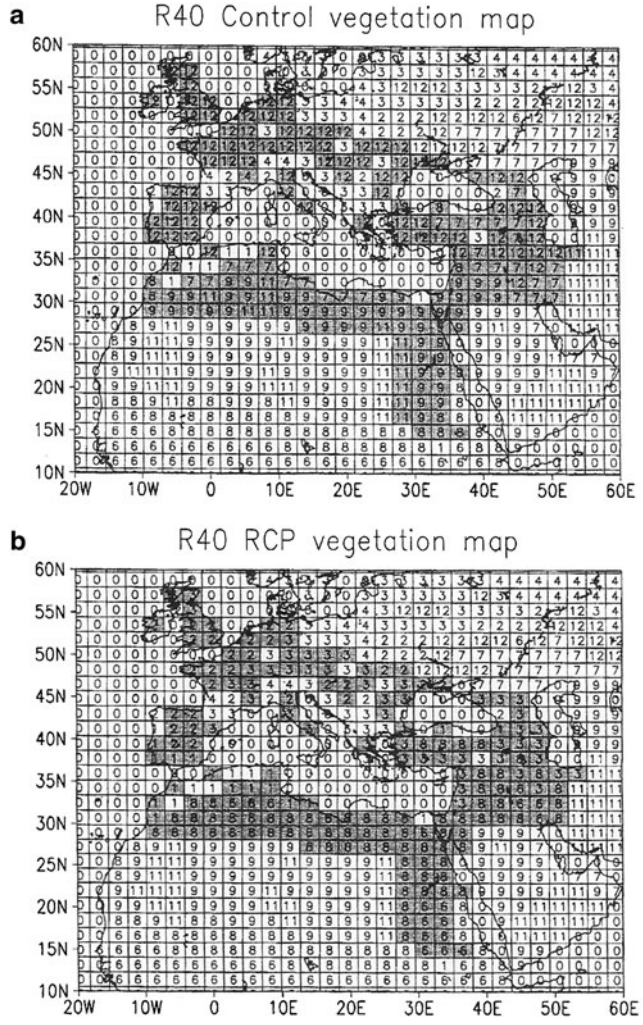

Fig. 1. Vegetation Map at R40 Resolution. The numbers correspond to the vegetation types and are listed in Table 1. Panel a: Control; Panel b: RCP. Shading indicates gridboxes where modern and RCP vegetation differ.

Figure 4. Grid of vegetation types used in computer model by Reale and Shukla at R40 resolution (the rectangles are approximately 2.8° longitude and 1.8° latitude). Control represents modern conditions; RCP represents conditions during the Roman Classical Period. The vegetation types indicated numerically are as follows: 0, no vegetation (water); 1, Mediterranean forest (evergreen oaks, palms, pines, olive, cypress); 2, deciduous forest (deciduous oaks, beech); 3, mixed deciduous/needle-leaf (deciduous oaks, beech, fir, spruce, pine, cedar); 4, evergreen needle-leaf (fir, spruce); 5, deciduous needle-leaf (larch); 6, savanna; 7, perennial herbaceous types, 8, Mediterranean scrub; 9, shrubs with bare soil; 10, tundra; 11, bare soil; 12, agricultural land (from Reale and Shukla, 2000)

What can we learn from the Reale experiments? First, although two takes at different resolutions reached approximately the same results, a much higher resolution is needed to give confidence in the results. The advance of computer technology has made this possible in the interim.[28] Second, Reale and his associates are scientists faced with the same problem of evidence for ancient deforestation that environmental historians are, and he has reached very much the same conclusion that I have reached about deforestation.

Conclusion

Environmental historians considering the problem of ancient deforestation must constantly revisit the work being done by scientists. This review touches on three lines of scientific work: anthracology, palynology, and climatological computer models. There are obviously other areas of scientific research bearing on the problem, including but not limited to soil studies, hydrology, sedimentology, landscape archaeology, ice cores, and more general climate studies. The body of information, even limited to the ancient Mediterranean, is large and expanding.

My work on this subject has been characterized as pessimistic.[29] Indeed, I have found evidence showing that there was major deforestation in many parts of the Mediterranean Basin in classical Greek and Roman times, and that it caused environmental damage contributing to the disruption of ancient economies. In revisiting the question and examining new scientific evidence, I have modified my views concerning details, but my overall view has been sustained.

References

Andrieu, Valérie, Brugiapaglia, Elisabetta, Cheddadi, Rachid, Ponel, Philippe, Reille, Maurice, de Beaullieu, Jacques-Louis, and Barbero, Marcel. 1999. "A Computerized Data Base for the Palynological Recording of Human Activity in the Mediterranean Basin." In *Environmental Reconstruction in Mediterranean Landscape Archaeology*, ed. Philippe Leveau, Frédéric Trément, kevin Walsh, and Graeme Barker, 17–24. Oxford, UK: Oxbow Books.

Asouti, Eleni. 2009. *Charcoal Analysis Web*. http://pcwww.liv.ac.uk/~easouti/index.htm. Accessed 2 June 2010.

[28] Another simulation using the Max-Planck-Institute's global general circulation model at a higher degree of resolution reached conclusions very similar to those of Reale and associates: see Gates and Liess, 2001.

[29] Walsh, 2004, p. 240.

Chabal, Lucie and Laubenheimer, Fanette. 1994. "L'atelier gallo-romain de Sallèles d'Aude: les potiers et le bois." *Terre Cuite et Société, la Céramique, Document Technique, Économique et Culturel* (XIVes Recontres Internationales d'Archéologie et d'Histoire d'Antibes), Juan les Pins, CNRS, pp. 99–129.

Cheyette, Fredric L. 2008. "The Disappearance of the Ancient Landscape and the Climatic Anomaly of the Early Middle Ages: A Question to be Pursued." *Early Medieval Europe* 16(2): 127–165.

Cicero, Marcus Tullius. 1880–1885. Joseph B. Mayor (ed.), *De Natura Deorum 2*. Cambridge, UK: Cambridge University Press.

Davis, Diana K. 2007. *Resurrecting the Granary of Rome: Environmental History and French Colonial Expansion in North Africa*. Athens, OH: Ohio University Press.

Gates, Lydia Dümenil and Liess, Stefan. 2001. "Impacts of Deforestation and Afforestation in the Mediterranean Region as Simulated by the MPI Atmospheric GCM." *Global and Planetary Change* 30: 309–328.

Godwin, H. and Tansley, A.G. 1941. "Prehistoric Charcoals as Evidence of Former Vegetation, Soil and Climate." *Journal of Ecology* 29: 117.

Grove, A.T. and Rackham, Oliver. 2001. *The Nature of Mediterranean Europe: An Ecological History*. New Haven: Yale University Press.

Horden, Peregrine and Purcell, Nicholas. 2000. *The Corrupting Sea: A Study of Mediterranean History*. Oxford: Blackwell.

Hughes, J. Donald. 1975. *Ecology in Ancient Civilizations*. Albuquerque: University of New Mexico Press.

—— 1994. *Pan's Travail: Environmental Problems of the Ancient Greeks and Romans*. Baltimore: Johns Hopkins University Press.

Huntley, Brian J. and Birks, Harry John Betteley. 1983. *An Atlas of Past and Present Pollen Maps for Europe: 0–13,000 Years Ago*. Cambridge, UK: Cambridge University Press.

Lamb, H.F., Eicher, U. and Switsur, V.R. 1989. "An 18,000 year record of vegetation, lake-level, and climatic change from Tigalmamine, Middle Atlas, Morocco." *Journal of Biogeography* 16: 65–74.

Laubenheimer, Fanette. 2001. *20 Ans de Recherches à Sallèles d'Aude: Le Monde des Potiers Gallo-Romans*. Besançon: Presses Universitaires de Franche-Comté.

Manten, A.A. 1967. "Lennart von Post and the Foundation of Modern Palynology." *Review of Palaeobotany and Palynology* 1: 11–22.

Meiggs, Russell. 1982. *Trees and Timber in the Ancient Mediterranean World*. Oxford: Clarendon Press.

Neumann, K. 1992. "The Contribution of Anthracology to the Study of the Late Quaternary Vegetation History of the Mediterranean Region and Africa." *Bulletin de la Société Botanique de France* 139: 421–440.

Papanastasis, Vasilios P. 1985. "Integrating Goats into Mediterranean Forests." FAO Corporate Document Repository, *Unasylva* No. 154.

Pinto, Bruno, Aguiar, Carlos and Partidário, Maria. 2010. "Brief Historical Ecology of Northern Portugal During the Holocene." *Environment and History* 16(1): 3–42.

Planchais, N. 1982. "Palynologie lagunaire de l'etang de Mauguio: Paléoenvironnement vegetal et evolution anthropique." *Pollen et Spores* 24(1): 93–118.

Reale, Oreste and Dirmeyer, Paul. 2000. "Modeling the Effects of Vegetation on Mediterranean Climate During the Roman Classical Period; Part I, Climate History and Model Sensitivity." *Global and Planetary Change* 25: 163–184.

Reale, Oreste and Shukla, Jagadish. 2000. ''Modeling the Effects of Vegetation on Mediterranean Climate During the Roman Classical Period; Part II: Model Simulation.'' *Global and Planetary Change* 25: 185–214.

Runnels, Curtis N. 1995. ''Environmental Degradation in Ancient Greece.'' *Scientific American* 272(3): 96–99.

Salisbury, K.J. and Jane, F.W. 1940. ''Charcoals from Maiden Castle and Their Significance in Relation to the Vegetation and Climatic Conditions in Prehistoric Times.'' *Journal of Ecology* 28: 310–325.

Triat-Laval, H. 1978. Unpub. ''Contribution Pollenanalytique à l'Histoire Tardi-et Postglaciare de la Basse Vallée du Rhône.'' Ph.D. Thesis, University of Aix-Marseilles III, Marseilles.

Vernet, Jean-Louis. 1999. ''Reconstructing Vegetation and Landscapes in the Mediterranean: The Contribution of Anthracology.'' in Environmental Reconstruction in Mediterranean Landscape Archaeology, ed. Philippe Leveau, Frédéric Trément, kevin Walsh, and Graeme Barker, 25–36. Oxford, UK: Oxbow Books.

Walsh, Kevin. 2004. ''Caring About Sediments: The Role of Geoarchaeology in Mediterranean Landscapes.'' *Journal of Mediterranean Archaeology* 17(2): 223–245.

Willcox, G.H. 1974. ''A History of Deforestation as Indicated by Charcoal Analysis of Four Sites in Eastern Anatolia.'' *Anatolian Studies* 24: 117–133.

Willcox, George. 1999. ''Charcoal Analysis and Holocene Vegetation History in Southern Syria.'' *Quaternary Science Reviews* 18(4–5): 711–716.