Deforestation, Erosion, and Forest Management in Ancient GREECE and ROME

by J. Donald Hughes, in collaboration with J. V. Thirgood

I. INTRODUCTION

There is a close interconnection between ruined cities and ruined land. The fact that the broken statues and scattered column drums of the centers of ancient civilization have deforested and eroded landscapes as their settings does not seem to be an accident. The general impression of synchronicity, the contemporaneous ruin of ancient societies and ancient environments, has been inescapable.

Forests provided the major material for construction and almost the only fuel source of the classical world, and depletion of this source precipitated a number of crises. As forests retreated with land clearance, wood decreased in availability and increased in price, contributing to the ruinous inflation that plagued late antiquity. Competition for forest resources ignited military conflicts, which themselves created demands for timber. Erosion weakened the economic base of the predominantly agrarian societies, contributing to a population decline that made it ever more difficult for Greco-Roman civilization to resist the incursions of barbarians from beyond the frontiers. In the more arid regions, forests that formerly moderated the climate and equalized the water supply were stripped away, permitting the desert to advance. The image of the ruined cities of North Africa, from which olive oil and timber were exported in ancient times but which later were buried beneath the desert sand, epitomizes the environmental factor in the decline of civilization, as do the swamps along the northern Mediterranean margin from which malaria spread to debilitate the population.

Without in any way discounting the importance of other causes of the passing of classical culture and its replacement by less glorious successors, we must say that such keen observers as George Perkins Marsh, Henry David Thoreau, and Fairfield Osborn were at least partially correct in their assertions that the nations of antiquity were consuming their own future as they felled their forests and allowed their soil to wash away. While it would be incorrect to attribute to the ancients all the ills of the present-day Mediterranean landscape (for it has been subjected to pressures by successive societies over the centuries), it seems clear that the peoples of the classical world in many instances set in motion a process best described as a wearing away of the heartlands of western culture.

Environmental problems have affected human societies from very early times, and since the past represents human experience, scholars concerned with ecology and land use today may profit by drawing upon earlier examples. Classical Greece and Rome are particularly instructive, not only because such problems as deforestation and erosion beset those civilizations, but also because written sources exist to supplement the archaeological record of environmental change. The ancient philosophers and historians to some extent recognized and reflected upon the process. Their attitudes have been influential in determining the way in which subsequent civilizations have viewed and treated the natural environment.

All too often, historians, in a laudable attempt to avoid the subjective reading of the present into the past, have ignored the modern implications of earlier interactions between human beings and nature, while some ecologists in turn have disregarded earlier historical periods as remote and without contemporary applicability. A few perceptive individuals, however, recognized that ecological studies benefit from a historical perspective, just as history often benefits from an ecological viewpoint. Fairfield Osborn maintained that environmental history, and specifically that of Greece and Rome, "assumes the character of a pro-

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Where a generally accepted English title exists for classical works cited in this article, it has been used. In other cases the forms given are those found in *The Oxford Classical Dictionary*, second edition, edited by N. G. L. Hammond and H. H. Scullard (Oxford: Clarendon Press, 1970).

A scene of total deforestation, viewed through the columns of the Temple of Apollo and Acrocorinthos at Corinth, symbolizes the "contemporaneous ruin of ancient societies and ancient environments." Photographs in this article were provided (except where otherwise noted) by J. Donald Hughes.

logue to modern times. Assuredly there is an affinity between *then* and *now*." In the decline of ancient societies, he sensed "a contemporaneous deterioration of environment and peoples," of which "the causes were man-made, not natural."[1] Osborn recognized the cycle of deforestation, erosion, and agricultural decline in the late classical world, reminding us that in some desolate Mediterranean areas "the forests have never reappeared . . . because the land has been denuded of its soil."[2] Similar observations were recorded by Henry David Thoreau:

> **The civilized nations-Greece, Rome, England-have been sustained by the primitive forests which anciently rotted where they stand. They survive as long as the soil is not exhausted. Alas for human culture! Little is to be expected of a nation, when the vegetable mould is exhausted, and it is compelled to make manure of the bones of its fathers.**[3]

Although Thoreau's irony is more poignant, Osborn's comments gain importance from their immediacy, written as they were when the extent of modern human damage to the worldwide natural environment, and its consequences, were becoming apparent.

The purpose of this article is to examine in some detail the role of deforestation and erosion in the decline of ancient civilization. We shall investigate the needs, practices, and attitudes that brought about deforestation and soil erosion in ancient Greece and Rome. We shall examine the extent of those forces of environmental deterioration, and their interaction with one another in producing direct and secondary impacts on the economy (including agricultural production), health, population, and social structure. Efforts undertaken to remedy environmental problems, whether successes or failures, will be described. Finally we shall attempt a new estimate of the importance of deforestation and erosion as causes of the decline of classical civilization and of the extent to which these peoples understood and practiced forest management.

We recognize that to a degree this is an ongoing process. Much evidence exists to indicate that, apart from the thin-soiled limestone regions such as Attica, catastrophic erosion occurred *after* the decline of Roman power — as is certainly the case in Palestine and Syria and probably much of North Africa, while in southern Italy denudation and the resultant soil loss has been ascribed to the Spanish occupation during the sixteenth century.

II. THE DEMAND FOR FOREST PRODUCTS

The single most important use of wood and its carbonized product, charcoal, was as fuel. As in many underdeveloped countries today, probably close to 90 percent of all wood used was consumed for this purpose. Coal and petroleum were known to the ancients, but they were not used to a great extent in any area. Although populations were much smaller in the classical period than today, the depletion, we may assume, was considerable. Every householder might have said with Vergil (70-19 B.C.):

> **My hearth is piled with branches of pitch-pine;**
> **Free burns my faithful fire, and every hour**
> **My walls are black with smoke.**[4]

And those who set out on foot into the night might well have remembered that "the loftier forest gives

[1] Fairfield Osborn, *The Limits of the Earth* (Westport, Connecticut: Greenwood Press, 1971), pp. 11-12.

[2] Osborn, *Our Plundered Planet* (Boston: Little, Brown, 1948), p. 67.

[3] *The Writings of Henry David Thoreau*, 10 vols., edited by Horace Elisha Scudder et al. (Boston: Houghton Mifflin, 1884-1894), 9:281.

[4] Vergil, *Eclogues* 7.49-50.

our torches," referring to the resinous heartwood of the mature pine trees.[5] Woodcutters were kept busy supplying fuelwood, and haulers were well paid for transporting it into cities on mules and donkeys. One of these, Phaenippus of Athens, was reported to have made twelve drachmas a day in this way.[6]

Much wood was reduced to charcoal before being used as fuel. Theophrastus (390-286 B.C.), Cato (234-149 B.C.), Pliny (A.D. 23-79), and others describe the process. Charcoal burning occupied thousands of men like the Acharnians of Aristophanes (448-388 B.C.). Charcoal produced a higher, more even heat with less smoke and flame, and thus found uses in industry as well as in the ubiquitous braziers that warmed chimneyless rooms. Wood and charcoal fired the kilns that hardened Greek and Roman ceramics, including pottery, bricks, and tiles; melted the metal for statues, utensils, and weapons; forced pitch out of pinewood; and reduced limestone to fertilizer. Finally, the ashes served to enrich the soil. In addition to warming meals and drinks, these fuels heated the water and the floors in the many huge Roman bathing establishments. So numerous were fires in ancient cities that air pollution was a problem on which ancient authors commented.

Mines and smelters used prodigious amounts of fuel, primarily for reducing ores to metals, but also for supports in mineshafts and for underground fires to crack resistant rocks. Reasonable estimates hold that a single major ancient metallurgical center would have required as much as a million acres of coppice forest to supply these needs.[7] Osborn identified this as a major cause of deforestation, but this, of course, would not necessarily occur if the coppice was managed on a basis of sustention.[8] Such concentrated demands could have led to the development of a rational, continuous forestry. Indeed, we know from our reading of the classical texts on rural economy that the principles of coppice management were practiced and well understood. These varied mining activities required a continuing supply of wood that could hardly have been met over hundreds of years in the principal centers of mining if indifference to forest destruction had been universal. Nevertheless, it is hardly coincidental that the principal mining centers of antiquity are among the most treeless today.

In addition to fuel, forests were used for building materials. Lumber and other forest products constituted a basic article of trade in the Mediterranean basin. There is no doubt that the ancients regarded forests as a valuable commercial advantage. Wood was a material so commonly used for so many purposes that the Greek word for it, *hyle,* came to mean "substance" or "matter" in general. In Latin, both concepts are also expressed by a single word — *materia.* A city well supplied with forests, then, was rich in a necessary resource and item of commerce. Plato (427-347 B.C.) and Aristotle (384-322 B.C.) agreed that an ideal city would have its own forests near enough to ensure self-sufficiency (although Plato, who disliked the political influence of sailors, thought there ought not to be too much shipbuilding timber around).[9] But not all cities could expect to have an adequate domestic timber supply, and the timber trade, which generalized the exploitation of the Mediterranean forests, was the result.

Classical literature and inscriptions give much information (although little quantitative data) on the process of forest exploitation. The actual cutting of trees was a specialized task at which loggers took great pride; Alfred Zimmern quotes one epitaph on Mount Parnes: "I never saw a better woodcutter than myself."[10] Men like these knew the forests well; Theophrastus (390-286 B.C.) often quotes the expertise of lumbermen from Mount Ida, Macedonia, and Arcadia, among the most important suppliers of the Greek timber trade.

We learn which species of trees the ancient foresters chose for various types of wood and how they judged which specimens to cut: location, exposure, age, habit of growth, and appearance of the bark were all considered. The time of felling trees was carefully prescribed; wintertime was preferred, but not when the timber was wet, frosted, covered with dew, or during a south wind. There was a strong, almost universal opinion that trees ought to be cut during the waning

[5]Vergil, *Georgics* 2.431-32.

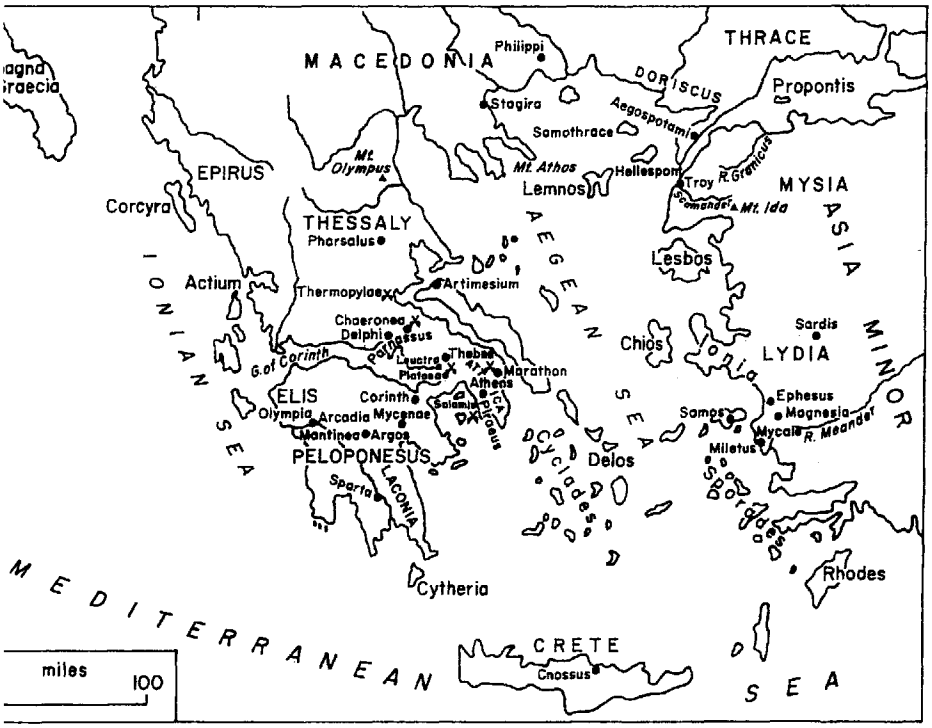
[6]Demosthenes, *Against Phaenippus* 42.7(1040-41).

[7]Theodore Wertime, "Prime Culprit: The Pyrotechnologic Furnace or the Goat?" Paper presented at the Conference on Deforestation, Erosion, and Ecology in the Ancient Mediterranean and Middle East, at the National Museum of Natural History, Smithsonian Institution, Washington, D.C., April 19, 1978.

[8]Osborn, *Limits of the Earth,* pp. 19-20.

[9]Plato, *Laws* 4.705C-707D.

[10]Alfred Zimmern, *The Greek Commonwealth,* fourth edition (Oxford: Clarendon Press, 1924), p. 278.



Map of Greece about 450 B.C. A young forest (primarily Greek fir) near a campground at Arcadia is a reminder of the once-plentiful timber resources of the Peloponnesus.

Map courtesy of J. V. Thirgood

moon, possibly deriving from an immemorial taboo whose original purpose can only be guessed. (It is of interest that a similar belief is found still in traditional European forestry lore.) Some believed the waxing moon made timber moist and soft. Pliny says the practice made the wood last longer, but he also cites a similar admonition to cut the hair only during the waning moon as a precaution against baldness. It is perhaps fanciful to suggest that the rule about cutting trees was a silvicultural measure to prevent "baldness of the earth."[11] At any rate the taboo was widespread. In one case Emperor Tiberius (42 B.C.-A.D. 37) ordered that larches for his naval arena be felled between the twentieth and thirtieth days of the lunar month. One of these logs measured 120 feet — one of the longest ever seen in Rome — suggesting a concern with forest preservation that extended beyond quaint taboos, at least in the Alpine province from which it was taken.[12]

The trees were cut with axes, saws, and wedges; smaller ones were often uprooted by digging. Sometimes trees to be felled were first girdled, or conifers gradually girdled by removing the bark to make the pitch flow. After the branches were lopped off, logs were pulled out by draft animals and either shipped whole or hewn into thick beams and planks first. Theophrastus gives directions for splitting pine and fir logs with the grain.[13]

Often logs were floated down rivers or canals to ports on the coast. Rome brought much timber down the Tiber directly to the city. The Po was a major artery for Alpine timber. A typical lumber port might be at the mouth of a river with a mountainous, forested area at its watershed, like Luna, Ravenna, or even Colchis at the farther end of the Black Sea. Those without major rivers usually had the mountains at their backs, like Genoa or Antandros.

From such ports timber was shipped to populated centers; we hear of businessmen in the import trade and are told that long sea voyages were sometimes involved. Rome's timber market was located at the Porta Trigemina on the downriver side of the city, indicating that major supplies were brought up the Tiber through Ostia on the coast.[14] Overland transport was sometimes necessary; Russell Meiggs reports that the great building inscription of the palace of Darius (d. 486 B.C.) at Susa, which today stands in the desolate border country of Iran and Iraq, records Ionian and Carian Greeks "engaged in the transport of timber and in skilled labour on the building."[15]

Cities required timber to build houses and public buildings such as temples, theaters, and basilicas. Even after most large buildings began to be constructed of stone or brick, beams and rafters were of timber, and scaffolding and ramps were needed. Doors and their frames and hinges were often of wood, and roofs were covered with shingles — that was the old custom of Rome, according to Pliny.[16] Images of the gods were

[11]Pliny the Elder, *Natural History* 16.75(194).
[12]*Ibid.*, 16.74(190), 76(200).
[13]Theophrastus, *Historia Plantarum* 5.1.5-12.
[14]Livy 35.41.10.
[15]Russell Meiggs, *The Athenian Empire* (Oxford: Clarendon Press, 1972), pp. 143, 619.
[16]Pliny *HN* 16.15(36).

anciently made of wood, as were the frameworks of colossal chryselephantine statues. Plato advised painting public notices on cypress wood.[17]

Cabinets and household furniture were fashioned by skilled woodworkers who knew techniques such as inlaying and veneering. All sorts of tools and utensils, including cups, jars, bowls, combs, and barrels, were made of wood — even metal objects such as daggers needed wooden handles. Willows found widespread use in basketry and were even cultivated for the purpose. Musical instruments like the lyre and aulos required wood, as did agricultural and industrial machines, including those used in irrigation and construction, and vehicles such as wagons, chariots, and carts. Shipbuilding was the most frequently mentioned use of wood in ancient literature. From keel to mast, almost everything in a ship came from trees, as did pitch used to caulk the vessel.

Wood was not the only forest product used by the ancients. Forests also supplied cork, pitch, and tar; dyes from bark, flowers, and forest insects; cedar oil, resins for varnishes, and preservatives; spices, medicines, and drugs from trees and shrubs — not to mention beeswax, honey, nuts, and fungi. Wine jars were waterproofed with pine resin.

Ancients also depended upon the woodlands for war materiel. Forests supplied wood not only for ships but also for chariots, battering rams, and other huge siege engines, and stock for a host of weapons. Ramparts of fortifications often consisted of tree trunks set closely together.

Armies took their toll upon the forests. Detachments of soldiers cut wood for fortifications and fuel.[18] The Spartans brought wood all the way from Asine to Pylos for engines, and it is said that during sieges of North African towns, Caesar had to send to Sicily for timber to reconstruct his engines.[19] Deliberate destruction of forests often occurred in warfare; Xerxes burned the woods during his invasion of Greece. The Aeotolians set forest fires to harry the troops of the Athenian general, Demosthenes, who later used the same weapon against the Spartans at Sphacteria.[20]

A major cause of forest removal was the clearance of land for farming. Writers such as Lucretius saw forests giving way to farms:

> **They made the woods climb higher up the mountains**
> **Yielding the lowlands to be tilled and tended.[21]**

The axe and saw were part of regular farm equipment. Trees were uprooted and removed or cut down, burned in place, and the ashes plowed under as valued fertilizer.[22] The trees that grew naturally on a plot of land were used as indicators of what crops would do well if planted there, although Pliny recognized that good forest sites were not necessarily suited for other crops:

> **A soil in which lofty trees do brilliantly is not invariably favorable except for those trees: for what grows taller than a silver fir? Yet what other trees could have lived in the same place?[23]**

Even more destructive than agricultural clearing were the wide-ranging herds of grazing and browsing animals. As Varro (116-27 B.C.) complains, "Grazing cattle do not produce what grows on the land, but tear it off with their teeth."[24] Herds of goats, sheep, cattle, and swine grazed through the ancient forests. Theophrastus saw cropping by animals as a major cause of damage.[25] Not only were animals pastured in forests, often being herded up the mountainsides as the forests, at least during part of the year, each so cattle, sheep, and goats could eat the leaves when other sources of forage failed.

All the herd animals were encouraged to graze in the season advanced, but branches of trees were cut species having its own preference among available forest vegetation. Cattle, says Varro, "are most conveniently pastured on wooded land where there is much undergrowth and foliage."[26] Swine were allowed to root on the forest floor, "bringing home full paunch of acorns," and the mast of beech and chestnuts.[27]

But the goat was identified as the true destroyer of forests. Although goats will graze almost anywhere, given free choice they prefer woody plants. According to Vergil,

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[17]Pl. *Laws* 5.741C.
[18]Vegetius, *Epitoma Rei Militaris* 27-30, 49, 82-85.
[19]Caesar, *Bellum Africum* 20.3.
[20]Thucydides, *Peloponnesian War* 3.98.2-3; 4.30.2-3.
[21]Lucretius, *De Rerum Natura* 5.1370-71.
[22]Columella, *De Re Rustica* 2.2.8, 11-12.
[23]Pliny, *HN* 17.3(26).
[24]Varro, *De Re Rustica* 2, intro., 4.
[25]Theophrastus, *De Causis Plantarum* 5.17.6.
[26]Varro *Rust.* 2.5.12.
[27]Verg. *G.* 2.520.

A goat flock will find its food
In leafy woodlands and the highest peaks
Of an Arcadian mountain; it will browse
On thorny vines or hardy shrubs that spread
On inaccessible slopes.[28]

But not only there; in an unprotected plantation, he says, "raiding goats come crowding in."[29] The preference of goats for wooded country was well known, as was their appetite for a wide variety of plants. Eupolis, in Greek Old Comedy, had his chorus of goats bleat out a list of some of their favorite foods:

We feed on all manner of shrubs, browsing on the tender shoots
of pine, ilex, and arbutus, and on spurge, clover, and fragrant
sage, and many-leaved bindweed as well, wild olive and lentisk
and ash, fir, sea oak, ivy, and heather, willow, thorn, mullein,
and asphodel, cistus, oak, thyme, and savory.[30]

This sounds like a botanist's plant list of the typical Mediterranean scrub forest community, the *maquis*, and it should be noted that on the goat's bill of fare a number of timber trees are included. The significance of pastoralism is not that it actually destroys forests but that it makes permanent what destruction goes before. While goats are often observed to climb trees and browse on foliage and bark, a mature forest is relatively immune to their depredations. Even the shrubby *maquis* will withstand all but the most severe overgrazing, and, as may be seen today in Mediterranean countries where economic advance has brought a halt to free-range grazing, the forest communities have a remarkable capacity for recovery. But where woodcutters or a forest fire have stripped a hillside, goats will eagerly consume the seedlings and young trees that start up, effectively preventing forest regeneration.

Forest clearing was practiced by the shepherds, as well as by their flocks, as Vergil indicates:

Just as, in summer, when the winds he wished for
Awake at last, a shepherd scatters fires
Across the forests; suddenly the space
Between the kindled woods takes fire, too.[31]

The object was to improve grazing by replacing forest and *maquis* with grass. Added to this, wildfires usually ranged unchecked unless they threatened a settlement. Fires in Mediterranean vegetation tend to be catastrophic, almost completely denuding the slopes, although the plants have adapted to fire and show remarkable powers of recovery if not prevented by grazing.

Goats forage on a hillside of typical maquis vegetation near Athens. Overgrazing, particularly by goats, was a primary cause of deforestation in ancient Greece and Rome.

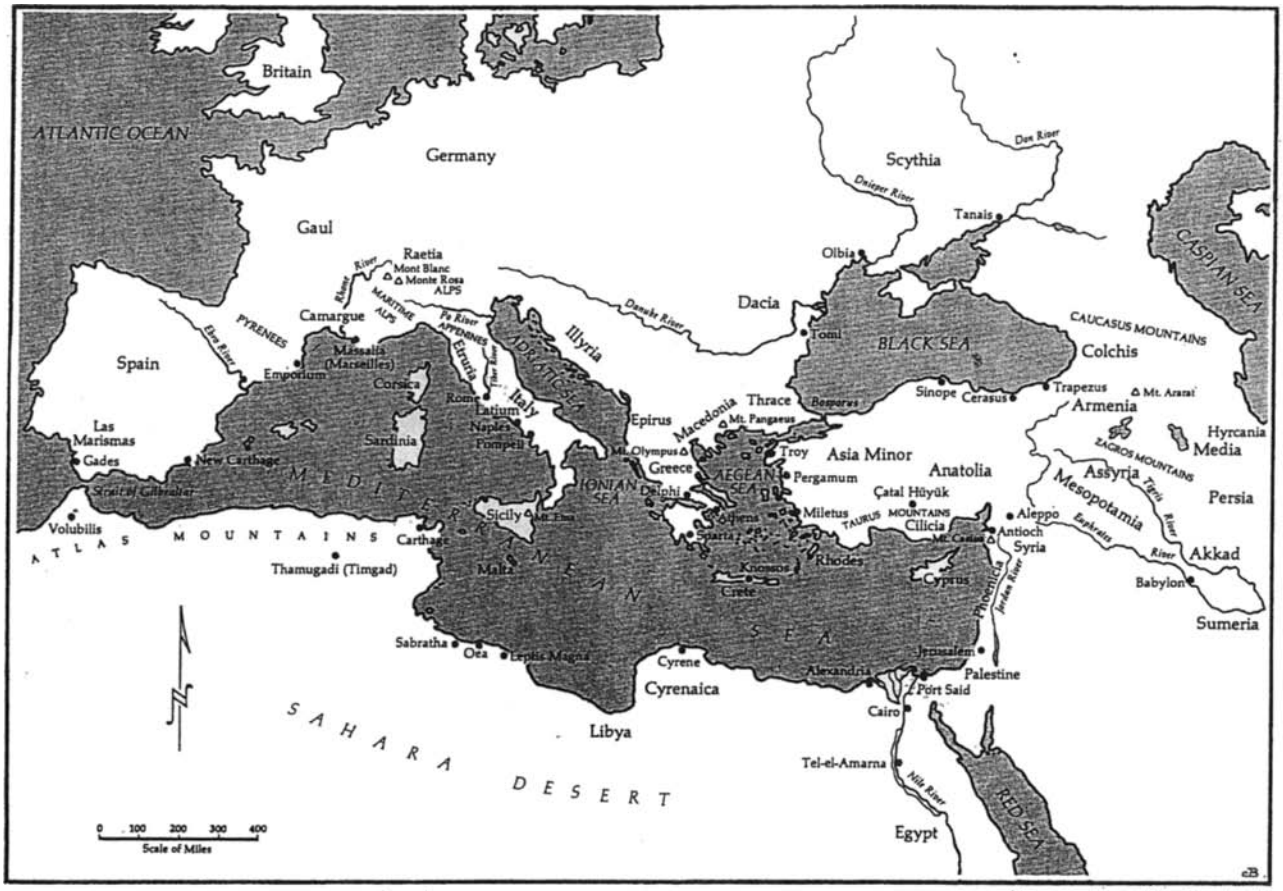
A final cause of deforestation is urbanization. As the cities and towns grew, they encompassed forest districts that were later remembered, if at all, by place names formerly attached to groves of trees. Pliny the Elder mentions quarters of Rome named after a laurel grove, an oak forest, beeches, and willows.[32] Speaking of the disappearance of the famous forest of *thyon* trees from the Greek colony of Cyrene (modern Cyrenaica in Libya), Theophrastus says, "There was an abundance of those trees where now the city stands, and people can still recall that some of the roofs in ancient times were made of it."[33] And the Aventine Hill, one of the seven on which Rome was built, was once "covered with trees of every kind . . . but the whole place is now covered with buildings, including, among many others, the Temple of Diana," according to Dionysius of Halicarnassus (late first century B.C.).[34]

III. THE EXTENT OF DEFORESTATION

How widespread was deforestation in the ancient Mediterranean basin? Classical writers leave the impression that it was extensive. Forests of various types

[28]*Ibid.*, 3.314-15.
[29]*Ibid.*, 2.374-75.
[30]Macrobius, *Saturnalia* 7.5-9.
[31]Vergil, *Aeneid* 10.405-9.

[32]Pliny *HN* 15.40(138); 16.15(37).
[33]Theophr. *Hist. Pl.* 5.3.7.
[34]Dionysius of Halicarnassus, *Antiquitates Romanae* 3.43.1.



Map courtesy of J. Donald Hughes

originally covered most of the land surface. Examples of vanished forests mentioned range from Pliny's region of giant trees in Egypt to the woods of Sicily and Spain whose passing Diodorus (d. after 21 B.C.) chronicled.[35] "In those days," says Livy (59 B.C.-A.D. 17) of fourth-century-B.C. Italy, "the Ciminian forest was more impassable and appalling than were lately the wooded defiles of Germany."[36] Readers in Livy's day would have found precious little forest where the army of Fabius had marched with such difficulty against Hannibal two centuries earlier. The lines of Homer and Vergil resound with axes and falling trees. Strabo (63 B.C.-A.D. 21) complains that the forests around Pisa were being consumed in order to construct public and private buildings in Rome and ostentatious villas in the countryside.[37]

Classical writers could see that deforestation was widespread and severe; we are told that it was difficult to find timber suitable for shipbuilding, that good forests were generally limited to the mountains, and that sources of valuable wood were exhausted. Mediterranean forests were retreating from population centers, up the hillsides, and into moister and more isolated seclusions. Early authors may call an area forested that later writers know as barren, while traces of vanished forests persist in place names like Elatea ("Firtown"), Pityoussa ("Pineville"), Castanea ("Chestnutburg"), or Xylopolis ("Timber City").[38]

Destruction or at least exploitation of forests began, as would be expected, near regions of greatest demand — urban centers and mining districts. The environs of Athens were mainly bare by Plato's time, and Euboea, whose relict forests suggest abundant original growth, produced only inferior timber once the extensive silver mining complex at Laurium had stripped the island of accessible wood. The earlier Mediterranean cities and civilizations flourished in the eastern and southern parts of the basin — Egypt, Syria, Phoenicia, Asia Minor, and Greece — and therefore forests in these regions came under pressure before other areas. Since the east and south were more deficient in rainfall (for example, Genoa in northern Italy gets 52 inches per year, Athens 16 inches, Alexandria only 8 inches), the forests there were less abundant to start with and recovered more slowly from heavy use.[39] To generalize, exploitation progressed from east to west and from south to north, with the movement of civilization. Locally, more accessible

[35]Pliny *HN* 13.19(65).
[36]Livy 9.36.1.
[37]Strabo, *Geography* 5.2.5(C223).

[38]These names can be found in Allan Chester Johnson, "Ancient Forests and Navies," *Transactions and Proceedings of the American Philological Association* 58 (1927): 199-209; Herodotus, *Histories* 7.183, 188; and Claudius Ptolemy, *Geography of Claudius Ptolemy*, translated and edited by Edward Luther Stevenson (New York: New York Public Library, 1932), map of Macedonia, p. 87.
[39]Ellen Churchill Semple, *The Geography of the Mediterranean Region* (New York: Henry Holt, 1931), pp. 90, 98.

forestlands were cleared before the more isolated — lowlands lost their trees while the mountains preserved theirs and forests near rivers that could float logs were exploited before those further away. Some forests were leveled by the woodcutters' axes, recovered, and were cut again. The areas most often praised as sources of good timber at the height of classical times tend to be mountainous regions with heavier than average rainfall. Macedonia on the northern Greek borderlands, the Alps of Europe, the Atlas Mountains of western North Africa, the mountains of the Black Sea coast, and the island of Corsica may serve as examples. Lebanon, Cyprus, and the Taurus Mountains of southern Turkey were the prime sources of "cedar" from which successively the Byzantines, the Crusaders, the Levantine Frankish kingdoms, the Arabs, the Turks, and the Mamelukes obtained timber.

IV. THE IMPACTS OF DEFORESTATION

It is important to emphasize the significance of Mediterranean forest ecosystems for environmental stability. The basin as a whole is mountainous and characterized by sparse rainfall that comes mainly in a few heavy winter storms; if there are summer rains, they descend in violent thunderstorms. The result of forest removal in such an environment can be catastrophic. Unprotected by the former forest cover, the soil is exposed to powerful erosion forces. George Perkins Marsh, the nineteenth-century Vermonter, understood this factor of environmental degradation well:

> **vast forests have disappeared from mountain spurs and ridges; the vegetable earth accumulated beneath the trees . . . the soil of alpine pastures . . . are washed away; . . . rivers famous in history and song have shrunk to humble brooklets: . . . harbors . . . are shoaled by the deposits of the rivers at whose mouths they lie.**[40]

The common results of deforestation in the Mediterranean basin are erosion of the hillsides, flooding as the gathering waters are no longer retarded and absorbed, disruption of the water supply, and siltation of lowlands and coastlands.

Ancient writers were aware of these problems. The Roman engineer Vitruvius (late first century B.C.) understood the role of forests in providing and preserving the flow of water in springs, as this passage demonstrates:

> **Water . . . is to be most sought in mountains and northern regions, because in these parts it is found of sweeter quality, more wholesome and abundant. For such places are turned away from the sun's course, and in these especially are many forest trees; . . . nor do the sun's rays reach the earth directly and cause the moisture to evaporate. Valleys between mountains are subject to much rain, and because of the dense forests, snow stands there much longer under the shadow of the trees and the hills. Then it melts and percolates through the interstices of the earth and so reaches to the lowest spurs of the mountains, from which the product of the spring flows and bursts forth.**[41]

The connection between forests and water supply was noted by several authors. In A.D. 174 Pausanias visited a place "clothed with oak woods" and remarked of it, "No town in Greece is more abundantly supplied with flowing water than Phellae."[42] Ancients also understood the effects of deforestation. As Pliny noted, "often indeed devastating torrents unite when from hills has been cut away the wood that used to hold the rains and absorb them."[43] Pliny mistakenly thought that deforestation also produced springs, but Plato observed more accurately that the water that rushed unimpeded down the mountainsides was no longer available to feed the springs. Perhaps for this reason, Plato portrays his ideal Atlantis as having springs surrounded by plantations of appropriate trees."[44]

Plato also tells us that soil erosion following the deforestation of Attica left the mountains wasted like rocky skeletons.[45] Pausanias compares the silt deposits laid down at the mouths of two rivers: the Achelous, whose watershed was uninhabited (and presumably forested), "does not wash down so much mud on the Echinadian islands as it would otherwise do," but the Maeander, whose valley had been cleared, "had turned the sea between Priene and Miletus into dry land."[46]

The cycle of deforestation and erosion, once begun, tends to reinforce itself. The high forest gives way to *maquis*, a dense evergreen thicket, and this in turn to *garigue*, a sparse growth of spiny and often aromatic low shrubs than can support itself on the dry, denuded slopes. Further destruction can produce landscapes as bare as any steppe, a condition seen on countless Mediterranean hillsides today.[47] Recovery and reforestation occur only over an extended time scale, and then only if there are surviving seed sources and all destructive impacts — especially fire and grazing — are kept out.

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[40]George Perkins Marsh, *Man and Nature*, edited by David Lowenthal (Cambridge: Harvard University Press, 1965), p. 9.

[41]Vitruvius, *De Architectura* 8.1.6-7.
[42]Pausanias, *Description of Greece* 7.26.4.
[43]Pliny *HN* 31.30(53).
[44]Plato, *Critias* 117A.
[45]Plato, *Phaedo* 110E.
[46]Paus. 8.24.5.
[47]Oleg Polunin and Anthony Huxley, *Flowers of the Mediterranean* (Boston: Houghton Mifflin, 1966), pp. 5-13.

Destruction of watersheds results in intermittent flows and increased siltation, here demonstrated by the braided channels of the River Peneios in Thessaly, Greece.

Erosion and siltation were extensive in classical Greece and Rome. The amount of soil actually removed from the highlands is hard to measure. Much of it washed to sea, but some came to rest in valleys and lowlands, and these deposits can be dated from artifacts found in them or from the radiocarbon content of organic materials. The studies now being made of erosive deposits in the Mediterranean basin (some not yet published) indicate that erosion was a complicated and often highly localized process.[48] Serious erosion, however, occurred at least in some areas during classical times. Thermopylae, the well-known pass between the cliffs and sea near the mouth of the Sperhios River, was narrow enough in 480 B.C. to be defended by a relatively small army. Today, accretion of river silt has widened the delta of the river at least five miles seaward from the site of the famous battle. A study by Sheldon Judson indicates that erosion rates near Rome increased dramatically during the second century B.C., a period of agricultural reform that presumably involved extensive land clearing. The erosion rate, averaged over the entire drainage basin, increased from 2-3 centimeters per 1,000 years before the second century B.C., to 20-40 centimeters per 1,000 years afterwards.[49]

Deforestation and erosion must have affected both the larger environment and the social and economic welfare of the Mediterranean people. Some of the primary physical effects have already been mentioned. Soil in the uplands was washed away so that, as Plato noted, "What now remains compared with what then existed is like the skeleton of a sick man, all the fat and soft earth having wasted away, and only the bare framework of the land being left."[50] Without forests to absorb and impede the rainfall, torrential floods increased. Roman records, for example, indicate increased flooding on the Tiber River from the third century B.C. onward. (The first flood is recorded in 241 B.C.)[51] Streams that formerly flowed clear all year long became intermittent and muddy, existing only as dry courses during the long Mediterranean summer, while hundreds of springs dried up. Deposition began in the lowlands and along the seashore, where over the centuries vast marshlands have appeared. Those around the mouths of the Po are one example.

Microclimate also changes when forests are removed. The deforested tract will be more arid and windier. How far beyond the immediate area such effects might be felt is a matter of conjecture, but it seems almost certain that the general aridification that occurred over much of the Mediterranean basin since the classical period is due to human interference with the regional environment. One thinks of the so-called Fertile Crescent of Palestine, Syria, and Iraq. Theophrastus recorded changes in local climate occurring in his own lifetime; after the trees had been cut around Philippi, he records, the waters dried up and the weather became warmer.[52] Such impacts have been most serious in marginal areas such as the borderlands of the Sahara and Arabian deserts.

Agricultural productivity suffered in such cases. Siltation and salinization, the accumulation of salts in the soil due to evaporation in areas where crops are grown under irrigation, is worsened by deforestation in the headwaters because the resultant erosion clogs irrigation canals and ditches and increases the amount of dissolved salts in the irrigation water. Today, areas of extreme salinization occur in the Near East, North Africa, and even in some parts of Italy.

Despite its neglect by most historians in recent times, soil exhaustion has been one of the most important causes of the decline of agricultural productivity. Roman agricultural writers certainly were aware of it. Many of them noted that forested areas, when first

[48]John Kraft, "The General Picture of Erosion in the Mediterranean Area," and Colin Renfrew, "Erosion in Melos and the Question of the Younger Fill," papers presented at the conference described in footnote 7.

[49]Sheldon Judson, "Erosion Rates near Rome, Italy," *Science* 160 (1968): 1444-46.

[50]Pl. *Criti.* 111B.

[51]Orosius, *Historiae Adversum Paganos* 4.11.

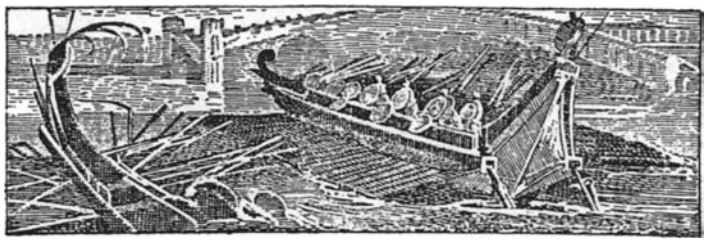
[52]Theophr. *Caus. Pl.* 5.14.5.

cleared and cultivated, usually produced abundant crops — the assart effect — but in subsequent years were less and less fertile. Columella (first century A.D.), the Roman writer with the greatest practical insight into these matters, shrewdly observes that this is not chiefly because cleared lands are "young" and have been lying fallow but rather because the leaves and roots of woodland plants had provided nourishment to the soil, of which it was now deprived.[53] Soil erosion has contributed to agricultural decline throughout much of the Mediterranean basin and seems to have reached a particularly critical stage during and after the third century A.D., when the classical cultures were in decline. It has been viewed as a failure of nature to support mankind, but in reality it has been a failure of mankind to support nature.

The code of Emperor Theodosius II, issued in A.D. 438, records a series of imperial edicts designed to shore up the sagging agricultural base of the Eastern Roman Empire.[54] Increasing reference is made to *agri deserti* (deserted fields), abandoned either because they were no longer sufficiently productive or because of the disastrous military campaigns that disrupted and depopulated the countryside in some sections. Chronic shortages of food resulting from agricultural decline further contributed to a downward demographic trend throughout most of the period from the second century A.D. to the end of the classical age. The loss of accessible productive forest and the impact of deforestation upon the potential of remaining croplands exacerbated the problem.

Malaria and other swamp-bred illnesses — a secondary result of deforestation and erosion — also contributed to population decrease. The sediments that clogged the rivers were deposited in low-lying valleys or along the Mediterranean shores where few tides exist to carry the material away. The resulting new marshlands became breeding grounds for mosquitoes and contributed to the spread of malaria, which seems to have entered the classical world during the fourth century B.C. Opinions differ as to how quickly malaria actually spread in Italy after its introduction, but eventually thousands of acres of land were abandoned to it. The fact that mosquitoes were the carriers was unknown to the ancients (although some of them came tantalizingly close to the truth), but they certainly knew that low, swampy places had to be avoided at the peril of one's life and health. The Pontine marshes near Rome were one famous example. The Romans drained them several times but without permanent success because the basic causative factors remained.

The effects of deforestation and erosion on trade, while not as dramatic as those on health and popula-



tion, were certainly important. As abundant sources near the centers of consumption disappeared, wood became rarer as a commodity and had to be imported over long distances. The result was a rise in price, particularly noticeable in fine woods but affecting other kinds of timber and fuel as well. Detailed price lists have survived from a few periods, and these can be interpreted to show a pattern of rising prices. People caught in areas of short supply might well have found, as did later Mediterranean travelers, that the wood for a supper fire cost as much as the meat in the pot.[55] Pay in kind for Athenian jurors included fuelwood, recognized as the third necessity along with bread and *opson* (fish, fruit, etc.).

The shortage and high cost of building timber due to deforestation contributed to the observable shift from wood construction to stone in both Greece and Rome, or even from the much-used brick of the Roman era to marble, since the latter required no wood fuels and firing.

Deforestation also increased transportation costs, due not only to the greater distance merchants had to go to find wood but also to the scarcity of good shipbuilding timber adjacent to principal shipbuilding centers, which drove up the price of the merchant ships themselves. Warships had priority over merchant vessels in the competition for materials. Moreover, siltation constantly clogged harbors, and herculean labors were needed to keep them usable. The repeated efforts of the Romans to keep open Ostia, Rome's major port at the mouth of the River Tiber, are described in ancient written sources, are apparent in archaeological studies of the site, and are evident in modern aerial photographs showing the successively constructed and abandoned basins for the use of shipping.[56] They can be compared with the ongoing river dredging and harbor development of present-day port authorities.

Warfare and diplomacy were other areas of human activity affected by the depletion of forests. The Greek *poleis*, the Hellenistic kingdoms, and republican and imperial Rome were all forced to develop strategies directed toward obtaining supplies of timber and other

[53]Columella *Rust.* 2.1.5-6.

[54]*Code of Theodosius* 11.16.15,18.

[55]Fernand Braudel, *The Mediterranean and the Mediterranean World in the Age of Philip II*, translated by Sian Reynolds (New York: Harper and Row, 1972), 1:239.

[56]Russell Meiggs, *Roman Ostia* (Oxford: Clarendon Press, 1960).

One of several remaining groves of the famed cedars of Lebanon, this stand is protected as part of a monastery; a stone fence keeps out foraging goats. In ancient societies one form of forest protection was the designation and regulation of sacred groves.
Walter C. Lowdermilk photo, courtesy of Robert K. Winters

essential forest products and guarding the sea-lanes and roads over which they were transported. Historians in Greece and Rome saw the timber supply as a major factor in determining naval strategy in particular. During the Punic Wars, Rome is said to have rushed ships to completion — from tree to sea — in as little as forty to sixty days.[57] Most of that timber came from Rome's state forests and Etruscan vassal communities.

Domestic ships' timber, if available, was preferred. Dionysius of Syracuse (430-367 B.C.), for example, found all the shipbuilding material he needed in the rich forests he controlled in Magna Graecia (southern Italy), although Hiero (270-215 B.C.), a later tyrant of the same city, had to search far and wide for a suitable mast for a very large warship.[58] Athens' lack of timber was common knowledge; Plato believed that, from early times, Attica had not been "rich in timber suitable for the easy construction of a navy."[59]

One way to get forests was to conquer them. As Alcibiades told the Spartans, this was one of Athens' major purposes in launching the Sicilian campaign (415 B.C.) during the Peloponnesian War.[60] Areas both strategically located and rich in forests, like Cilicia and Cyprus, were often the object of conquest by those who needed to build ships. Colonies were established in forested regions to assure the founding cities' timber supplies. This, together with the presence of gold and silver, was the reason for Athens' founding of Amphipolis in Macedonia on the River Strymon, below heavily wooded mountains, and also for Augustus Caesar's foundation of Nicopolis (31 B.C.), a Roman colony in forested Ambracia, in northwestern Greece.

International diplomacy often hinged on obtaining shipbuilding supplies. Pharnabazus, the Persian Satrap of Phrygia (in Asia Minor), helped to sway the course of the Peloponnesian War (431-404 B.C.) by giving the Spartans access to the forests of Mount Ida and counseling them "not to be discouraged over a lack of ship's timber, for there is plenty of that in the King's land."[61] A short-lived treaty between Athens and Perdiccas (d. 321 B.C.) pledged the Macedonian regent to export wood suitable for oars only to Athens, and a later treaty between Amyntas, king of Macedonia, and the Chalcidians required the latter to obtain the king's permission and pay duties to export fir timber for ship's masts (while allowing them to trade less strategic lumber freely).[62]

The realities of warfare forced states to protect their own sources of timber against challengers and to attempt to seize the areas that supplied their enemies. The Etruscans, who were exploiting the forests of Corsica, thwarted the attempt of the Phocaeans to found a colony there. As previously indicated, much of the strategy of the Peloponnesian War revolved around timber supplies; the northern campaign of the Spartan general, Brasidas, was intended to cut off Athens' timber supply from that region and direct it to Sparta and her allies. "The Athenians," Thucydides reported, "were greatly alarmed by the capture (424 B.C.) of Amphipolis. The chief reason was that the city was useful to them for the importation of timber for ship-building."[63] The great extent to which warfare was affected by, and interacted with, the timber supply is quite clear.

V. AWARENESS AND RESPONSE — FOREST MANAGEMENT

The importance of timber supply and the effects of deforestation and erosion were evident to ancient observers, since they described and often lamented them. It would seem strange, therefore, if people, both individually and collectively, had not devised means to remedy the problems and mitigate their impact.

[57]Pliny *HN* 16.74(192); Livy 28.45.15-21.
[58]Diodorus of Sicily, *World History* 14.42.4; Athenaeus, *Deipnosophists* 5.206f, 208ef.
[59]Pl. *Laws* 4.706B.
[60]Thuc. 6.90.
[61]Xenophon, *Hellenica* 1.1.24-25.
[62]Marcus Niebuhr Tod, *A Selection of Greek Historical Inscriptions* (Oxford: Clarendon Press, 1933), 2:111.
[63]Thuc. 4.108.

Indeed they did, and though some of these efforts may seem minor, they had important cumulative results.

We shall begin with the private efforts to conserve forest resources. Agriculture involved the preservation of some forestland and the planting of trees for timber as well as fruit. Greek and Roman farmers did not usually clear all their land. An ideal farm, they reasoned, should be partly wooded and rough; Cato included a woodlot as the seventh of nine requirements for every good farm.[64] Some farm estates in fact contained large forests that supplied wood for construction, manufacture, table food (nuts, wild berries, and honey) and foliage for fodder. The cultivation of forest trees was widespread for all these purposes, and in addition trees were planted to line roads, mark field and property boundaries, and support grapevines. Large-scale afforestation was not unknown in the ancient Mediterranean. Landowners propagated trees by starting seeds or cuttings in nurseries and transplanting the young trees. Pliny the Younger (A.D. 62-113) remarks that the mountain slopes around his villa were "covered with plantations of timber."[65] Willows and other water-loving trees were planted along streams and in swampy ground. Pollarding was a common practice, as was coppice. Cultivated trees were esteemed for the protection they offered from winds; they added so greatly to the value of a property that when Crassus (d. 53 B.C.) would not sell some large trees with his estate, Domitius refused to buy it, even though he had previously offered a princely sum.[66] It is no wonder that Columella condemned a neighbor who cut down trees near his property line.[67] In addition to timber-producing trees, the Mediterranean peoples planted thousands of crop trees. In the first century B.C., Varro asked, "is not Italy so covered with trees that the whole land seems to be an orchard?"[68]

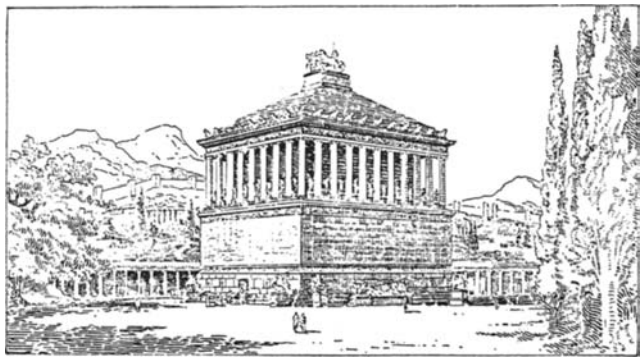
As woodlands were removed to make room for cultivation and grazing, birds and animals were killed and their habitat destroyed. Lucretius exhorted, "convert the woods to open harvest fields, kill the wild beasts."[69] But there were also some attempts at conservation. Vergil noted that as trees were felled, the birds had no place to nest.[70] Columella remarked that "the task of a good huntsman, tracking his prey in a vast forest, is to catch as many wild beasts as he can, but no blame has ever been attached to anyone if he did not catch them at all."[71] The wealthier landowners limited the process of forest clearance by enclosing tracts of forestland as private hunting reserves and stocking them with deer, boars, and other wild animals. Quintus Hortensius (114-50 B.C.) had more than 50 jugera (33 acres or 13.3 hectares) enclosed within a wall.[72] Others maintained artificial parks, planted trees of many species together in studied disorder to make an artificial wilderness, or imported exotic trees. How far all these efforts contributed to the development of forest management is unclear, but they do indicate an appreciation for trees inconsistent with thoughtless forest destruction.

A practice that averted deforestation to some extent was the protection of sacred groves. This involved both individuals and government, since many such groves were first set aside by private landowners and later given legal protection by local governments. Thus a pious appreciation for trees was enforced by laws carrying penalties that were by no means negligible. The multifaceted association of gods with trees and forests was so intimate that a particularly impressive grove of trees might prompt an ancient observer to exclaim, "There's a god in there!"[73] At Dodona and elsewhere the god's voice was heard in the rustling of leaves. Groves were places of worship; the temple buildings that were erected in them later were at first simply protective shelters for the images of the gods, while the altars remained outdoors under the trees. Sacred groves were carefully demarcated and consecrated. The earliest were tracts of virgin forest, although later many were special plantings. To the ancient sacred groves were added new zones to honor living emperor-gods, such as those Claudius (10 B.C.-A.D. 54) permitted in Egypt.[74] Some were quite large; one at Daphne in Syria was ten miles in circumference. As a result of the protection given to them, the individual trees often reached remarkable size; an oak at Corne reached fourteen feet in circumference, and the high cypresses of Psophis "overshadowed a mountain."[75]

The rules to prevent injuries to sacred groves were many: almost any act producing environmental change was forbidden, although rules varied considerably from place to place. The most serious sanction prohibited felling trees, breaking or cutting branches, and setting fires. Removal of dead wood and stripping leaves for fodder was likewise forbidden. Tilling the soil and sowing grain were prohibited, and in some groves no iron object such as an axe or saw could be introduced. Generally, no animals could be brought in, except for sacrifice.

Sacred groves were protected by local magistrates

[64]Cato the Elder, *De Agricultura* 1.7.
[65]Pliny the Younger, *Epistles* 5.67.7-13.
[66]Pliny *HN* 17.1(3-6).
[67]Columella *Rust.* 1.3.7.
[68]Varro *Rust.* 1.2.6.
[69]Lucr. 5.1248-49.
[70]Verg. *G.* 2.207-11.
[71]Columella *Rust.* 5.1.2.
[72]Varro *Rust.* 3.13.2-3.
[73]Ovid, *Fasti* 3.295-96 ("numen inest.").
[74]A. S. Hunt and C. C. Edgar, *Select Papyri,* vol. 2 (London: Harvard-Heinemann, 1934), no. 212.
[75]Pliny *HN* 16.91(242); Paus. 8.24.4.



who had jurisdiction over religious matters; in Athens it was the *archon* called the *basileus* (king). The priest of the grove, or indeed any witness, was expected to report infractions to the appropriate official, and there were penalties for witnesses who failed to do so. Penalties for desecrating the groves were moderately severe; slaves or aliens might be whipped (Plato additionally recommends imprisonment), and citizens were generally fined an amount sufficient to deter any attempt to make illegal profits from the groves.[76] Sometimes mandatory sacrifices were assessed, amounting to not inconsiderable fines in themselves.

To these legal penalties were added ritual curses and the far more intimidating imprecations that were believed to be hurled by the outraged gods and goddesses to whom the groves were sacred. Individual trees were inhabited by nymphs and dryads. Each of these dryads was believed to live only as long as her tree and to die when it was cut down. Anyone who ignored the pleas of a dryad and felled her tree risked terrible retribution. Erysicthon was stricken with hunger that could never be satisfied — perhaps a uniquely appropriate punishment for one who wantonly destroyed trees.[77]

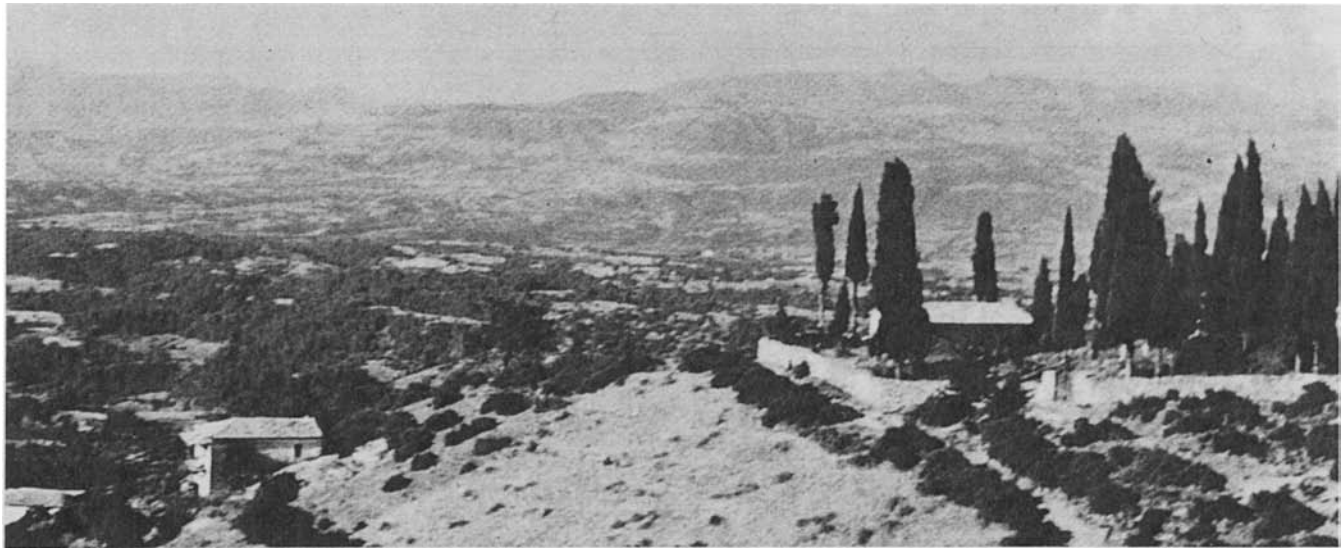
While religion threatened penalties, it also offered expiation in the form of prayers, sacrifices, and acts of restitution. The replanting of trees in a sacred grove, whether they had succumbed to decay, lightning, or the woodsman's axe, was regarded as a religious duty and was specifically required in the rules of the Arval Brethren. It was also written into leases. As a means of maintaining sacred places, such expiation is to be commended, but often it appears that prayers and sacrifices only eased the consciences of those who found it expedient to use the groves for their own purposes. Cato advises the sacrifice of a pig with an all-purpose prayer in order to obtain permission from a god or goddess to cut wood or to till the earth in a sacred grove.[78] Felling timber in a grove for a sufficiently religious purpose was also allowed — with the proper sacrifice. A tall cypress, taken from the precinct of Apollo on Carpathos, was sent to Athens to use in the rebuilding of the temple of Athena, and the Athenians were grateful enough to put up an inscription honoring their benefactors.[79]

Sacred groves near populated centers were used for many purposes other than those that might be considered religious in modern times. In addition to temples, they might contain baths, spring houses, arenas, gymnasiums, exercising grounds, schools, and the ancient equivalents of hospitals. In Greek and Roman eyes each of these had a religious purpose, although they could not have enhanced the sylvan qualities of the groves. Other uses could hardly be called sacred. Groves were evidently rented out to private entrepreneurs. We hear complaints that in Rome sacred precincts were rented out to foreign squatters.[80] It seems clear that although some religious attitudes and practices tended to preserve certain designated woodlands and individual trees, others weakened this effect.

There were numerous public efforts to control the use of forests, assure the water supply, and mitigate the effects of erosion. Because of the great military and economic importance of timber, forests were considered a proper area of concern for governments. Government supervision of forests and watersheds was relatively widespread, involving regulation of the forest products trade, of the timber harvested, and of land use, as well as the construction of works to provide and control water supply and drainage. Responsibility for these matters was delegated to certain government officials; in some cities, for example, the timber trade was under *agoranomoi* (overseers of commerce), while forestland in the countryside was supervised by *hyloroi* (custodians of forests) who, Aristotle (384-322 B.C.) says, had "guard-posts and mess-rooms for patrol duty."[81]

It was a recurrent policy of Greek and Roman governments to encourage private exploitation of forests by leasing the right to cut trees on public land, (probably a lucrative source of revenue), or by outright sale or grant of public forestland to private individuals or consortiums. During the Hellenic settlement of Cyprus, says Eratosthenes (275-195 B.C.), rulers wished to open to cultivation land that was thickly overgrown with trees, so "they permitted anyone who wished, or was able, to cut the timber and to keep the land thus cleared as his own property, and exempt from taxes."[82] Rome also sponsored the clearing of land and the cultivation of wasteland by granting title to it. Forestland in the city of Rome was turned into a residential subdivision for the plebeians by the tribune Icilius.[83] It was Roman practice to rent huge tracts of woodlands for development to syndicates of *equites,* citizens of second-highest rank who were usually businessmen. There is evidence from the late

[76]Pl. *Laws* 6.764B.
[77]Ovid, *Metamorphoses* 8.738-878.
[78]Cato, *Agr.* 139-40.
[79]Tod, *Greek Historical Inscriptions,* no. 110.
[80]Juvenal, *Satires* 3.13-16.
[81]Aristotle, *Politics* 6.5.4(1321b); 7.11.4(1331b).
[82]Strabo 14.6.5(C684).
[83]Dion. Hal. *Ant. Rom.* 10.31.2.



A cemetery in the southern Peloponnesus contains a grove of cypresses and suggests the appearance of the ancient temenos (reserved temple grounds), in which felling trees, cutting branches, removing wood, starting fires, and other disturbances were prohibited.

Empire that forestland belonging to the emperor was regularly sold to private owners who would clear the land, pay taxes on it, and provide other services, either as regular obligations or as liturgies — supposed "free gifts." These could include payments in kind of lumber, charcoal, burnt lime for mortar and fertilizer, and wood for weapons.

While governments in this manner encouraged deforestation, they were not unaware of the danger of a diminishing supply of wood, and they also sometimes regulated private land so as to encourage conservation. Plato's recommendation that landowners be fined if fire spread from their property to the timber of a neighbor's land doubtless represented actual Greek law.[84] Published decrees of Ptolemy Euergetes (d. 221 B.C.), ruler of Egypt, prohibited unauthorized cutting of wood by private individuals on their own land and required the planting of trees.[85] Land leases elsewhere also contained restrictions on timber cutting and stipulations for replanting.

Government ownership, whether by the monarch or by the sovereign people, of all unoccupied forestland as well as the forests of conquered provinces was universally assumed. Although such lands were often granted to individuals or communities, large tracts remained in governmental hands, and measures were taken, albeit sporadically, to prevent encroachment and assure their use for the good of the state. When Scipio (185-129 B.C.) needed fir trees to make masts for the fleet he used against Carthage, he found them in "forests belonging to the State."[86] Wise administrators limited timber harvest; Theophrastus says that in Cyprus, "the kings used not to cut the trees . . . because they took great care of them and managed them."[87] He goes on to note that later rulers of the island reaped the benefit of their predecessors' restraint; Demetrius Poliorcetes (377-283 B.C.) cut timber of marvelous length there for his ships.

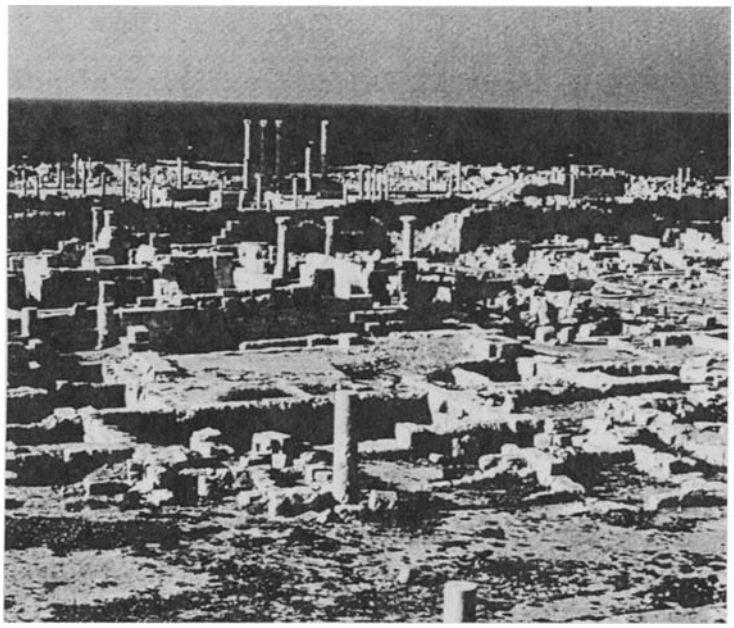
Tree plantations were encouraged by some governments. Egypt, where the need for wood was particularly acute, is a case in point. Michael Rostovtzeff sifted the evidence on the Ptolemaic period found in the papyri and discovered a nationwide tree-planting project covering wasteland, private land, royal estates, and the banks of rivers and canals.[88] Trees were started in government nurseries. Plantations were protected by laws regulating the felling of older trees, the lopping of branches, and the removal of fallen trees. Sheep and goats were excluded from areas where young trees had been planted.

Parks with groves of trees in them, called *paradises*, were a tradition perpetuated by Persian kings and adopted by other monarchs. Theophrastus says that the *paradises* in Syria protected especially fine, large Lebanon cedars.[89] Exotic trees imported and planted in these arboreta were more than curiosities: Apollonius advised Zeno to plant three hundred fir trees in the *paradise* at Philadelphia, "for the tree has a striking appearance and will be of service to the king."[90] By service, he no doubt meant that they would eventually be felled for timber. Hadrian (A.D. 76-138) demarcated large areas of strictly protected state forest in Lebanon; his inscribed boundary markers listing the protected species remain today in the midst of a treeless, eroded wilderness.

The state should take measures to keep water pure and regulate its supply from the hills, advises Plato in the *Laws*, and the abundant archaeological evidence of dams, tunnels, aqueducts, tanks, terraces, and drainage canals all around the Mediterranean basin reveals

[84]Pl. *Laws* 8.843E.
[85]Hunt and Edgar, *Select Papyri*, vol. 2, no. 210.
[86]Livy 28.45.18 ("ex publicus silvis").
[87]Theophr. *Hist. Pl.* 5.8.1.

[88]Michael Rostovtzeff, *The Social and Economic History of the Hellenistic World*, 3 vols. (Oxford: Clarendon Press, 1941), 1:299, 480-81; 3:1169-70.
[89]Theophr. *Hist. Pl.* 5.8.1.
[90]Rostovtzeff, *Hellenistic World*, 1:357.



Its ruins excavated from beneath desert sands, the Roman city of Sabratha in Libya was an exporter of grain and olive oil in ancient times. Drastic environmental changes affected many such cities along the northern margin of the Sahara.

the scale of the effort to make maximum use of available water, direct its supply, and protect against drought, flood, and erosion.[91] Roman dams and canals in North Africa and Syria stand in dry *wadis* today as witness to the fact that destruction of the vegetation and consequent dessication have changed the environment and that the extension of Roman *limes* (areas of settlement) far into water-deficient regions depended upon the efficient use of available supplies.

Literary and archaeological evidence reveals that both the Greeks and Romans were pragmatic people who approached environmental problems in a rational, commonsense way. Their traditional religions taught them to stand in awe of nature and interfere as little as possible in natural processes. Although these sanctions lost their original force over time, the best insight of traditional religion was later couched in the language of Greek rationalism, as was expressed succinctly by the practical philosopher Xenophon (430-355 B.C.): "The earth willingly teaches righteousness to those who can learn; for the better she is served, the more good things she gives in return."[92] The converse thesis, that a mistreated earth will take vengeance on mankind, was also pronounced by ancient writers. Thus the *do ut des* of the archaic prayers — "I will give to you so you will give to me" — became the "cause and effect" of philosophers and agricultural writers.

There was, however, an incomplete understanding as to how to realize such ideals. The Romans in particular came to have complete faith in their ability to maintain their environment. Their sense of mastery over, yet responsibility for, the environment is epitomized by Cicero (106-43 B.C.):

> **We are the absolute masters of what the earth produces**
> **We enjoy the mountains and the plains,**
> **The rivers are ours, we sow the seed and plant the trees.**
> **We fertilize the earth . . . we stop, direct, and turn the rivers,**
> **in short by our hands we endeavour, by our various operations on**
> **this world, to make, as it were, another nature.**[93]

Greeks and Romans knew how to farm, fertilize, rotate crops, grow trees, and terrace hillsides to prevent erosion. But they had no concept of an ecosystem nor of the possible effects of human interference in one aspect of the natural environment upon seemingly distant and unrelated matters. This is perhaps to state the case too bleakly, for there were classical thinkers who were aware of ecological interdependencies. Some of the early naturalists proclaimed philosophical principles that could have served as the foundation of ecological science, but they were only beginnings.[94] Although supported by extensive observations, theories about the interconnectedness of the natural world must have been considered speculative by the vast majority of the men who made government decisions in classical times.

A Roman consul who directed the construction of an aqueduct thought only of supplying potable water to the city, ignoring the possible effect on streamside ecosystems below the point of diversion. The *aedile* who issued a license to an equestrian consortium to strip the trees from some watershed did not consider whether the water in the aqueduct would become muddy or its flow less dependable. When the same *aedile* depleted North Africa of its lions for the arena, it never crossed his mind that, in the absence of predators, wild goats might strip the vegetative cover from hillsides on the margin of the Sahara. This is not to condemn the Romans but simply to point out their lack of some ecological insights that, due to the advance of research in modern times, we take for granted.

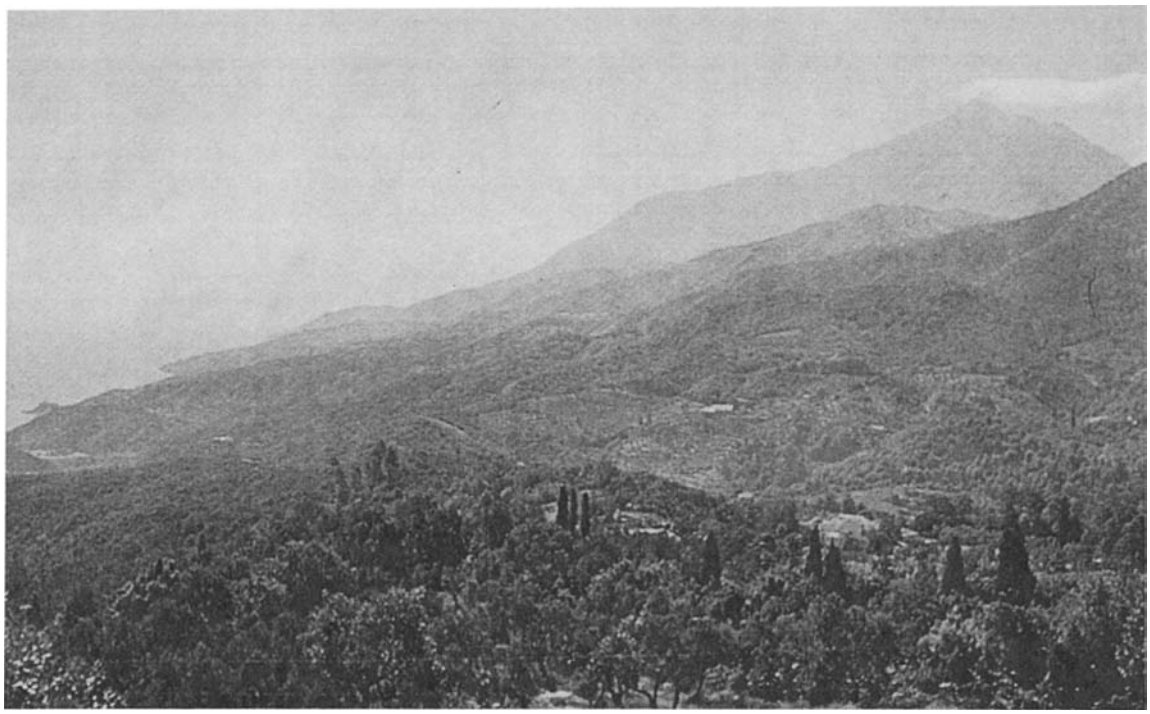
The Romans were premier engineers and agricultur-

[91]Pl. *Laws* 6.761B-C, 8.845E.

[92]Xenophon, *Oeconomicus* 5.12.

[93]Cicero, *On the Nature of the Gods* II, 39, 45, 53.

[94]Anaxagoras' (500-428 B.C.) statement, "Nothing exists apart; everything has a share in everything else" (fr. 6), verges on such an awareness, as does Empedocles' (495-435 B.C.) teaching, "There is no birth in mortal things, and no end in ruinous death. There is only mingling and interchange of parts" (fr. 8). Aristotle sharpened the thought: "All things are ordered together somehow, but not all alike — both fishes and fowls and plants; and the world is not such that one thing has nothing to do with another, but they are connected" (*Metaphysics* 12.10.2[1075a17-20]). The botanical writings of Theophrastus contain the actual beginnings of scientific ecological thought.



The monastic preserve of Mount Athos in Greece has been protected from overgrazing and deforestation for more than a thousand years. The vegetative cover of this peninsula, which contains many endemic species of plants, stands in contrast to the eroded, deforested landscapes typical of many Mediterranean areas since antiquity.

ists who were fully capable of maintaining the complex structures they had erected, but their efforts often dealt with the symptoms rather than the roots of the problem. During the last days of the Empire and the regimes that followed, the centralized administration necessary to keep the system working fell into decline, and the system collapsed. The eventual result is the North African and Near Eastern environment of the present day.

In all fairness to the Greek and Roman agricultural engineers, the constant warfare that, except for a few happy decades, afflicted the Mediterranean world also contributed to instability. The works constructed to prevent erosion and carry water — terracing in particular — were monumental, extensive, and in terms of human labor, very expensive to maintain. Yet taxation was directed toward supporting armies, not farmers. Moreover, frequent wars and military campaigns conscripted farmers, and casualties decimated the countryside. Deliberate destruction occurred over and above the fact that hostilities disrupted normal work. When maintenance was neglected, terraces collapsed and irrigation channels became clogged with silt. Erosion, in fact, can be correlated with periods of widespread war, breakdown of government, and social dislocation.[95]

VI. CONCLUSION

In retrospect, let us consider the role of deforestation and erosion in the decline of ancient civilization. Did the destruction of the Mediterranean forest and related soil erosion make it impossible for the classical cities and nations to continue? Were the forests of the Mediterranean basin devegetated and denuded by the end of the classical period? Scholars have differing views on the matter, and the present state of knowledge leaves the question open, particularly in view of the historian's limited sources and consequent inability to quantify many crucial points. Moreover, since so many interconnected factors were at work in the fall of Greece and Rome, it is difficult to isolate any single development. The ecologist, used to thinking in terms of systems and synergies, can sympathize with the historian at this point.

But we have examined sufficient evidence to document several forms of environmental deterioration and to make a preliminary judgment that the ancients who described deforestation and erosion as a serious problem were correct. Although the extent of those problems is unclear, they undoubtedly contributed, at least locally, to the problems that led to the political and economic demise of the ancient world.

Since we have criticized those who avoid consideration of modern implications of historical studies, it seems only just to add a brief reflection in that vein. The problems we have been describing continued through the postclassical era into modern times. At intervals they were greatly intensified, and they persist today. Man's strong dependence on timber persists, although much expanded in scope and different in detail. Though parallels are dangerous, and though Greece and Rome were civilizations vastly different from ours, the fundamental premise is clearly applicable: wise use of the forest and related resources is an inescapable necessity. □

[95]Claudio Vita-Finzi, *The Mediterranean Valleys: Geological Changes in Historical Times* (Cambridge: Cambridge University Press, 1969).