Landscape Ecology and the End of Antiquity: The Archaeology of Deforestation in South Coastal Turkey

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History and Purpose of the Rough Cilicia Survey Project

The purpose of the Rough Cilicia Archaeological Survey Project is to examine the process of Roman provincial acculturation through the lens of Rough Cilician material and cultural remains. As high range theory we employ a number of competing models for social organization (such as world systems theory and structuration) to explain the development of the Roman agrarian imperial world system and the place of peripheral populations therein. Rough Cilicia (south coastal Turkey) was a mountainous coastal region of marginal significance. In less than 30 km, its terrain rises from sea level to a broad highland plateau (the Taşeli in the Tauros Mts.), the crest of which attains 2300m elevation (**Figs. 1-4**). Although its narrow cache basins furnished limited means of subsistence, our research indicates that its population generated surplus commodities far exceeding the region's carrying capacity.[1] In particular, Rough Cilicia was celebrated by sources such as Theophrasus and Strabo for its verdant stands of cedar trees whose rot-resistant properties made them desirable for shipbuilding.[2] An important component to our field work is an investigation of the paleo-environmental record of Rough Cilician landscape deformation to determine the approximate scale and timing of forestry resource production, as well as to identify the socio-cultural mechanisms by which surplus production was stimulated in the highlands.

During the course of twelve campaigns (1996-2008), the survey has investigated some 300 km^2 of archaeological terrain in the vicinity of modern Gazipasha (Fig. 2).[3] The team has mapped architectural remains and processed ceramics at approximately 150 "loci" of past human activity. The architectural team has produced plans of 14 built environments ranging from large urban sites on the coast to village and isolated farm sites in the hinterland. The pedestrian team has processed 8350 ceramic fragments to generate localized and general use chronologies for regional habitation during antiquity. Given the scale and difficulty of the Gazipasha landscape, the team has attempted to investigate a

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[1] This is indicated by the presence of Cilician transport jars in distant regions such as Rome, Carthage, and the Red Sea: Lund 2000, Rauh et al. 2006; Autret 2009. Regional population density was larger during the Early Roman era than at any other time (Blanton 2000: 60). As Table 5 of temporal ceramics data indicates, the Romanization of the region during the first two centuries CE appears to have marked peak ancient development; Rauh et al. 2009.

[2] The late first century BC geographer Strabo (14.5.3 [669]) asserted that Hamaxia near modern day Alanya was an important center for the collection of cedar timber hauled down from the interior. He adds that M. Antonius ceded this territory to Cleopatra precisely to obtain the resources necessary to construct the naval armada that they used at the Battle of Actium. Cf. Theophrastis *De Causis Plantarum,* 4.5.5; Appian *Mithridatica* 92, 96; Strabo, 14.5.6 (671); Meiggs 1982: 54; Blumenthal 1963: 117.

[3] We have been funded by the National Science Foundation, by the National Geographic Society, and by participating universities. Our conclusions do not reflect the views of these institutions.

variety of land forms ranging from the river valleys and low ridges along the coast, to the "foot hills" of the midlands (the Adanda Canyon campaigns, altitude range 600-800m), to the highland canyons at the base of the Taurus Mts (the Biçkici and the Karasin Canyons, altitude range 800-1200m).

To the extent that sherd densities of datable ceramic remains reflect historical patterns of settlement in western Rough Cilicia, the results of our ceramic investigation form a consistent pattern (see **Fig. 5**). With approximately 8350 processed ceramic fragments, our sherd counts exhibit a minimal pre-Roman occupation (900-50 BCE) followed by a significant spike during the Early Roman era (50 BCE-250 CE). Sherd counts then drop significantly during Late Roman era (250-650 CE) and precipitously again during the early Byzantine era (900-1200 CE). Although Byzantine sherd counts are minimal, these and their associated structural remains have been identified in the highlands as well as along the coast.[4] This pattern of intensive regional development during the Roman and Late Roman eras followed by a dramatic decline in sherd counts for medieval pottery has proven relatively unchanging. Preliminarily, the assembled archaeological data of the survey points to widespread landscape abandonment following Persian and Arab incursions during the late 6th and the early 7th centuries CE.

To the theoretical constructs noted above, I would add one further perspective articulated recently by Bryan Ward-Perkins (2005) and referred to hereafter as the "theory of comfort." This theory assumes that the relative level of creature comfort achieved by a society furnishes a valid metric for that civilization's significance and accomplishment. The assessment of creature comfort is determined by analyses not only of its scale and permanence but also by the extent to which standards of comfort were enjoyed across society, geographically (from core cities to remote settlements on the periphery) as well as vertically (from wealthy urban elites to impoverished rural inhabitants). This theory bears directly on the question of deforestation in Rough Cilicia because the production of creature comfort here and elsewhere in the Roman world relied on fuel-driven firing technologies (kilns, forges). In Rough Cilicia timber was likely to have been the predominant source of fuel.

When one considers the material remains of Roman Mediterranean civilization, one is most struck is the enormous quantities of household possessions enjoyed by its inhabitants, particularly ceramics. Ward Perkins (2005, 88) notes two salient features of Roman pottery: its quality was excellent and displays considerable standardization, and the quantities in which it was produced were massive and widely disseminated. In Rough Cilicia our survey frequently identifies fragments of finewares originating from Cyprus, Syria, Italy, Gaul, and Libya not only at the urban coastal settlements but in sherd scatters in the highlands. This indicates that imported finewares were acquired and used by

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[4] Including an isolated single-era farmstead in the Hacimusa River valley. Medieval archaeologists elsewhere have demonstrated that ceramic remains are not necessarily a certain indicator of human occupation. General impoverishment of laboring forces oftentimes led to reliance on wooden implements that do not survive in the archaeological record. Architectural construction and increasing finds of Byzantine amphoras in the sea suggest a larger Early Byzantine presence in western Rough Cilicia than is indicated by sherd counts.

laborers and pastoralists lacking permanent homes. Our ceramic specialist, Richard Rothaus, meanwhile, has identified some 150 locally produced forms of common, coarse, and cooking ware, including basins, bowls, mugs, jugs, fry pans, stewpots, and casseroles. Coarse wares and cooking wares were, of course, produced locally throughout the Mediterranean, nearly everywhere that estuaries furnished clay beds suitable for production, so local production here is not all that extraordinary.[5] Ceramic production in Rough Cilicia was not restricted to kitchen wares, however. Our survey has identified at least three likely kiln sites for the production of internationally traded transport jars (amphoras; **Fig. 6**).[6] When combined with our identification of more than 30 press complexes and installations, it becomes evident that these shipping jars were used to transport locally produced wine and olive oil throughout the Mediterranean. Even by regional standards the scale of these kiln operations were significant. In Gazipasha our investigation of the Biçkici Kiln Site, that produced two types of internationally traded amphoras and various kinds of basins, has led Turkish specialists to conclude that this locus is one of the largest Roman-era kiln sites ever to be identified in Turkey. Directly beside a Roman-era tower overlooking the kiln site, looters have exposed several press elements (olive crushing stones and press beds) indicating that the installation incorporated a massive olive oil and wine production complex that generated the commodities to be shipped in the transport jars directly on site (**Fig. 7**). This one archaeological locus, in other words, exhibits a fundamental triad necessary to stimulate economic activity in this region – firing production of transport containers, agricultural processing of wine and oil, and a combined storage (the neighboring tower) and transport facility (located directly beside the sea). Rough Cilician production of common, coarse, and cooking wares and transport amphoras thus reflects the local application of fuel-driven firing technology employed by kilns. Based on the morphology of the amphora forms and the context materials of the kiln sites, all of this production began in the Early Roman era (60 BCE-250 CE).[7]

In addition to ceramic wares Ward Perkins (2005: 94-96) places considerable emphasis on the omnipresent remains of ceramic roof tiles in Roman Mediterranean built environments. It is striking that in peripheral settlements even menial sheds and animal pen display evidence of a solid roof construction.[8] As Ward Perkins notes, a tiled roof can function well for centuries and furnished a crucial element of permanence to Roman era built environments. Like ceramic wares the production of roof tiles demanded high levels of labor and energy expenditure. The production of construction elements and

[5] Production activities for every day wares such as these were so localized in south coastal Anatolia that the typologies for coarse and commonwares change nearly every 50 km along the coast.

[6] Kiln debris indicates that the region produced three types of amphoras: the Koan-style (1st cent. BCE- 1st cent. CE), Pamphylian (2nd – 4th cents. CE), and Pinched Handled amphora (1st – 4th CE). Fabric analysis points to the existence of at least 4 additional kilns in the region . Rauh and Slane 2000; Rauh and Lyding Will 2002; Rauh 2004; Rauh et al. 2006, Autret 2009, Autret and Rauh in press.

[7] The Koan-styled amphora is the earliest form, generally dated 1st century BCE-1st century CE.

[8] Ward-Perkins 2005, 96 significance of roof tiles, a tiled roof can function well for centuries; whereas even today a professionally laid thatch roof, of straw grown specifically for its durability will need to be entirely remade everfy 30 years or so.

commodities such as these, their storage requirements, and their costs of transportation sometimes across vast distances confirm the existence of production and supply systems, however little these are discussed by ancient literary sources. In Rough Cilicia the reliance on fire-based technologies and production systems can be taken at least two steps further. Like the pottery production discussed above, regional building construction was remarkably limited during the pre-Roman era, but spiked during the Early Roman era.[9] As the accompanying urban plans prepared by Rhys Townsend and Michael Hoff demonstrate, building construction boomed in Roman Rough Cilicia (**Fig. 8a**). The region exhibited at least nine small urban communities, village sized really, but characterized, nonetheless, by textual and epigraphical data as cities (*polis*). For our purposes what is most significant about this is the building materials employed, namely, stone rubble and lime mortar. Mortar-based construction appears to have existed for centuries in this region, but it saw little use until the early first century CE, probably because the availability of mortar and its transportation were not cost effective until this time.[10] Construction with mortar is obviously more convenient than stone because it requires less labor to quarry and to dress irregular- shaped fragments of locally obtained stone. The basic materials, stone rubble, lime, water, and sand were readily available along this coast, particularly sand from river beds and beaches and stone and water from the exposed limestone outcrops and plentiful springs that characterize the region's topography.[11] Much like the production of Cilician transport amphoras, common and coarsewares, the production of lime mortar required the firing of natural, readily available limestone at significantly high temperatures. As the photographs presented here of large bath complexes in the survey region demonstrate (**fig. 9**), the result was the construction of built environments of significant stature and permanence.

However primitive the levels of technology employed, there can be no doubt that the creation of urban society in Rough Cilicia, and the Roman world generally, required the consumption of enormous quantities of fuel by fire-based artisanal production systems. Another form of firing technology utilized in Rough Cilicia was metallurgy. The region was known for its mining capacity and the occasional finds of iron slag and even what appears to be an iron ingot by the survey team point to local production (**fig. 10**).[12] As Andrew Ward (2002) has recently demonstrated, ore smelting operations during the Roman era were so significant that contaminants such as heavy metals released into the

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[9] Hellenistic era structures survive primarily in the form of ashlar constructed defensive installations – acropolis citadels, fortresses, or isolated defensive towers all built of massive hand-quarried stone blocks. Durugönül (1998: 83) argues that the lack of stone-built domestic architecture at Hellenistic-era Cilician sites such as Olba demonstrates a reliance on less permanent building materials, such as wood or mud-brick, or in the case of the native pastoral populations of the hinterland, simple tents; cf. Huber 2005, 26, 43.

[10] Huber 2005, 25.

[11] Large theater-shaped and theater-sized gouges are visible in the outcrops of Selinus and Kestros, for example, demonstrating the massive extent of local quarrying that occurred on site during the building phase of these small communities. and it is probably not a coincidence that nearly every community was constructed on limestone outcrops near natural springs.

[12] For evidence of mining in this region, Forbes 1950: 386.

atmosphere were deposited in measurable quantities in ice cores obtained at Greenland.[13] Although the survey is not equipped to assess the remains of mining operations undertaken in the survey region, this production activity would likewise have required organized production and distribution systems and large quantities of fuel. Another underestimated manner in which fuels were utilized in Rough Cilicia was to heat installations such as public baths. Heated baths were arguably the most successfully exported attribute of mainstream Greco-Roman society; it was readily adopted by populations who otherwise demonstrated limited interest in mainstream ideals. In the survey region no less than 13 baths have been identified and others undoubtedly existed but remain unidentified at urban sites such as Kestros and Nephelion.[14] Several of these complexes, shown here (**Fig. 9**), were quite large. Heated baths, thus, furnish another example of the diffusion and construction of modes of creature comforts by Roman civilization. Much like the amphoras, the ceramic wares, the roof tiles, the lime mortar, and the metal production, the furnaces that heated these large installations required significant quantities of fuel.

To put it another way, urban development in Rough Cilicia during the Early Roman era was rapid and robust. The region entered the Roman era in a relatively backward state with little evidence of fire-driven production activities. Nonetheless, during the *pax Romana* the region's inhabitants (who remained abstemiously "Anatolian") adapted quickly to mainstream production systems and transformed their landscape into a mosaic of small built environments surrounded by lush plots of terraced vineyards and groves of olive, fruit, and nut trees. The inhabitants replaced the region's natural forest cover with manicured, artificially maintained agricultural landscapes, and they built houses and public buildings of such permanence that their features survive to this day. Most this development was based on fuel-driven firing technologies and production systems that required enormous quantities of fuel. The most likely fuel source was the region's forests. Thus, in addition to the literary evidence for the region's contribution to shipbuilding, the global impact of urban development in Rough Cilicia needs to be considered when calibrating the extent and timing of regional deforestation. Since the region came so late to urban development and developed dramatically during the course of two centuries (1st-2nd centuries CE), the landscape of Rough Cilicia, presenting a very clear template of "before and after," furnishes a useful laboratory for analyzing the depletion of renewable forestry resources over time.

Various Interpretations of Mediterranean Deforestation

The degraded character of forests in the Taurus Mts. of south coastal Turkey has long been the topic of scholarly and scientific debate. As noted above, as late as the Hellenistic Era (323-27 BCE) the forests of these mountains were praised by sources such as

[13] Ward 2002, levels of pollutants grew steadily during the ancient period until attaining a peak in the Early Roman era. They then fell back to Neolithic levels.

[14] Most of these buildings were relatively small and in the case of the neighboring communities of Asar Tepe and Gocuk Asari, their design is identical, indicating design and construction by the same architectural teams. At the midland metropolis at Lamos no less than 3 baths are visible in the remains, though they may not have been contemporary with one another.

Theophrastus and Strabo for their highland cedar forests.[15] By the beginning of the 20th century, the forest was essentially exhausted. While scholars generally agree that human activity played a determining role in deforestation, the timing and pace of premodern forest utilization, what Horden and Purcell (2000) refer to as the "anthropogene process," is poorly understood. To the extent that forest history bears on past human experience in south coastal Turkey, this process warrants our attention.

Pollen data obtained from lake sediment in Beysehir, some 140 km northwest of the survey area), demonstrates that tree pollen was gradually supplanted by grass pollen in coring samples beginning around 1200 BCE; with tree pollen gradually rebounding after 600 CE.[16] Identified as the Beysehir Occupation Phase, this data is generally recognized as the best sustained record of anthropogenic influence on the Mediterranean landscape, reflecting as it does the gradual clearing of forested land for agro-pastoral purposes followed by land abandonment, population decline, and forest regeneration. This logic is based on an assumption that ancient inhabitants of the Mediterranean employed widespread burning, clearing, cutting, coppicing, terracing, cultivation, grazing, browsing and construction to develop urban settlements and maximize agricultural output. The resulting well managed but artificially sustained landscape collapsed at the end of the Roman era presumably due to the influx of pastoral elements (Persians, Arabs, Turkmen, Mongols) who drove off or greatly suppressed sedentary populations between the late 6th and 16th centuries CE. Landscape abandonment thus enabled the natural forest cover to regenerate. Despite the fact that tree pollen residue remains relatively localized, the evidence of the Beysehir Occupation Phase remains a foundation of ecological history for Anatolia in general and has profoundly influenced wider Mediterranean discussion. Notwithstanding the importance of this data, scholarly debate about the significance of this and similar data tends to cloud our understanding of the history of Mediterranean deforestation and its inverse relationship with human population growth.

For example, C. Vita-Finzi (1969) observed what he identified as widespread alluvial deposition at the end of antiquity in river basins throughout the Mediterranean, most particularly along the Aegean coast of western Anatolia. Calling attention to what he identified as an overlying layer of 'terra rosa' sediment, Vita-Finzi argued that this deposition resulted from widespread soil erosion following landscape abandonment at the end of the Roman era. Even though this thesis conforms with the evidence of the Beysehir Occupation Phase, Vita-Finzi's argument has generally met with skepticism. As Horden and Purcell (2000: 316) argue, the depositional record of neighboring river valleys in the Aegean, let alone the wider Mediterranean, exhibits significantly different and inconsistent timing. Nonetheless, along with the Beysehir Occupation Phase, the Vita Finzi thesis furnishes a second, controversial foundation for the ecologically based

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[15] Rauh 2008; Akkemik et al 2009; Caner et al. 2007; Rauh 2006b. For the habitat of cedars in south Anatolia, see Davis 1965; Zohary 1973; Meiggs 1982; McNeill 1992; Boydak 2003.

[16] See Eastwood et al. 1998; Eastwood et al. 1999, van Zeist et al. 1975; Vermoere et al. 2002; Roberts 1990. In southwestern Anatolia, a reduction in pine at Pinarbasi from 3300-1370 BP (1400 BCE-580 CE), and at Sogut from 2885-1900 BP (1250 BCE-50 CE) has been interpreted as reflecting the Beysehir Occupation.

reconstruction of human activity in the Mediterranean landscape, each with the potential to furnish important new means to calibrate the scale and longevity of past human settlement in the region.

Despite the apparent inconsistencies, accumulating geomorphologic data combined with the generally recognized degraded character of Mediterranean forest land (demonstrated everywhere by the presence of archaeological remains in abandoned, overgrown landscapes) have convinced many scholars that ancient urban civilizations irreversibly altered the natural landscape. Thirgood and others argue that natural forest land was gradually replaced by an arranged mosaic of cleared agricultural terrain: irrigated lowlands, terraced fruit and nut orchards in the midlands, and coppiced patches of forest and pastures in the highlands.[17] Based on limited evidence of state control of forest land, many scholars assume that the ancient populations of the Mediterranean carefully managed the renewable resources at their disposal, thus preserving a steady state forest in the highlands.[18] According to the general view, this irreversibly changed with the collapse of Roman political institutions at the end of the sixth century CE. Looking specifically at the example of western Rough Cilicia in south coastal Turkey, beginning in the 580s CE and continuing into the 8th century repeated Persian and Arab incursions ushered in political and social collapse, population decline, and land abandonment. According to the Vita-Finzi interpretation the carefully manicured landscape of western Rough Cilicia eroded through lack of maintenance. Soil freed from highland terraces entered the bed load of local river basins and propelled by periodic inundations came to settle in layers of deposited alluvium near the shore. The decline of the managed agricultural landscape was exacerbated by the immigration of pastoral elements, segmentary populations of Arabs, Turkmen, and Mongols, whose predatory behavior and destructive grazing practices (a combination of timbering of old growth trees and animal foraging of the understory) further eroded the landscape and prohibited agricultural settlement for a millennium.[19] In most regions of the Mediterranean low population levels are presumed to have continued until relatively modern times.[20] In Rough Cilicia and elsewhere the problem remains that there is little empirical data to confirm or deny this general description, particularly during the millennium in question, namely, the 7th through the 17th centuries CE, a prolonged era for which textual and archaeological information is limited. To understand the interrelationship between deforestation and

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[17] Thirgood 1981: 22, Thirgood 1987; Reifenberg 1955; Gregory 1994.

[18] See Hughes 1983 and Mikesell 1969, for Roman era finds of inscribed state-forest boundary stones in the Lebanese Mts and occasional textual references to forest marshals. See Gregory 1994 for an explanation of full utilization of the landscape and its consequences during late antiquity.

[19] Turkmen pastoralists known as the *tahtaci* (woodcutters) sustained themselves in the highlands for centuries through an economic practice that combined tree-cutting with pastoralism. Evidence of their presence survives in the Alanya vicinity: McNeill 1992: 93. Ecologists largely agree that grazing is destructive to alpine forests: Boydak 1996: 40; Boydak 2003; Naveh 1994: 262, 273; Zohary 1973: 384 Fontaine et al. 2007; Johann 2000: 168; Dewdney 1971: 109.

[20] The assumption is widespread: Reifenberg 1955; Lowdermilk 1944; Naveh and Dan 1973: 377; Naveh and Lieberman 1994: 262, 273; Thirgood 1981: 22, Thirgood 1987; Zohary 1973: 652.

human agency a series of questions need to be resolved: How long did it take for Rough Cilician forests to regenerate? Did these forests remain relatively untouched until modern times, or were they repeatedly denuded during the interim?

The hypothesis of long-term landscape abandonment and gradual forest rebound during the Middle Ages is contradicted, for example, by evidence of resurgent trade and ship construction in this region between the 10th and 13th centuries CE. During their attempts to consolidate control over the sea lanes of the eastern Mediterranean, early Medieval Byzantine and Seljuk rulers emphasized ship construction and the resettlement of abandoned Roman era sites along this coast.[21] The strength of Byzantine navies and concomitant merchant marines was acknowledged by Crusader elements that relied heavily on Byzantine ships to supply and defend their expeditions to the Holy Land.[22] During the brief 13th century Seljuk occupation of Alanya (ancient Korakesion; medieval Kalonoros, seized in 1221**)** Alaaldin Keykubat (1220-1237 CE) constructed impressive shipsheds that survive to this day.[23] Contemporary texts also record the reemergence of timber trade between Alanya and the Mamluke realm in Egypt.[24] Medieval archaeological remains in the Taurus highlands, such as the Late Roman- Early Byzantine fortress at Frengez Kale (RC 0409), indicate that the momentum for this reoccupation was generated in part by exploitation of regional highland forests. In other words, heightened maritime activity in the region indicates that the highland forests of Rough Cilicia either had regenerated sufficiently to accommodate ship construction and an overseas timber trade at this time or conversely that the forests had never entirely disappeared. The latter possibility calls into question the extent of deforestation during antiquity. Pollen data obtained at ancient Sagalassos in the highland region of Pisidia (approximately 200 km northwest of the survey area) appears to conform to this last scenario.[25]

Historical data such as this combined with anecdotal descriptions of thriving agro-

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[21] In western Rough Cilicia remains of early medieval fortresses survive at Alanya, Syedra, Iotape, Selinus, and Antiochia ad Cragum. At each locale settlement was reduced to a heavily fortified enclave within the ruins of the earlier Roman-era settlement. These and other bastions outside the survey area formed a chain of fortified harbors along the the coast that enabled the Byzanine Comneni and the Rum Seljuks to extend the reach of their naval empire to Cyprus, Syria and beyond.

[22] Pryor 1988: 151-2; Gregory 2005: 269, Lewis and Runyan 1985: 35. Along with the military foothold Byzantine church authorities attempted to reassert spiritual control over local populations by constructing churches and monasteries throughout the region. The basilica standing above Halil Liman and the Bickici Monastery in Gazipasha furnish well known examples.

[23] Dalglaze 2009; Lloyd and Storm Rice 1958.

[24] Pryor 1988; Redford 2000: 43; Cahen 1968: 157. Similar shipments of ship-building timber from Alanya to Antalya, Rhodes, Egypt, and Yemen, are recorded during the 16th century CE Ottoman Era**:** see Uckan.Doonan 2001.

[25] High pollen counts of cedar, fir, and pine in Hellenistic and Roman era soil samples at Pisidian likewise appear to conform with this pattern since they indicate the maintenance of managed forestry practices at that settlement until the early Byzantine period (Vermoere et al. 2003: 171).

pastoral landscapes in Medieval Palestine and Cyprus have led scholars such as Reifenberg (1955) and Thirgood (1971) to argue that significant landscape abandonment did not occur until the 15th -16th centuries CE, in other words, not until the early modern era. Other scholars, however, emphasize ancillary evidence that points to sustained timber shortages in the eastern Mediterranean throughout this period. As proof they point to the early Medieval adaptation of frame-first ship construction, a technique requiring less wood than the traditional Mediterranean shell-first design, as well as to the sustained eastern Mediterranean reliance on ceramic transport jars.[26] Since both ship construction and the production of ceramic transport jars continued in Rough Cilicia, an assessment of the relative health of Medieval-era forests based solely on textual accounts and material remains becomes unconvincing. Either regional forests had never been fully exhausted or they had regenerated adequately by this time to be reutilized, presumably only to be rapidly depleted again. Either scenario - limited scale deforestation during antiquity or progressive forest regeneration - allows for the possibility of a recurring pattern of forest utilization over time. And both scenarios contradict the widely held assumption that the grazing practices of Turkmen tribes who migrated into the Taurus highlands by the 11th century CE inhibited forest regeneration.[27]

More recently scholars such as Meiggs, McNeill, Horden and Purcell have attempted to diminish the importance of premodern deforestation by arguing that the Mediterranean forest landscape was never significantly depleted until modern times.[28] According to these scholars, genuine deforestation in regions like the Taurus Mts resulted from industrial-scale timbering operations of the 19th and 20th century. These scholars cite well-documented evidence of timbering enterprises (particularly in eastern Rough Cilicia) to furnish construction materials for projects such as the Suez Canal (1859-1869) and the Ottoman railway network (1880s) as the cause of the currently denuded landscape.[29] A finding that alluvial deposition in the river basins of western Rough Cilicia is very recent conforms with this scenario (Beach and Luzzadder-Beach. 2000:137). Much like previous interpretations the scenario for “modern-deforestation” masks an array of implied assumptions. It assumes, for example, that until the emergence

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[26] Instead of more efficient wooden barrels. For the transition to frame first ship construction at this time: Kreutz 1976; Steffy 1981:18. Wooden barrels were commonplace in western Mediterranean shipping by late antiquity: Pryor 1988: 82. Ceramic transport amphoras continued to be produced in coastal Anatolia through the early modern era; for example, the Gulsenin style amphoras found throughout the region and dated to the 9th-12th centuries CE; see Image Ten for a Gulsenin amphora recovered by the survey team in waters near Charadros.

[27] Kahraman, the founder of the Kahramanid (Turkmen) dynasty that seized control of the the wider Taurus region from the Seljuks in 1256 CE, was described by contemporaries as a shepherd, a woodcutter, a timber merchant, and a bandit: Cahen 1968: 281-2. Cf. Lindner 1983, for Ottoman strategies for settling Turkmen nomads on the land.

[28] Meiggs 1982: 386; McNeill 1992: 77, 102, 158, 242, 248, 349; Horden and Purcell 2000: 185.

[29]Culminating in the construction of the railroad to Palestine before WWI: McNeill 1992: 102, 148; 156-7; 248, 269. Cf. McNeill p. 349, “the evidence for massive deforestation and soil erosion in the mountains between 1800 and 1950 is compelling**.”**

of industrial-scale machinery the inhabitants of Rough Cilicia and the wider Mediterranean possessed neither the manpower nor the technology to exhaust remotely situated highland forests. It also assumes that unlike modern inhabitants premodern populations of the Mediterranean tended to manage the forest landscape more responsibly.[30] A similar bias is detectable in the anti-pastoral and implicitly anti-Muslim criticism of the destructive impact of Medieval nomads. Unquestionably the heaviest criticism is reserved for modern landuse practices that from the perspective of contemporary "green" ideologies are implicitly viewed as destructive.[31] Interpretations based on ideological assumptions - modern development is at odds with nature; human population pressure is destructive to nature; pastoral habits are bad for nature --obscure the fact that human activity, the anthropogene process, has always impacted the environment and that at no stage in history was it ever "pristine." As De Castri (1981) observed, human beings have essentially co-evolved with Mediterranean ecosystems. Horden and Purcell (2000) insist, moreover, that interpretations of Mediterranean deforestation based on anecdotal information obtained from specific localities in the premodern era possess minimal value. These scholars point to the need for ecological analysis that recognizes the Mediterranean landscape as a complex mosaic of separate though connected "micro-regions," each of which experienced its own unique pace of historical development. Variations in pollen counts from Anatolian region to region tend to bear this out.

Since the degraded character of the Rough Cilician highland forest is beyond dispute, the Taurus Mt. landscape furnishes both a palimpsest of past human activity in the forest and a laboratory with which to assess its impact over time. Our attempt to construct a properly calibrated timeline for human forestry activity in the Taurus highlands holds the potential to shed important insight on the scale and intensity of the 'anthropogene process' in a micro-region that throughout history was critical to the supply of timber in the Mediterranean maritime world.

Evidence of Deforestation in Western Rough Cilicia

For purposes of the history of deforestation the most important settlements include two highland areas exhibiting relic cedar forests, Gurcam Karatepe Mt. and the Biçkici Canyon (both at 1700m; Fig. 4). At the crest of Gurcam Karatepe Mt. the team identified structural remains of a Roman-era logging camp (RC 0305, 1687m elev.) and a village settlement on a lower bench (Taşlı Seki, RC 0306, 1500m). Approximately 15 km from the ancient harbor of Charadros, the forest along the crest of this mountain furnished the closest accessible source of cedar timber found anywhere along this coast. Further investigation along the Gurcam Karatepe ridge revealed road fragments linking the urban

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[30] Horden and Purcell (2000: 185),"Prior to the 19th century the urgency of societies' needs for woodland products led to the active integration of forest or scrubland into the managed environment more often than it caused irreversible loss of so flexible and varied a resource." Cf. Vermoere et al. 2002.

[31] As W. A. Reiners explains (1983: 83),"ecologists have traditionally been inclined to envisage the natural environment as relatively benign and disturbance free, nurturing a diversity of steady state systems. Thus, it has been customary to view the human-dominated world as a harsh and strange place for the native biota because of the predominance of disturbance associated with human activities."

center of Lamos and the logging camps at the crest of the mountain to fortresses and settlements leading down the Karasın river canyon to the ancient harbor at Charadros (**Figs. 3-4**).[32] A Roman-era inscription found at Charadros records that the harbor serviced the *Lamotis*, that is, the Roman era administrative district for which Lamos stood as metropolis. The combination of these details indicates, therefore, that the cedar harvesting at the crest of Gurcam Karatepe Mt. represented a significant production activity of the inhabitants of the Lamotis.

Similarly, in the highland canyon of the Biçkici or Woodcutter's River (30 km in length; Figs. 3-4), the survey team identified a substantial pattern of Roman era urban sites (Sivaste, RC 0301; Kenetepe, RC 0304), road remains (Akkaya Mah. RC 0302), isolated farm sites (RC 0803, RC 0804), and in this instance a prehistoric stone knapping complex (Karaçukur; RC 0303). In the cedar zone near the crest of Kara Dağı (Black Mt.), the team identified a Late Roman or Byzantine defensive structure (RC 0308, 1588m elev.). This combined with the finds of sherd scatters and a Late Roman coin hoard (dated to Constantine II, 340-361 CE) at Sugözü Yayla at the crest of the Taurus ridge (1700m elev.) indicates the presence of ancient timbering activity in this canyon as well. Relic and newly planted forests of cedar, fir, and black pine extend along the margin of the broad plateau of this highland from the steep slopes facing the sea to the equally precipitous ledges that descend to the Göksu River (the ancient Calycadnus) interior to the north.

Apart from the Chalcolithic remains at Karaçukur, datable sherds from processed fineware and transport amphoras show nearly continuous occupation of this highland from the Classical through the Byzantine eras, ca. 400 BCE–1200 CE. Evidence of combined agro-pastoral activity is demonstrated by an osthoteke at Sivaste (RC 0301) bearing a relief a shepherd accompanied by goats and sheepdogs (**Fig. 10**). Identified by Er Scarborough (1991, 1998) as Isaurian in style, the reliefs of this region demonstrate that the cultural reach of Isaurian populations from the interior extended all the way to this canyon facing the sea. These highland peoples engaged in a mixed economy of pastoralism (typically associated with banditry), limited agriculture, and timbering. Their predatory tendencies historically kept them at odds with the urban populations along the coast. In many respects their pattern of behavior was similar to that of pastoral peoples who migrated into these same mountains in the early Middle Ages.[33]

Geoarchaeological Results

Our paleo-environmental work in the highlands has embraced an array of related strategies: these include dendrochronological investigation of the surviving highland forest, geomorphic trench excavations of alluvial deposits along river basins, carbon and pollen analysis of soil samples, and mapping and modeling of river basin erosion over

[32] These include the remains of Roman road (RC 0202 and 0411); a fortress guarding the same (Frengez Kale RC 0409, mentioned above), a mountaintop settlement (Gokcebelen Kale, RC 0410), and a Roman era necropolis (RC 0402).

[33] Rauh 1997, 2003: 175; Hopwood 1983, 1986 1989, 1990, 1991; Shaw 1990. For the similar behavior traits of the founder of the Kahramanid dynasty, see above (note 27).

time.[34] Increasingly our research has focused on a reconstruction of the region's extremely fragile cedar forest. In Rough Cilicia the natural habitat of the cedar forest lies between 1500 and 1800m elevation.[35] The geology of the region is largely karstic (limestone) and exhibits complex formations of dolenes, uvales, poljes, high yield springs, underground rivers and lakes, caves, and submarine springs.[36] Cedar trees drive their roots into the rich black loam that collects in the fissures of the limestone surface. Cedar trees require a delicate balance of sunlight, moisture, and good drainage, conditions that the Taurus Mts with their hot, dry summers, moist sea breezes, and snow-laden winters amply provide (Boydak 1996: 16). If left undisturbed cedar trees will grow for more than 1000 years attaining heights in excess of 40m and diameters in excess of 2m (**Fig. 11**).[37] Once denuded, however, the cedar forest is difficult to restore.[38] The root structure disintegrates within 25 years, causing landslides such as those visible along the peaks of the Biçkici canyon.[39] Soil erosion inhibits regeneration along with animal grazing (Boydak 1996: 55; Lamotte 1983: 48). As natural colonizers highly adaptable to eroded landscapes at this altitude, juniper shrub trees invade deforested landscapes as secondary growth.[40] They eventually furnish the necessary over story and soil detritus to induce cedar forest regeneration; however, the time required for natural (as opposed to managed) cedar forest regeneration remains unknown.[41] Under carefully managed

[34] The first of these is geomorphologic mapping to evaluate patterns of erosion as indicated by highland landslides, relic river terraces, and braided river beds in three of Gazipasha's fluvial basins: the Biçkici, the Hacimusa, and the Kaledran. Hillslope data is based on procedures that combine computer analysis of the project's digital elevation model with in-situ field data for the locations and altitudes of relic river terraces.

[35] Boydak 1996: 12, wider habitat 800 to 2100m; Zohary 1973: 345-6, places it between 1200-1900m, though he identifies its optimum altitude as 1500-1800m elev.. Our research confirms its main concentration along the steep slopes of the Taurus at these altitudes. Hot dry summers enhanced by high humidity enable a mixed cedar (*cedretea libani*), and fir (*albies cilicica*) forest in these highlands. The subalpine coniferous zone typically consists of highland cedars, firs, and junipers, sometimes mixed, sometimes pure.

[36] Boydak 1996: 15; the survey team mapped the spring line in the Bickici Canyon at 800m elev..

[37] Boydak 1996: 21-2, where photographs of cedar trees 800 and 650 years old are displayed.

[38] Cedars typically produce seeds every 3-5 years (Boydak 1996: 23); seed dispersal is highly localized and in natural regeneration the seeds require transfer by birds and small animals to find suitable places for regeneration (crevices and outcrops). In planted forests seeds collected in the one zone can be transferred only to areas of similar elevation and sun exposure. In alpine forests such as Rough Cilicia seeding within 100m elevation of the seed stand is recommended (Boydak 1996: 49).

[39] Montgomery et al. 2000; McNeill 1992, 349; Thirgood 1981; Hughes 1983; Beach and Beach-Luzzadder 2000, 117.

[40] In time junipers replace diminished topsoil enabling cedar and fir trees to regenerate. As these fast growing trees rise above junipers they form a canopy that blocks the sunlight for the latter and ultimately replace them. Zohary 1973: 506.

[41] As Zohary keenly observed (1973: 506), "Consequently, vegetational changes within historical times must not always be attributed to climatic changes; the re-establishment of a destroyed climax community may be prevented or eliminated solely by the destruction of the soil subsequent to deforestation; this is because soil may need geological periods for its restoration."

conditions including systematic seeding, weeding of competitive vegetation and enclosed terrain to keep animals at bay, Boydak (2003) estimates an approximate period of 160-180 years for a cedar forest to return to timbering quality. Under natural conditions forest regeneration at this altitude requires significantly more time. Alpine forests in Austria, for example, are estimated to require 300-500 years to regenerate and Douglass fir forests in the Pacific Northwest require a similar timespan.[42] Given continuous occupation by pastoralists the cedar forest in Rough Cilicia probably required similar time to regenerate. Interviews conducted with Turkish Forestry Ministry authorities as well as with older local inhabitants in the area indicate that cedar trees in the Biçkici canyon were continuously timbered from late Ottoman times until 1980, when further removal of cedar trees was prohibited by the law.[43] At Sugözü Yayla (1700m) the presence of aged juniper trees where cedar ought to be present serve as testimony of sustained deforestation at the crest of the Biçkici Canyon.

Guided by Turkish forestry officials Unal Akkemik has conducted dendrochronological investigation of the oldest trees to survive at the crest of both Gurcam Karatepe Mt. and the Biçkici Canyon. His analysis indicates that the current, state-protected forest on Gurcam Karatepe is largely regenerated. Although the oldest cedar has survived for 423 years, the mean lifespan of seven sampled cedars was a mere 280.7 years while exhibiting remarkably close start dates.[44] Based on a relatively limited, if authoritative sample, the cedar forest on Gurcam Karatepe would appear to have been exhausted centuries prior to 1700 CE, that is, prior to the inception of modern mechanical timbering operations. In the Biçkici highland Akkemik sampled 15 old growth trees from the rim of the canyon to remote areas in the Taurus plateau.[45] Further removed from the coast, the cedar forest in this region appears to have regenerated earlier, with four sampled cedars yielding a mean lifespan of 366 years. Three of the four sampled cedars date between 1600 and 1620 CE. The close proximity of the ages of relic cedar trees in both areas, Gurcam Karatepe and the Biçkici highland, is noteworthy, as they point to the occurrence

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[42] In the Austrian Alps, the time needed to regenerate the alpine forest ecosystem of firs and pines impaired by forest grazing has been estimated between 300-500 years (Johann 2000: 169). In Douglass fir forest of Pacific Northwest the cycle of reestablishment of super dominant trees excited by random mortalities of large trees requires a estimated 200-250 years (Shugart et al 1980: 90).

[43] In fact as early as 1896 the illegal cutting of trees in the wider Alanya district became punishable by fines (*Orman ve Meadin iradeleri* 40/4). In 1897 a certain Ahmet Besim was fined 600 TL for cutting trees illegally (*Orman ve Meadin iradeleri* 110/7). In order to save the forest of Alanya a secretary (katip) was sent to assist the forestry inspector in 1902 (*Orman ve Meadin iradeleri* 311/1); see Uckan Doonan 2001 and Boydak 1996: 22. The Turkish Forestry Ministry planted 61,611 hectares of cedar between 1983 and 1989 alone.

[44] Of the nine trees sampled in 2004, seven were cedars, one was pine, and one was juniper. The juniper proved to be the oldest surviving tree (483 years). The ages of five of the cedar trees fall between 350 and 250 years.

[45] Five samples were Juniper, five Black Pine (*pinus nigra*) and five were cedar. See Table in Image Fourteen.

of synchronous "harvest events" approximately 80 years apart.[46] Given the stochastic nature of mortality in natural forests, a wider range of tree ages ought to be visible in these highlands.[47] Preliminarily, we can assert that "secondary" growth in the highland cedar forests of this region began some 300-400 years ago and that the "original" forests had been depleted significantly earlier.[48] At the very least the dendrochonological evidence obtained thus far indicates that the "old growth" forest in western Rough Cilicia was eliminated centuries prior to the modern era, thus negating the modernist argument of Meiggs, McNeill, et al. Admittedly, cedar trees represented a particularly valuable resource with specialized uses in the premodern era; the timing of their disappearance need not necessarily have coincided with that of lower altitude pine and oak forests, for example. The remoteness of its habitat does enable us to focus on its depletion and regeneration as a control on wider regional deforestation, nonetheless. For our purposes the relative health of relic cedar forests arguably functions as the "canary in the coal mine."

Geomorphic Trench Excavations

Under the direction of geologists Sancar Ozaner and Martin Doyle, the survey project has conducted more than 20 geomorphic trench excavations along relic river terraces and ancient lagoons in the Gazipasha coastal plain (**Figs. 12-14**). The team employed a backhoe to excavate trenches approximately 6-8m long, 2m wide, and 4m deep (the reach of the backhoe shovel). The scarp of each trench was then cleaned and examined for carbon, pollen, and macrobotanical residues as well as for the stratigraphical record of alluvial deposition. Although the depth obtained is not as deep as that obtainable by core drilling, the breadth of the trench and the length of its scarp wall enabled team members to inspect its stratigraphy over a broader extent for carbon samples and vegetative residue. As demonstrated below, this depth preliminarily appears to be sufficient to attain stratigraphical data contemporary with ancient forestry activities. Due to the high water table in the vicinity as well as to disturbances caused by extremely recent development in the river basins, many of these trenches failed to render reliable carbon dates. Preliminarily, our carbon data was obtained from four locations, one in the Biçkici river

[46] Reiners 1983: 86, who adds that only combustion by wild fire or clear cut logging can effect such dramatic impact on the forest. However, fires are more destructive to understory forests of 100 years or less. Due to their larger biomass, old growth trees tend to survive wildfire events: Shugart et al. 1980; Franklin and Hemstrom 1980: 218-224.

[47] The abruptness of the "old growth" forest in these regions indicates that even these trees represent secondary growth from an earlier forest. In natural settings fire can eliminate young forests (100 years or younger) but the biomass of aged trees enables them to survive (see previous note). The presence of a 765-year-old black pine in the Bickici highlands argues against fire as the event, for example. The most logical explanation for the abruptness of the chronology is the anthropogene process.

[48] A similarly dated forest of 90 relic cedars aged 250-300 years survives at Kahramanmaras in eastern Rough Cilicia above Mersin, Boydak 1996: 55. Peter Kuniholm at Cornell U. has shared with us the dates for a sequence of tree-ring samples obtained from 65 trees in the wider region of the Taurus Mts. For *Pinus nigra* his samples indicate a 557 year chronology (1444-2003 CE), based on 23 trees; for *Juniperus sp*. his samples indicate a 276 year chronology (1728-2003 CE) based on 12 trees; for *Albies cilicica* a 207 year chronology (1797-2003) based on 7 trees; and for *Cedrus libani* a 581 year chronology (1423-2003) based on 23 trees.

basin and three from the neighboring Hacimusa River basin. Our preliminary analysis suggests that the overall rate of deposition recorded in all trenches amounts to 12.65m of alluvium over 9852 years or 0.128m/100 years. If one isolates the rate of alluvial deposition recorded between 654 BCE and 1007 CE from that recorded afterward (1007-2007 CE) the rates emerge as 0.08m/100 years for the "ancient" period vs. 0.135m/100 years for the "modern" period (**Fig. 14**). The fact that these rates of deposition refer to land disturbances generally throughout the river basins and not specifically to deforestation in the Taurus highland needs to be borne in mind. The results are nonetheless significant. While it is true that higher rates of deposition have occurred since 1007 CE, the difference in ancient vs. modern rates of deposition is hardly overwhelmingly (not even twofold), as the argument for massive deforestation and soil erosion in extremely recent times would require. In short, the available data obtained from the survey's geomorphic trench excavations indicates preliminarily that the Gazipasha river basins experienced significant landscape deformation commensurate with deforestation prior to the modern era. High water tables and repeated disturbances to the coastal landscape in extremely recent years have, unfortunately, prevented us from obtaining a more finely calibrated timeline for this deposition.

Pollen Analysis

In addition to the chronological data to be obtained from geomorphic trench excavations, Hulya Caner is analyzing pollen samples extracted stratigraphically from our trench excavations. Pollen samples analyzed thus far indicate that native tree species in the Gazipasha basin were gradually replaced by various species of grass as well as by cultivated orchard trees such as black walnut (*juglans*).[49] The preliminary results of our palinological investigation hint at a pattern of increasingly degraded vegetation resulting from severe overgrazing on the one hand and the human impact on natural high altitude forests and their replacement by secondary scrub colonizers on the other.[50]

Remote Sensing of Grape and Olive Growth

Christopher Dore's remote sensing analysis of multispectral satellite imagery for the survey region is helping to determine the range and typology of existing ground cover in western Rough Cilicia. Dore's investigation is enabling the team not only to gauge the extent of landscape deformation over time but also to identify the habitat of surviving vegetative species. Preliminary analysis of the chromatic signature of regional grape vines has demonstrated, for example, that grape vines thrive throughout the survey area, especially uncultivated growth otherwise obscured by dense maquis scrub.[51] In a manner

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[49] McNeill 1992: 94 argues for recent cultivation of black walnut (last 200 years), but pollen data obtained at ancient Sagalassus exhibits a similar pattern of grapevine and black walnut cultivation during the Roman era, especially in the vicinity of the city: Vermoere et al. 2003: 167.

[50] Caner et al. 2004: from two of our trenches Caner observed a transition from elevated cedar, black pine, and juniper pollen at lower trench levels to decreased cedar and increased scrub pine (*Pinus brutia*) and macquis brush-associated pollen at upper levels. More extensive AMS dating is required to better establish the timing.

[51] We presume that the maquis scrub expanded following deforestation and the abandonment of agricultural terrain at the end of antiquity. The scrub vegetation (kermes oak, wild olive, spartium; juniper, pistachio,

unmatched by pedestrian archaeological investigation, Dore's remote sensing procedures furnish an accurate means to identify and to locate the presence of natural resources in the survey region. His preliminary results regarding grape vine habitation in western Rough Cilicia, for example, help to confirm the archaeological and textual evidence for surplus wine production during antiquity.[52]

Highland Geomorphic Trenches

In 2007 and 2008 the survey team experimented with excavating geomorphic trenches by hand in the immediate vicinity of relic cedar and juniper forests in the Biçkici highland (one at 900m, the other at 1700m). Our purpose was to obtain more reliable carbon and pollen samples in the natural habitat of the ancient cedar forest. A chance discovery of a 6m deep excavated pit at 1700 meters altitude at Sugözü Yayla enabled Rauh and Caner to obtain excellent carbon and pollen samples (**Figs. 15-16**). After cleaning and dressing the scarp to expose fresh soil, the team cut a “step-trench” of seven levels, extracting pollen samples every 5cms at each step. Carbon samples obtained from the lower four levels of the trench have yielded dates ranging from 11713 to 6561 BCE, indicating that the record of alluvial deposition and commensurate pollen and carbon data remains undisturbed at this altitude and offers greater promise at yielding reliable data about the history of regional forests.

Conclusion

The progress attained by our paleo-environmental research is decidedly limited. Recent studies have demonstrated that nearly every method we have employed exhibits some inherent limitation susceptible to erroneous interpretation. Extreme caution is required when formulating any general conclusion. Our pollen data thus far shows a gradual transition from forest cover to grasses and fruit trees attributable to the creation of an agro-pastoral landscape during antiquity, but our calibration of the timing of this transition is too imprecise to be of greater value for the present. Our data for sediment deposition poses similar problems, not least of which the fact that only 4 of 20 trenches produced datable carbon data. As presented here, the available data points to the phenomenon of landscape abandonment after 500/600 CE, as the likely explanation for alluvial deposition in the region’s river basins. This supports a scenario for population decline at the end of antiquity as a likely cause of landscape deformation. In other words, after having cleared the land and converted it into a well manicured landscape of terraced vineyards, olive groves, farms, and gardens in the Early Roman era, the inhabitants of Rough Cilicia abandoned the land at the end of antiquity, thus permitting the artificially maintained landscape to decline. Terrace complexes eventually collapsed, causing stored sediment to enter the bed load and become deposited in the river valleys, particularly

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sage, etc.) represents a remarkable colonizer, impervious to fire and drought (Caner et al. 2004; Atalay 1994; Bottema and van Zeist 1990; Davis 1965; Zohary 1973). Wild grape vines appear to thrive in the scrub, meanwhile, using it as a form of trellis to extend their habitat along the top of the scrub canopy (Rauh et al. 2006).

[52]The pedestrian team has identified 20-30 press installations and at least 3 amphora kiln sites in the survey region, all largely associated with regional wine production: Rauh and Slane 2000; Rauh and Will 2002; Rauh 2004; Rauh et al. 2006; Autret 2009; Autret and Rauh in press.

during periodic flooding. Eventually the landscape achieved some level of equilibrium, albeit one that is highly eroded and deformed. However, the tables presented above are based on measurements far too limited to hold significant value to the question of the timing of deforestation.[53] Our remote sensing of grapevine and olive tree signatures, meanwhile, offers a dramatic picture of the extent of natural growth of these two plants, particularly grapevines. When combined with our repeated identification of the material remains of rural settlements obscured today by dense pine forests and maquis scrub, and the remains of what appear to be extensive ancient terracing, not to mention those of some 30 press complexes in the region, this does seem to indicate that the peak period of regional land clearance (and hence fuel consumption) occurred in the Roman and Late Roman eras. As indicated by the pottery table presented earlier (**Fig. 5**), the vast majority of the datable processed ceramic remains likewise date to these eras. Even in this respect it needs to be recognized that the Mediterranean is a natural habitat for grapevine and olive tree growth. What the remote sensing of these plant forms appears to demonstrate most of all is the fact that these resources were widely available to the inhabitants of Roman Rough Cilicia and were cultivated and harnessed by them in ways that are not continued today.[54]

The one form of data that does hold promise is the tree-ring data obtained from relic cedar and fir forests in the Taurus Mt. highlands. The absence of relic forests older than 300-400 years and the lack of stochastic patterns in the surviving tree population indicates quite clearly a) that the depletion of this highland forest occurred long before the advent of modern mechanically driven forestry industries (ca. 1850 CE) and b) that it was nonetheless systematic (clear cut) and thus anthropogenic in form. The 80-year age difference of the relic forests at Gurcam Karatepe and the Biçkici highland (approx. 30 km apart) warns us, however, the timing of these timbering events may have varied significantly from canyon to canyon. As Horden and Purcell remind us, the Mediterranean region consisted of hundreds of micro-environments such as these two canyons. Continued investigation of ancient forests in the dozens of ravines carved along this rugged coast is likely to reveal similar variation in the timing of forest clearance. The remoteness of many of these canyons and their difficulty of access may explain how patches of old growth forests possibly survived antiquity to sustain ship-building enterprises during Byzantine, Seljuk, and Ottoman eras. Or the forests generally may have rebounded sufficiently following widespread population decline at the end of

[53] In a recent unpublished paper Dusar et al. (In Press) argue that one of the reasons why so many of our trenches failed to yield ancient carbon dates arises from the possibility that the landscape after antiquity became so highly eroded that little alluvial material remained to be deposited, regardless of continuing anthropogenic impact. This would mean that economic activities in later times left less evidence of deposition than those during earlier phases of the process. These scholars raise a number of additional issues. For example, sediment archives pose difficulties at various scales within the geomorphologic system. There are temporal variations in connectivity between different zones within a catchment (slopes, footslope, alluvial plain and river) as well as reworking of sediment originally deposited higher up the system. Depending on specific geomorphologic conditions, small scale deposits may significantly buffer an erosion pulse on the hillslopes, obscuring this signal within larger scale alluvial deposits.

[54] Today regional grapevines grow wild, due to the decreased demand for wine in modern predominantly Islamic Turkey. Regional grape production focuses entirely on its use as a foodstuff.

antiquity. Eventually, our array of field methods should enable us to construct a timeline of cedar forest depletion and regeneration in this crucial micro-region of the Mediterranean world. The methods employed here demonstrate the potential for a reconstruction of the history of human experience in Rough Cilicia as seen through the lens of the region's historic highland forest.

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Landscape Ecology and the End of Antiquity: The Archaeology of Deforestation in South Coastal Turkey: Images, Maps, and Tables

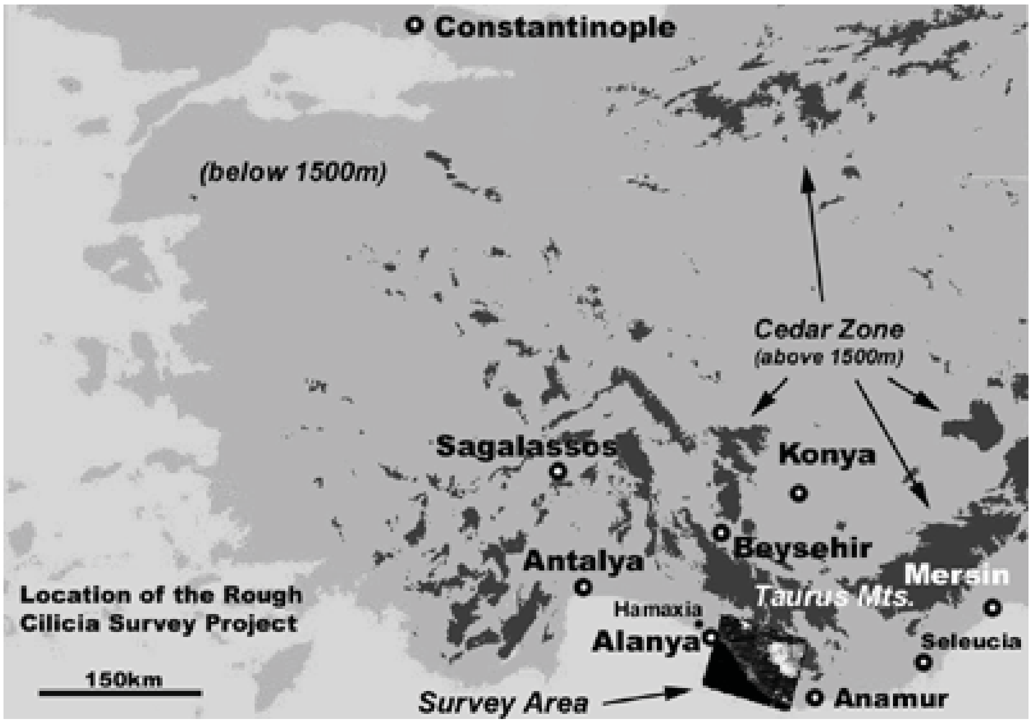

Figure One: Geographical Location of the Survey Area

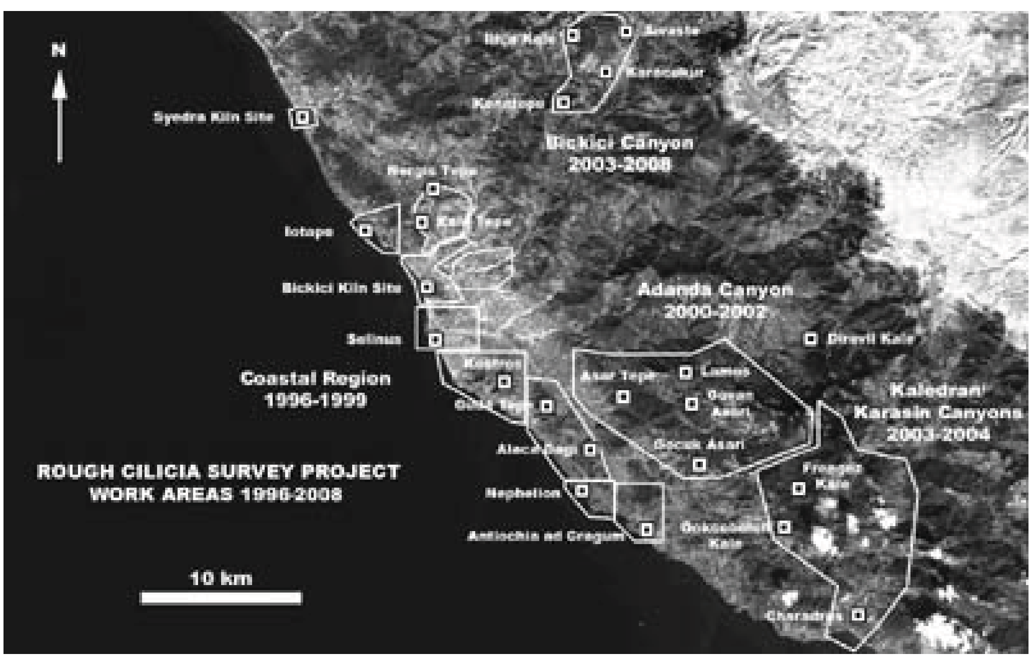

Figure Two: Survey Work Areas to Date

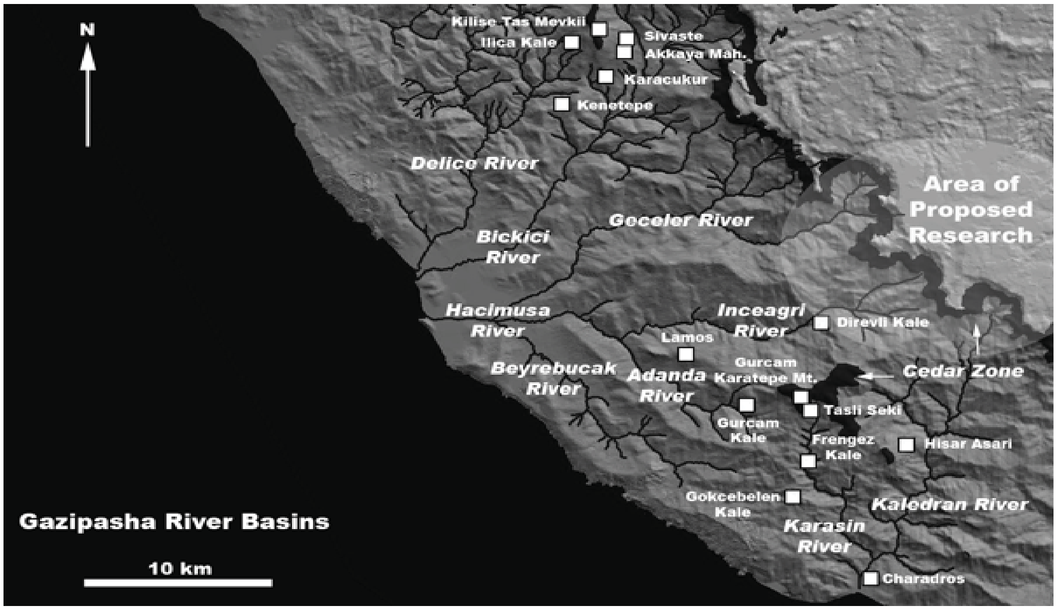

Figure Three: Gazipasha River Basins

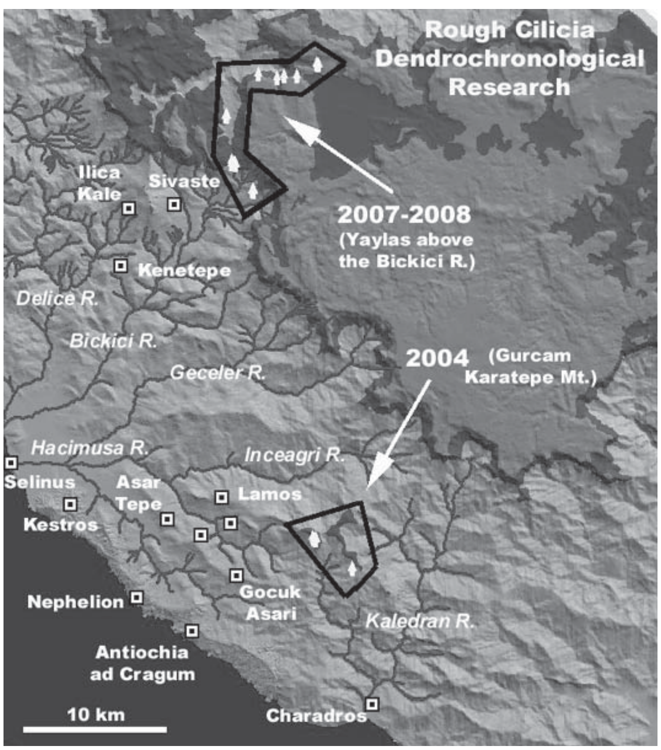

Figure Four: RCSP Areas of Dendrochronological Research

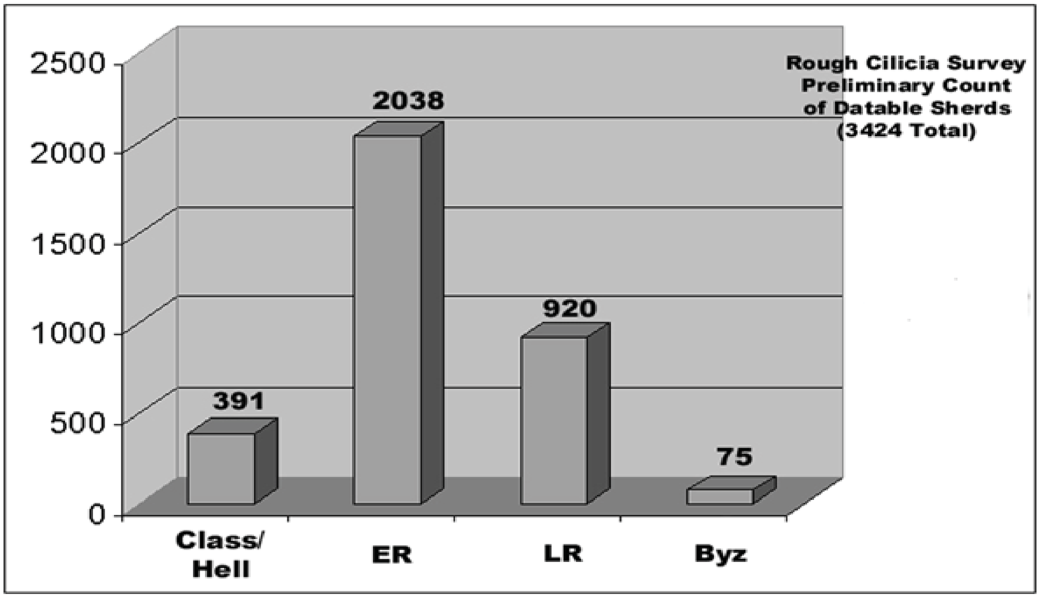

Figure Five: Preliminary Chronology of Unrefined Survey Pottery Counts, All Sites, 1996-2008

Figure Six: Zemer 41 Pinched-Handled Amphora in the Anamur Archaeological Museum (Inv. No. 4.3.90x)

Figure Seven: A&C, Exposed Press Basins at the Biçkici Kiln Site; B, Roman-Era Tower Overlooking the Biçkici Kiln Site

Figure Eight: Left, Iron Ingot (?) from Laertes; Right, Iron Slag from Antiochia ad Cragum

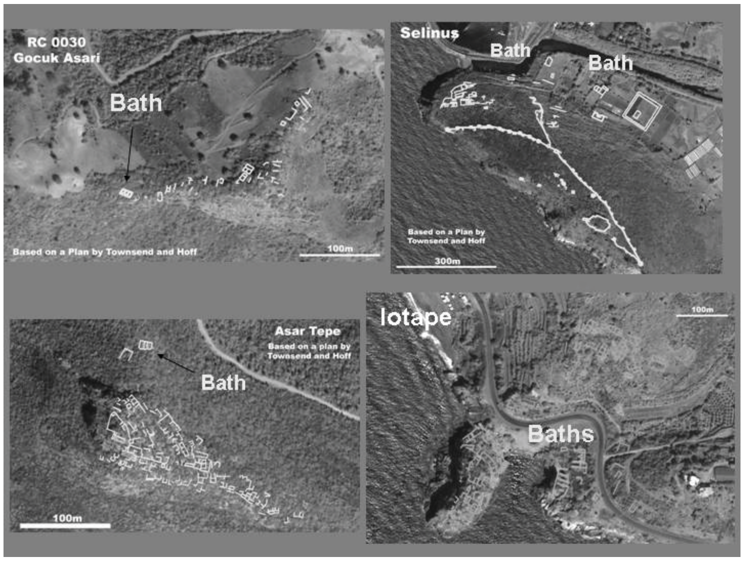

Figure Eight A: Site Plans of Urban Settlements in Western Rough Cilicia

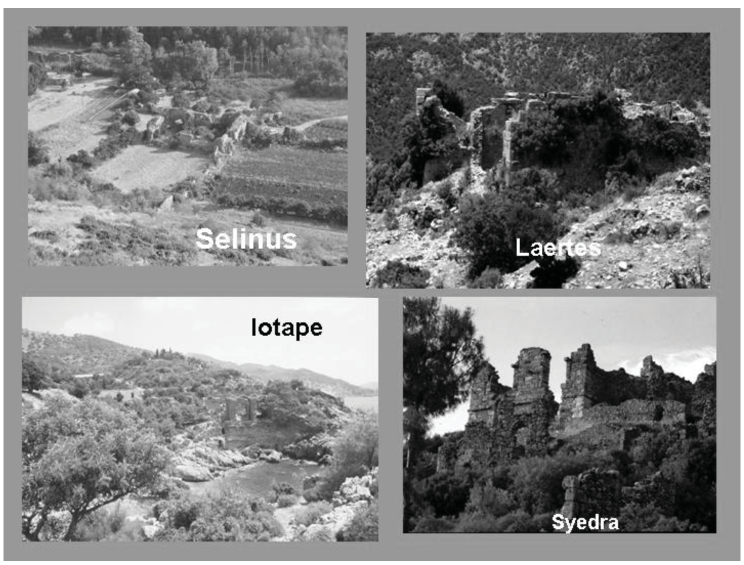

Figure Nine: Large Bath Complexes in the Survey Region


Figure Ten: Sheperd Relief at Sivaste (RC 0301)

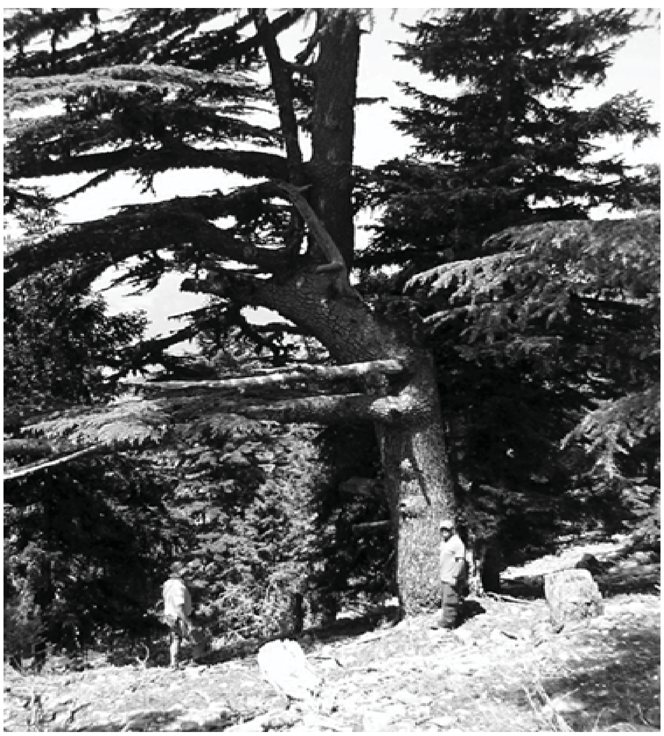
Figure Eleven: Relic Cedar Tree at Gurcam Karatepe

Figure Twelve: Geomorphic Trench Work at the Biçkici River Basin

Figure Thirteen: Locations of Geomorphic Trench Excavations in the Biçkici and Hacimusa River Basins and Estimated Area of Alluvial Deposition (3m)

Table Two: Recorded Rates of Alluvial Deposition in RCSP Geomorphic Trench Excavations, 2001-2004

OVERALL RATES

Excavation Location	Dates	Timespan/years	Deposition/m	Rate/100 years
Sand Pit Kizilin Beach	654-274 BC	380	015	0.05/100yrs
Trench D Bickici River Terrace	532 BC-1007 AD	1538	0.75	0.48/100
Trench 5 Kizilin Cave	19 BC - 417 AD	435	1.0	0.23/100
Trench D Bickici River Terrace	1007-2007 AD	1000	1.4	0.14/100
Trench 5 Kizilin Cave	417-2002AD	1685	2.0	0.12/100
Sand Pit Kizilin Beach	274 BC-2007AD	2281	3.35	0.146/100
Trench 2 Kuru Lagoon	532 BC-2007 AD	2533	4.0	0.157/100
Totals		**9852**	**12.65m**	**0.128/100 years**

PREMODERN RATES

Excavation Location	Dates	Timespan/years	Deposition	Rate/100 years
Sand Pit Kizilin Beach	654-274 B	380	0.15	
Trench D Bickici River Terrace	532 BC-1007AD	1538	0.75	
Trench 5 Kizilin Cave	19 BC - 417 AD	435	1.0	
Totals		**2353**	**1.9m**	**0.08/100 years**

MODERN RATES

Excavation Location	Dates	Timespan/years	Deposition	Rate/100 years
Trench D Bickici River Terrace	1007-2007 AD	1000	1.4	
Trench 5 Kizilin Cave	417-2002 AD	1685	2.0	
Sand Pit Kizilin Beach	274 BC-2007 AD	2281	3.35	
Totals		**4966**	**6.75**	**0.135/100years**

Figure Fourteen: Table of Alluvial Deposition Rates in Gazipasha River Basins

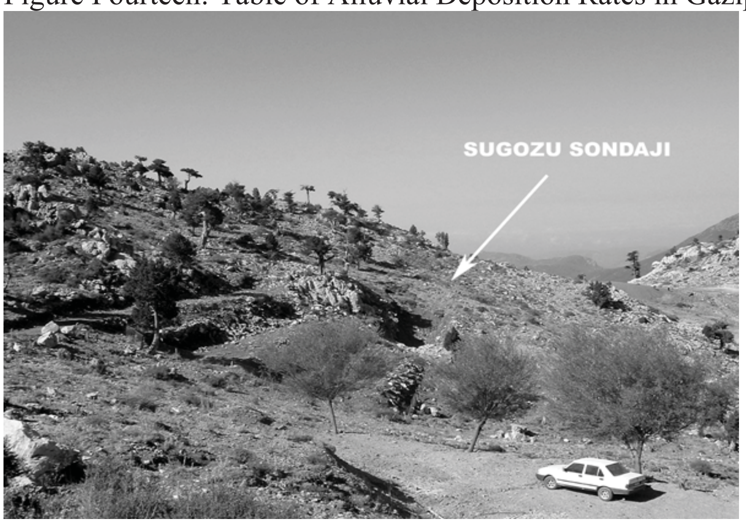

Figure Fifteen: Copse of Juniper Trees at the Excavation Pit at Suguzo Yayla (Crest of the Bickici 1700m asl)

Figure Sixteen: Step Trench Displaying 5cm Scarp Samples at Sugozu Yayla