Not the end of the world? Post-Classical decline and recovery in rural Anatolia

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Abstract

Between the foundation of Constantinople as capital of the eastern half of the Roman Empire in 330 CE and its sack by the Fourth Crusade in 1204 CE, the Byzantine Empire underwent a full cycle from political-economic stability, through rural insecurity and agrarian decline, and back to renewed prosperity. These stages plausibly correspond to the phases of over-extension (K), *subsequent release (Ω) and recovery (α) of the Adaptive Cycle in Socio*-Ecological Systems. *Here we track and partly quantify the consequences of those changes in different regions of Anatolia, firstly for rural settlement (via regional archaeological surveys) and secondly for land cover (via pollen analysis). We also examine the impact of climate changes on the agrarian system. While individual histories vary, the archaeological record shows a major demographic decline between ca .650 and ca. 900 CE in central and southwestern Anatolia, which was then a frontier zone between Byzantine and Arab armies. In these regions, and also in northwest Anatolia, century-scale trends in pollen indicate a substantial decline in the production of cereal and tree crops, and a smaller decline in pastoral activity. During the subsequent recovery (α) phase after 900 CE there was strong regional differentiation, with central Anatolia moving to a new economic system based on agro-pastoralism, while lowland areas of northern and western Anatolia returned to the cultivation of commercial crops such as olive trees. The extent of recovery in the agrarian economy was broadly predictable by the magnitude of its preceding decline, but the trajectories of recovery varied between different regions.*

Keywords: Byzantine; adaptive cycle; pollen; archaeological survey; Anatolia

1. Introduction

Mediterranean landscapes have been transformed by human actions during repeated long cycles of land-cover conversion and agricultural intensification followed by agrarian decline and environmental recovery (Butzer 2005). The last, and arguably the most important, of the pre-modern cycles of decline and recovery occurred during the middle of the first millennium CE, as the unified Classical world was fractured and eventually metamorphosed into the medieval world

(Horden and Purcell 2000). The post-Classical transformation of the Western and Central Mediterranean, including the Balkans, began early, notably in the fifth century, with migrations of peoples from Northern and Eastern Europe, and beyond. In the Eastern Mediterranean, by contrast, the Classical world system maintained itself for a further two centuries. In Anatolia west of the Euphrates, the Levant, Cyprus and Egypt, economic and political continuity was achieved under the aegis of the late Roman (= early Byzantine) Empire. These regions only came under serious military threat in the late sixth and seventh centuries, initially from Sasanian Persia and then, more significantly, from Islamic Arab invasions. The Levant and Egypt were quickly lost to the Caliphate, while the Anatolian peninsula became a militarized frontier zone between Arab invaders and Byzantine defenders. From the mid-ninth century onwards, this frontier was pushed back eastwards and inner Anatolia became secure militarily. This development heralded a mid-Byzantine 'Golden Age', which lasted up until the battle of Mantzikert (1071 CE), after which Byzantium permanently lost inner Anatolia to incoming Turkic nomadic tribes. Thus during the centuries between ~300 and ~1200 CE, most of Anatolia underwent a full cycle from political stability and economic prosperity, through rural insecurity and agrarian decline, and back to renewed prosperity. How did the intervening 'Dark Age', for which fewer relevant textual sources are available, transform the rural landscape and economic system, and did this vary from one sub-region to another? How far was there a real decline and recovery of rural population and settlement? And what was the role of climatic changes in this transformative process? Anatolia in the second half of the first millennium CE offers us a *longue durée* historical experiment in human-ecological relations.

2. Conceptual frameworks, methodologies and data sources

The Adaptive Cycle described by Haldon and Rosen (this volume) provides one conceptual framework for analyzing long-term system dynamics, whether social, ecological, or socio-ecological. Holling (2001) argued that Socio-Ecological Systems (SES) move through four principal developmental stages dependent on key properties, including their inherent potential for change, the degree of connectedness between internal controlling variables, and their adaptive capacity (or resilience). Following their r-phase of increasing complexity, a stage of over-extension (K-phase) is reached, limiting the system's resilience to stress, whether internal or external. The subsequent release (or Ω) phase represents a period of positive feedback and instability, leading to system simplification. From this base, numerous new system trajectories can emerge during the following α-phase: some of these are radically new, while others represent a return to something close to the previous r-phase condition. The α-phase is considered both resilient and dynamic. Allcock (2017) has applied the Adaptive Cycle model to Cappadocia (central Anatolia) and identified four principal cycles of demographic growth, decline and recovery during the Holocene. The conservation K-phase of her third cycle potentially corresponds to the Late Roman period (ca. 330 to ca. 650 CE), with the subsequent period of rural decline/abandonment representing a release (Ω) phase (ca. 650 to ca. 900 CE). The tenth to twelfth century recovery and mid-Byzantine golden age might then equate to Holling's re-organisation α-phase (see also Izdebski et al., this volume). However, such a heuristic framework needs to be tested against empirical evidence for goodness-of-fit if it is to be more than a "Just so" story. This, in turn, requires measurable proxies for rural population, economy and environmental conditions.

One of the main ways to reconstruct rural population dynamics during early historical periods, such as the period covered here, is via systematic regional archaeological site surveys

(Alcock and Cherry 2004). Survey work is among the most rewarding and frustrating activities in archaeology. It allows us to witness the entire scope of a region and landscape, to note construction and habitation trends, and to hypothesize a community in much larger interconnected narratives. However, it is not always easy to date precisely the things that are found, nor are there clearly established evidential proxies available to indicate specific patterns in settlement, land holding and production. The clearest archaeological picture emerges from an integrated program of survey and related regional research, together with excavation of archaeological sites, in order to place artifacts such as pottery into a dateable functional and stratigraphic context. The survey results summarized in this paper derive from different methodologies, sampling practices and recording practices, which limits their commensurability. For more specific discussion of archaeological methods and the details of several archaeological case studies summarized here please refer to Cassis et al. (this issue). Combining results from multiple projects is a difficult process. However, the discipline of archaeological fieldwork is highly reflexive, such that many of the problems of integrating data from disparate projects are already well known. Despite these difficulties, the benefits of survey work outweigh the frustrations because the data help to create an overarching picture of the built and used environment.

A second, and completely independent, archive for reconstructing rural land-cover change derives from pollen analysis. By using multiple pollen records it is possible to reconstruct regional vegetation histories, so long as there is reasonable dating control (primarily through ^{14}C) and a suitable sampling interval. Although pollen analysis provides a record of past vegetation and land cover, there are certain limitations linked to taphonomy (production, dispersal and preservation of pollen grains) that may hinder data interpretation, sometimes producing a record that is biased and/or incomplete. Some taxa (e.g. pine) produce more pollen grains and/or their pollen is dispersed more widely than that of others (e.g. *Cerealia*-type). Other plant types, such as the daisy family (*Asteraceae*/*Compositae*), have pollen that is relatively resistant to oxidation, and hence can be over-represented when there is poor pollen preservation. A number of economically useful plants, such as cultivated fig trees (*Ficus*), are completely absent in the pollen record because they are pollinated by insects rather than by the wind. This means that past pollen percentages cannot be directly equated to former plant abundances. Most pollen grains can only be identified to genus (not species) level, and for some herbs even genus-level identification is not possible, although it is possible to distinguish different cereal types (e.g. *Secale*-type or rye) from other grasses.

Notwithstanding these problems, most pollen sequences represent time-continuous vegetation histories that can span periods for which historical (e.g. documentary) records may be sparse or lacking (Haldon et al. 2014). For this reason alone, pollen data have a special value in understanding the economic and environmental transition from Antiquity to the medieval world, whose textual record is far from complete (Izdebski 2013).

In order to test how rural landscapes and economies were transformed in different sub-regions, we focus on four sub-regions within Anatolia west of the Euphrates, shown in figure 1. It is possible to calculate regional means for key pollen taxa in all four of these sub-regions, and to establish demographic trends from archaeological surveys in three of them. These results can be compared in turn against well-dated climate records from northwest Anatolia and from Cappadocia, in south central Anatolia. Spatial congruence between data sets is essential if multi-disciplinary reconstruction is to become genuinely interdisciplinary. In that regard, some regional ecologies vary greatly from each other. For example, environmental resources in coastal lowlands of Anatolia stand in marked contrast to those in interior landscapes, whether montane or on the low-relief plateaux of inner Anatolia. Those interior landscapes experience colder winters and the latter are also marked by aridity that can make dryland cereal farming unreliable when climatic change brings lower moisture availability. About half of the available archaeological site surveys have been carried out in coastal lowland regions, with the rest in montane/plateau interior areas. By contrast, almost all of the available pollen sites, except in western and northwestern Anatolia, come from interior uplands. Consequently, it is only here that it is possible to make a direct comparison with archaeologically inferred palaeodemographic data sets. The analysis that follows is consequently incomplete and only partly commensurable internally. Nevertheless, where they do overlap in space and time, pollen and archaeology can allow rigorous inter-comparison and provide genuine insights into long-term SES dynamics.

3. Demographic reconstructions from regional Anatolian archaeological surveys

In the present discussion we focus as far as possible on *longue durée* questions outlined in the introduction, such as potential connections between major changes in settlement patterns that accompanied the collapse of the Roman Empire in the seventh century and systemic resilience in the context of climate change. Critical to understanding the intersection of these systems, we will attempt to discern changes in crop choices, taking into account variations by ecological zones, demographic and transportation systems. Within this framework, we then consider other factors such as climate, changes in markets and historical events.

Changing patterns of settlement are not easily amenable to simplification. Cassis et al. (this volume) discuss constraints on the use of archaeological site survey data for interdisciplinary syntheses while at the same time avoiding over-simplification. Previous work in landscape archaeology has argued that vestiges identified in the landscape are fraught with interpretative vagaries; these arise from a plethora of transformations resulting from use, abandonment and post-abandonment actions that are both human and natural in origin. Nonetheless, in order to create a common denominator, we have used variations in site counts over four chronological phases as a measure of changing settlement over time. Because of fundamental topographic and methodological differences these numbers are not comparable across projects, but our hope is that the overall trend of each settlement pattern trajectory over time provides a basis for cross-project comparison.

3.1 Archaeological Surveys: a synthesis of results

There follows a brief synthesis of the rural settlement data, broken down by periods and/or by regions. The main surveys discussed here have been selected because they included significant elements of intensive survey that have been published in detail, and this selection leads us to a geographical focus on the north and south coasts of Anatolia. In order to ensure that inner Anatolia is also represented in our discussions and comparisons with pollen evidence, we also summarise published settlement histories from archaeological site surveys in southwest Anatolia (Balboura, Sagalassos) and south central Anatolia (Konya plain). Other regional surveys, such as Paphlagonia in north central Anatolia (Matthews and Glatz 2009) and Cappadocia in south central Turkey (Omura 1998; summarized in Allcock and Roberts 2014), do not provide sufficiently detailed periodization to allow robust testing of the Adaptive Cycle model.

From historical sources we have a good sense of the sorts of societies that we are investigating archaeologically. Thus Roman structures might be described as follows: rural (core, marginal, nomadic), suburban (within ca. 2 km over land or close proximity over water of a city) and urban. Cities may be categorized as small (e.g. Sinobuç, Euchaita, Cakıroğlu, Balboura), medium (e.g. Sinope, Claudiopolis), large (e.g. Tarsus, Attaleia, Sardis, Amorium), and giant, (e.g. Ephesus, Antioch, Constantinople) (Mitchell 1993; Potter 2011). These definitions are based on population, not on physical size. This set of divisions does not work well for the post-Roman period, where a better model might be rural, nomadic, town, and giant city (Brandes and Haldon 2000; Henning 2007).

We established four broad period categories for this project, intended to ease inter-project comparisons of data rather than to imply anything meaningful about the periods themselves. The periods potentially correspond to the four stages of the Adaptive Cycle model described above;

1. Roman, first century CE to third century CE. Ceramic assemblages include Eastern TS A and B, Dressel 2-4 amphorae; (r-phase)
2. Late Roman, fourth to seventh centuries CE. Ceramic assemblages include ARS, PRS, CRS, LRA 1-7; (K-phase)
3. Intermediate, seventh to ninth centuries CE. Ceramic assemblages included Glazed White wares of various sorts, globular amphorae; (Ω-phase)
4. Middle Byzantine, tenth to twelth centuries CE. Ceramic assemblages included lead glazed wares, especially early forms of sgrafitto, much harder fired ceramics; (α-phase)

In broad terms, the archaeological surveys analyzed lay in three ecological zones. The first was the coastal strip with harbors and generally good trade access to distant markets (Cide, Sinop). Second was the interior uplands with varying degrees of forests and meadows (Sagalassos, Balboura, Göksu), and third were interior plains, notably on the Anatolian plateau (e.g. Konya

Plain). These zone definitions are focused both on ease of access to markets – i.e. judgments based on economic opportunities – and also altitude, which serves as a good way to understand the sorts of crop choices available to farmers (Table 1).

3.1.1 Northern Anatolia

In order to reconstruct the demographic evidence for northern Anatolia, we built on a basic framework provided by the three archaeological surveys that provide sufficient statistically suitable data and a sufficiently detailed chronological scheme to facilitate meaningful analysis. Cide and Sinop lie north of the Pontic coastal mountains, while Avkat lies south of them. The farmstead excavated at Cadır Höyük will also be considered here as it provides a look beneath the surface that is necessarily emphasized in the survey projects. Here summaries are presented; for detailed discussion of relevant evidence please see Cassis et al (this volume).

Imperial Roman (r-phase), 1 to 330 CE

Roman administration of northern Anatolia featured a number of processes that are highly visible in the settlement record. Indigenous settlement that had, up to this point, been based on fortified sites atop high ridges and outcrops, moved down into the flat lands administered by newly founded cities. These cities were integrated into a network of good-quality roads, and the secure conditions permitted the spread of small-scale rural settlements including farmsteads. Establishment of an integrated imperial economy brought even rural farms and villages into a system that spanned the greater Mediterranean, encouraging agricultural production of specialized cash crops where ecological and transportation conditions permitted. North of the coastal mountains, the high rainfall regime together with the high efficiency of transporting bulk goods over long distances by sea encouraged participation in broader overseas trade networks. The interior area to the south of the mountains featured agriculture linked to a regional economic distributions system by the developing road system.

Late Roman/Early Byzantine period, 330 to ca. 650 CE (K-phase)

Between the fourth and seventh centuries, rural settlement north of the Pontic mountains appears to have been dominated by two major factors: the distinctive sub-tropical climate and the easy access of coastal ports to Constantinople and other Black Sea markets. A nearly five-fold rise in the number of sites compared to Roman imperial times (see Cassis et al., this volume), together with the nature of site assemblages in rural parts of Sinop promontory, point to the emergence of an industrial-scale production of olive oil. The distinctive microclimate of Sinop together with easy access to maritime trade routes may have produced the spectacular rise in rural sites during this period. A more modest (three-fold) rise in rural settlements in the Cide survey during the Late Roman/Early Byzantine period (Figure 2) may be due in part to the demand from Constantinople for other agricultural products, even those less lucrative than olives.

In the interior of northern Anatolia, rural settlement seems to be largely characterized by continuation of the previous Roman model. The pattern of habitation remained similar to that of the first-third centuries: dispersed small settlements connected to larger urban centers. However, the area around Çadır Höyük was more conducive to dispersed farms commanding large areas, while settlements on the Black Sea coast seem to have been more nucleated, with fields surrounding them. In the interior, the habitation pattern seems to have consisted of central urban centers surrounded by extensive estates and villages. Çadır Höyük, for example, sits among a network of peer sites, which included the larger Late Roman settlement at Kerkenes (Summers 2001), as well as settlements in the vicinity of Uşaklı Höyük and Alişar. In antiquity, these were connected by the Tavium–Sebasteia road – the same one that runs between Yozgat and Sivas today (Mazzoni et al, 2010).

Overall, there are three elements that characterize these settlements in this period. First, they possess modest wealth, as defined by the presence of imported goods and public architecture such as churches. Second, the structures seem to fall into the same norms of habitation as were seen throughout the Roman Empire, that is, small-scale villas or farms found in the rough vicinity of larger centers. Finally, and most importantly, there are clear connections to urban centers, even if those centers are not particularly large. Thus, this period can be recognized by substantial trade networks and non-isolated settlements, even in seemingly isolated modern environments.

Intermediate Period, ca. 650 to ca. 900 CE (Ω-phase)

In most places in Anatolia, the Intermediate period remains one of the most difficult to assess, because there is little archaeological survey can clearly identify as coming from this period. Rather, at present, we need to rely on stratigraphic excavation and other forms of evidence (e.g. pollen). With caveats, we may say that absence of evidence may provide evidence of absence. At the excavated settlement at Çadır Höyük, it is precisely this absence of traditional material evidence that identifies this period. It is a period marked by the lack of coins, luxury goods, and fine ware. However, it is visible in minor rebuilding that is contiguous with floor levels exhibiting the lack of clearly dateable goods. Furthermore, there are times where we need to stretch our accepted categories. For example, at Çadır Höyük we have found levels that occur later than the clearly identifiable Late Roman levels and that contain locally made red wares. These wares are poorly produced by any comparison with earlier ones, and often contain mica in their matrix, an element known from the region. More interestingly, they are poorly decorated, with rough scratches and asymmetrical wavy lines. They are imitations of something earlier, and possibly something lost, and they challenge traditionally accepted ceramic categories. The problem is that it is only with excavation that we can date these wares correctly. Thus in the Cide survey, there is not enough evidence to make an assessment either for or against the presence of habitation during the Intermediate period. Logic would certainly suggest that the population was there, particularly because the Black Sea area was both habitable and protected. The strong Late Roman presence, primarily in the coastal towns, followed by the substantial Middle and Late Byzantine presence in the region, also suggests that the population remained in the area. However, as this Intermediate period seems to have been characterized by local ceramic assemblages, it is almost impossible to identify these people in survey material alone.

Data from the Avkat Survey presents an increase in the number of habitational/agricultural sites beginning in the mid-seventh century and extending to the end of the eighth (ca. 626-800), and overlapping with the hypothesized Ω-phase. Despite the reduction in the number of sites, landscape use continues as in the prior period, including the expanded use of the fortified *kale* (castle) overlooking the town of Euchaita. The enhancement of this space corresponds to the increased militarization of Anatolia, within which Euchaita played a role. Thus the increase in activity could arguably reflect a region that, while maintaining its earlier agricultural practices, was nonetheless under stress, given its strategic location for military activities.

Middle Byzantine Period, ca. 900 to 1204 CE (α-phase)

Site patterns in the Middle Byzantine period in coastal and interior areas of northern Anatolia conform to geographical differences. Rather than forming imperial networks from urban to suburban to rural sites, they appear to emphasize localized protection. For example at Çadır Höyük in inner Anatolia, this period is represented by a substantial fortification on the mound, a small prominence of approximately 2.5 ha. dominating the terrace below. As noted in the previous article (Cassis et al., this volume) the fortified area included a number of structures, and likely also to offer protection both to the settlements on the terrace below it as well as to other villages or farms in the immediate vicinity. Yet it must have had a connection to a larger center that could provide both troops and logistical support. Kerkenes, which is largely unexplored for the Byzantine period, may be a Middle Byzantine *kastron* (fortified settlement), and might have fulfilled this function. The material culture is sparse and local; there is virtually no fine ceramic ware at this site from the Middle Byzantine period. Despite the lack of luxury goods, the presence of large numbers of coins (particularly in the early eleventh century), suggests connections to external sites, although not on the large scale visible during the Late Roman period. The Avkat Survey identified similar tendencies. Use of the fortifications above Euchaita continued, enhanced by several smaller watchtowers to the northeast and southwest to extend the region's defensive capacity.

At Cide on the Black Sea coast, the Middle Byzantine period was marked by a contraction of urban centers, as well what looks like more localized organization. The survey evidence suggests that the population largely moved inland, leaving the protection of the sea in the hands of small fortifications located on seaward promontories. Two major fortifications that appear to be related to villages are found inland at Okçular. While useful to the farms below them, they were of limited value for protecting the coastline or even warning of an impending attack. At Gideros, which is a small natural harbor, there is a major fortification that seems to have been used consistently throughout antiquity. During the Middle Byzantine period, however, the major settlement here seems to have been centered on an inland village and monastic complex.

3.1.2 South central and southwest Anatolia

The south coast was not the most prosperous part of Anatolia. The west coast was dominated by major cities including Ephesus, Pergamum, and Nicaea, but in the south the only large cities were Tarsus and, in northern Syria, the huge city of Antioch. The river valleys of western Anatolia were fertile granaries, and there is abundant evidence of economic prosperity and well-integrated trade networks in the coastal regions, but there were fewer cultivable plains on the south coast. In the interior, e.g. in the Konya basin, large-scale irrigation works were required during Roman-early Byzantine times to supplement rain-fed cultivation of cereal crops.

Settlement in the *Upper Göksu valley* in inland Isauria included small cities, most of them created from villages during the first century CE. Some cities were located close together: for instance Claudiopolis (modern Mut), the largest city in the region, lay only 5 km west of Sinobuç, whereas its closest city in the other direction was Adrassus, 30 km away. These cities thus had territories of various sizes. There was some occupation of almost all the urban sites from the Roman to the Medieval period, though at lower levels of intensity after the seventh century. Around these cities were three zones of rural settlement, defined by altitude and agriculture. There was a lower-lying zone of cereals and fruit trees (apricots, figs) up to about 300 m. Between 300 and 800 m was an intensely exploited zone, the site of most vine and olive cultivation and of the majority of permanent settlements (villages). Above this was a zone of villages, seasonal rural settlement (*yaylas*), and refuges, with cereals and more fruit trees (especially apples). Many sites were not occupied in all periods, but there is no clear pattern to settlement continuity. Lack of settlement continuity in modern times is often correlated with shortage of water, which would have left settlements vulnerable to any changes in climate during late antiquity and early medieval times. Cities were distinguished from villages in several ways. One was size, but another was defensibility. Several regional cities lay above 1200 m (Ermenek, Adrassus, Dağpazarı), and it was common to construct a city around an acropolis on high ground (e.g. Mut, Sinobuç).

At a very simple level, occupation of the countryside increased in intensity over time from the Hellenistic period to the Late Roman period. This probably reflects a slow but continuous population growth over this time. The late Roman period of the 4th to 7th centuries CE (K-phase) saw the most intense occupation of the countryside at any period until the late twentieth century, but from the middle of the seventh century there was a dramatic loss of settlement continuity (Figure 2). The historical context for the 7th century onwards (Ω-phase) involved sustained insecurity and instability along the Taurus frontier, which one might also expect to see reflected in changes in settlement patterns. By the end of the Middle Byzantine period (10^{th} to 12^{th} centuries CE; α-phase), settlement numbers had returned to a level similar to that of the early Hellenistic period. Subsequent developments suggest a further change in exploitation strategies. In later periods, there were a number of cemeteries in the uplands, but these rarely have any settlements associated with them. These probably reflect Turkic nomadic groups with very different funerary traditions.

Some of the changes visible in the archaeology of rural settlement in the Upper Göksu Valley are a result of a reduction in the volume of identifiable imported pottery. As a result of there being fewer fine-wares, the number of sites recorded for the period after the early seventh century diminishes. This reduction is explained in a number of different ways, including demographic change (as a result of plague, war, migration), a change in trade as shown by ceramic supply (as a result of war, economic decline).

The results from the Upper Göksu Valley survey (GAP) can be compared with others from southern Anatolia (Figure 2). Whereas the GAP survey covers a very broad altitudinal range, from near to sea level up to over 1200 m, other regional archaeological surveys cover a narrower range at or above 1000 m. Those from southwest Anatolia represent the Taurus mountain zone comprising well-watered uplands (mainly limestone terrain) and intervening intermontane valleys, with surveys centered around important Classical cities at Sagalassos (which has also undergone excavation) and Balboura. On the plateau of south central Anatolia, the Konya basin archaeological survey covers an area that is climatically drier but contains potentially fertile alluvial soils that can be irrigated from inflowing rivers, such as the Çarşamba Çay.

The absolute values for site numbers by period are partly determined by the size of the survey area, and are therefore less important than trends though time for each survey. In that regard, the Konya basin survey shows a maximum in settlement numbers during early Byzantine times (fifth-sixth centuries), followed by a dramatic decline during the seventh century CE. The lack of detailed periodization for the subsequent periods (seventh-thirteenth centuries) makes it difficult to establish whether there was complete abandonment or only rural decline during the intermediate period of the eighth-ninth centuries. However, the recent identification of forms of seventh- and eighth-century pottery suggests that the contrast between the Balboura project and earlier projects is exaggerated. On the flat Konya plain, the lack of defensible sites and the need to maintain irrigation structures makes it likely that rural populations abandoned their fields and villages entirely for the greater security of the Taurus uplands during the Intermediate period. The 34 early medieval sites recorded in this survey may therefore date mainly to the mid-Byzantine revival and the subsequent Seljuk period, during which Konya was a leading urban center, with numerous *hans* (caravanserai) constructed along major roadways.

The period of late Roman/early Byzantine prosperity is also clearly recorded in the Balboura survey – although here settlement numbers appear to have remained high into the seventh-eighth centuries, after they had already declined sharply at Sagalassos, in Konya and in the Göksu Valley. The mountainous Lycian hinterlands of Balboura were economically marginal but defensible, and the previous (late Roman) way of life seems to have continued here for longer. The Balboura survey does, however, indicate complete abandonment during the ninth and tenth centuries, prior to re-occupation during the late eleventh, twelfth and thirteenth centuries. The re-occupation is associated in the Balboura survey with early Islamic Avlan ware, suggesting that this medieval economic and demographic revival was associated with the Turcoman pastoralists moving into an empty landscape, followed by the Seljuks, rather than a Byzantine re-occupation.

4. Pollen evidence for land-use and vegetation change

Changes in the archaeological record can be compared with evidence from pollen data for agricultural activity and environmental change. Palynology has identified a remarkably clear phase of anthropogenic land-cover change, labeled the Beyşehir Occupation Phase (BOP) (see

Roberts, 2017 for a recent review). The start of the BOP, typically in the mid-first millennium BC, is marked by a decline in forest taxa and an increase in the pollen of grasses (including cereal-type) and ruderals and by the presence of cultivated trees, such as olive and walnut. The BOP was initially identified in pollen records from the inter-montane basins of southwest Anatolia, but it has since been recognised – in modified form – from central and northern Anatolia (Bottema et al 1993/4; Izdebski, 2013), Cyprus (Kaniewski et al., 2013), and the southern Levant (e.g. Neumann et al., 2010). In its latter part (i.e. fourth-seventh centuries CE) the BOP appears to have been spatially congruent with provinces of the Eastern Roman Empire. The BOP came to a clear and often abrupt end in the middle of the first millennium CE, after which anthropogenic pollen indicators declined or even disappeared completely, being replaced mainly by pollen of secondary forest, especially of pine trees – a transformation that implies a re-wilding of the landscape. The ending of the BOP plausibly represents post-Classical economic and demographic decline, at least in the countryside. When examined in detail, however, there are apparent deviations from this pattern at individual sites, particularly concerning the end date for the BOP. In many cases, these differences can be explained by a lack of chronological precision. For example, at Lake Beyşehir itself, the main termination of the BOP appears to have taken place ca. 300 CE – that is, prior to the Late Roman period, rather than after it (van Zeist et al., 1975). However, because there is only a single late Holocene ^{14}C date from Beyşehir (3265±35 uncal. BP), the statistical uncertainty on the inferred age for the end of the BOP is rather large here, up to ±400 years using BACON age-depth modeling software. In other words, at Beyşehir itself the BOP could have ended at any time between 100 BC and 700 CE.

We have therefore focused on those pollen records with direct dating control during the period of interest (ca. 300 CE to ca. 1300 CE), and with a mean of at least one pollen sample per century. These criteria mean that we have been relatively selective about site inclusion (cf. those listed in Haldon et al., 2014). We have also avoided any interpolation where there are data gaps, since metadata will tend to smooth out and blur trends and reduce the amplitude of variability. This filtering process results in the inclusion of 11 sites, two of them with separate diagrams from the same site. In the case of south central Anatolia, the pollen synthesis is based on only a single record (Nar lake), although this site is unusually well dated by varve counting and it contains a similar number of total pollen samples ("spectra") to those of the other regions.

Where possible, we have used the same age-depth chronologies as Izdebski (2013), in order to facilitate comparison of results. Data have then been "binned" into 100-year time intervals (e.g. fifth century CE). Pollen sums are based on dryland pollen, excluding Cyperaceae. In some records, especially deep-water lakes such as Nar and Iznik, sedge pollen is only a minor component and probably derives mainly from non-aquatic habitats (e.g. grazing land). However at other sites (e.g. Demiryurt), Cyperaceae pollen values are very high and 'swamp' other taxa, because the former are derived from local wetland plants at the core site.

We have created three categories of agrarian land cover from pollen data, namely:

1. Tree crops (olive, walnut, vine, manna ash, chestnut)
2. Cereal-type
3. Grazing indicators (*Plantago lanceolata, Rumex acetosa*-type, *Sanguisorba*)

The data have been combined to establish mean values for each sub-region for each century, except for central Anatolia, where only one site (Nar) is available.

4.1 Results

The results of this regional pollen synthesis are shown in Figure 3. For cereal-type pollen, all sub-regions show a similar trend, with higher values during the first few centuries CE, followed by a decline in the middle of the first millennium, and a return to higher values by the end of the millennium. The phase of low cereal values lasts between two and three centuries, and is centered on the seventh-eighth centuries in northern Anatolia and the eighth-ninth centuries in southern Anatolia. These slight differences in timing lie within the dating uncertainty of the records used, so they should not be over-interpreted. The common trajectory between the four sub-regions indicates that cereal-based agriculture declined but then recovered across the whole of western and central Anatolia over a multi-centennial timescale.

Tree crop pollen shows a similar pattern to cereals between 300 and ca. 800 CE, namely one of high initial values in all sub-regions and subsequent decline. After ca. 800 CE, however, there was a recovery in tree crops in only one of the sub-regions, namely northwest Anatolia (=Roman Bithynia; Byzantine Thema of Opsikion). In the three other sub-regions, tree crop pollen remained low throughout the remainder of the study period used here. It should be borne in mind that regional mean values do not tell the whole story and can be distorted by individual records. In that regard, the recovery in tree crops was experienced most clearly at two of the four pollen sites from northwest Anatolia, namely in Iznik and Sapanca, both lowland lakes. At the densely forested upland site of Abant, by contrast, tree crop values never exceeded 2% throughout the study period. In effect, cultivation of tree crops was widespread across Anatolia up until ca. 600 CE, but after that time it retreated to coastal lowlands of the west and northwest. In the absence of pollen records, it is difficult to know how far a similar pattern for this time period also applied to the coastal regions of southern Anatolia (e.g. Pamphylia, Cilicia).

The pollen of grazing indicators shows a trend that is broadly similar to that of cereals, although values generally do not fall as low during the 'trough' of the saddle-shaped curve, and only partly recover afterwards in some areas (e.g. in southwest Anatolia). These pollen data also make it possible to calculate the amplitude of decline and subsequent recovery in agrarian activity by sub-region and type (table 3). Individual pollen taxa vary in their production and dispersal, which makes it difficult to compare between the three land cover types directly (e.g. cereals vs tree crops). However, because these taxa are broadly consistent *within* land cover classes, it is possible to establish long-term trends in agrarian economic activity. The pollen sites that we have are not fully representative of Anatolia's agrarian landscapes, and there is a need for more and better records from agriculturally productive lowland regions before we can generalize with confidence.

However, based on currently available pollen data, overall cereal production during the late seventh to ninth centuries CE seems to have fallen by over 80% compared to Late Roman times (i.e. to 19% of previous values). Across Anatolia as a whole, cereal production appears to have recovered to above previous levels by medieval times, but with significant regional variations. Hence in central and northern Anatolia, cereal production during the eleventh century reached values significantly above those achieved in the fifth-sixth centuries, but this was not the case in the southwest, where overall cereal production recovered to only about half of that in Late Antiquity.

The fall in tree crops was similar to that found in cereals (85% decline), but only two of the four sub-regions show evidence for medieval recovery. Pollen evidence for economically significant medieval arboriculture is restricted to the lowlands of northwest Anatolia (Bithynia/ Opsikion), the region closest to Constantinople and the heart of the Byzantine Empire. A similar pattern is evident in pollen records from western Anatolia (not included in the four regions used for pollen synthesis; = Roman Caria, Byzantine Trakesion) – for example, at Gölçük, near Sardis, where sweet chestnut appears to have been a major commercial crop (Sullivan 1988), and at Bafa, near Miletus, where olive and walnut cultivation continued through from Classical to medieval times (Izdebski 2016).

The decline in the pollen of grazing indicators was smaller than that found in arable crops, but it still fell to only about one third of the level in Late Roman times. Recovery was regionally variable, but overall the pollen of grazing indicators returned to about 70% of its previous value. It should be noted that these grazing weeds only provide an indirect proxy for the pastoral economy, and they cannot be equated to past livestock numbers.

How far is it possible to predict the economic recovery from the amplitude of the previous recession, in a way analogous to endogenic explanations for business cycles? Figure 4 plots the agrarian decline vs recovery for each sub-region and land-cover type. Although the data set is small and there are exceptions (notably for cereal output in south central Anatolia, which fell to 13%, but recovered to 154% of previous values), the pattern is in broad accord with the hypothesis that a larger decline leads to a smaller recovery. There are hints that the slope of the relationship varies between different agrarian land uses, notably for cereals, which appear to recover more strongly than either tree crops or grazing activity, suggesting a more elastic response following perturbation. As an annual crop with an immediate return on investment, this makes some sense.

There are also suggestions in the pollen data that human re-colonisation of landscapes that had previously been abandoned and turned wild may have been a two-step process. This involved firstly development of more mobile, less labour-intensive pastoral economies that turned to cereal cultivation once political conditions became more secure, notably after Byzantine victories during the tenth century. In the long run, cereal farming would have been more profitable and sustained larger populations.

5. Climate changes

A detailed consideration of changes in climate in the western half of Anatolia during the transition from antiquity to medieval times is beyond the scope of this paper, but a short summary is needed here in order to assess the role of this exogenous factor in triggering or amplifying shifts in the regional socio-ecological system. More detail on palaeoclimate can be found in the papers by Labuhn et al (2017), Izdebski et al. (2016), Xoplaki et al (2016) and Haldon et al (2014). The two best-dated and most detailed records of hydro-climate (i.e. moisture balance) from the study region come from Sofular cave in northwest Anatolia (notably $\delta^{13}C$) and Nar lake in Cappadocia (notably $\delta^{18}O$). These two records show a high degree of similarity, except for a minor dating offset in the fourth-fifth centuries, strongly suggesting that they have responded to a common climate forcing of at least regional extent. The primary data (from Göktürk et al. 2011; Jones et al., 2006; Dean et al., 2015) have been transformed here into z-scores in order to compare them statistically, and then averaged for 100-year time periods, following Labuhn et al (2017), in order to make them directly commensurable with pollen and archaeological data sets. The graphed data are shown in Figure 5.

The data show generally drier climatic conditions in Anatolia prior to the sixth century, with aridity being most marked during the fourth and fifth centuries. This dry phase was followed by a rapid, high-amplitude shift to a much wetter climate in the sixth, seventh, and eighth centuries. Although somewhat drier conditions prevailed in the ninth century, a wetter climate returned in the tenth and eleventh centuries. This sequence of climate changes is supported by documentary records of drought, flood and famine (Telelis 2008) and by other palaeoclimatic records that are less well dated than Nar and Sofular, for example, from Tecer lake (Kuzucoğlu et al., 2011) (see Haldon and Rosen, fig. 2, this volume). Tree-ring records of climate from Anatolia only go back to the start of the second millennium CE, and so are of only limited use for the current analysis. There are suggestions from the Jeita cave speleothem isotope record that the 'Anatolian' climate pattern extended as far south as Lebanon (see Labuhn et al 2017). On the other hand, proxy climate records from the Balkans and Greece show a different trend (Labuhn et al 2017); to judge from the stable isotope data from Lake Gölhisar (Eastwood et al., 2007), this 'Aegean' pattern may have extended into southwest Anatolia. Thus it seems very likely that that three of the four sub-regions shown in Figure 1 experienced a common hydro-climatic trajectory between 300 and 1300 CE, whereas the fourth sub-region (southwest Anatolia) may have experienced a somewhat different climatic history.

Temperatures change over a much larger spatial field than does precipitation, so that they are likely to have followed the same trends across the whole of the Anatolian study region. Although there are no proxy palaeo-temperature data for Anatolia, it is likely that tree ring-derived data for the Alps also apply in the Eastern Mediterranean (see Haldon and Rosen, fig. 2, this volume). Temperatures were above the long-term mean during the mid-first century CE and again in the early part of the third century, representing the peak of the so-called Roman Warm Period. Büntgen et al (2016) have proposed a 'Late Antique Little Ice Age' that followed the 536 CE 'dust veil' event and lasted until ca. 660 CE (ca. 615 CE in the Alps). The onset of this phase coincides with the climatic shift in Anatolia from dry to wetter conditions, and the cooler climate is likely to explain some of the shift in hydrology, because of reduced evapotranspiration losses of water at lower temperatures. On the other hand, wetter climatic conditions in Anatolia continued until ca. 750 CE, by which time temperatures (based on the records from the Alps) had returned to above the long-term average. Overall, changes in temperature and precipitation appear to have been largely decoupled during the study period. Changes in temperature would have been especially significant for tree crops in upland areas of Anatolia, many of which lie at or above the altitudinal limit for cultivation of olives and vines, both of which are sensitive to winter cold and spring frosts.

In relation to wider changes in the regional socio-ecological system, the Late Roman period (K-phase) overlapped with the shift to cooler but wetter climatic conditions of the sixth century. This may have encouraged the expansion of dryland cereal farming into climatically marginal lands in central Anatolia, and hence also societal "over-extension". However, any demographic pressure was reduced by the onset of bubonic plague during the reign of Justinian (527-565 CE) and recurring plague outbreaks during the following two centuries. There is no sign in the pollen record of a decline in olive cultivation in upland regions of Anatolia following the sixth-century onset of the Late Antique Little Ice Age; this suggests that any loss of olive trees or decline in harvests due to lower winter and spring temperatures was insufficient to deter farmers and landowners from retaining a Classical Mediterranean agrarian system. Before abandoning existing agricultural systems, farmers would have tried many adaptations, including changing crop types to hardier varieties (e.g. planting barley in place of wheat) or changing planting seasons.

In a simple explanatory model, it would be tempting to link the subsequent release (or Ω) phase of the late seventh and eighth centuries to a period of climatic deterioration, such as a drought phase, when pressure on environmental resources would have increased or populations exceeded carrying capacities. In practice, this was not the case – at least, not in a simple form. At the start of the release phase (ca. 650 CE), climatic conditions were still favorable, being relatively wet and not exceedingly cold. The absence of any simple relationship between societal 'decline' and climatic deterioration is unambiguously confirmed at Nar lake, where multi-proxy analysis of pollen (indicating agrarian land cover) and stable isotopes (indicating hydro-climate) in the same cores show that land abandonment at the end of the BOP did not coincide with a shift to a period of climatic aridity (England et al., 2008). On the other hand, the subsequent re-organisation α-phase after ca. 900 CE did coincide with a period of climatic amelioration, which may have aided the socio-economic recovery; hence the evidence supports climatic opportunism rather than climatic determinism and crisis.

6. Synthesis

6.1 Late Roman (Early Byzantine), K-phase

The main historical developments marking the transition between the Early and Late Roman periods occurred in the early fourth century: the foundation of Constantinople as the seat of Roman imperial power and the adoption of Christianity as the empire's official religion. Constantinople rapidly grew into a city of a half-million people, becoming the focus of much long-distance maritime trade. This trade involved transportation of goods – especially agricultural products, including wheat and barley, olives and grapes, olive oil and wine – to major cities. Evidence for this trade comes via proxies, particularly fine-ware ceramics and amphorae. As well as creating a new market and a new focal point for the redistribution of goods, the foundation of Constantinople also changed the trading relationships between the existing large cities of the Eastern Mediterranean, such as Ephesus, Antioch and Alexandria.

Christianity brought other changes, of which the most significant archaeologically was the widespread construction of churches in all rural settlements, often making this period highly visible archaeologically.

Pollen and archaeological evidence indicates a culturally transformed Late Roman agrarian landscape in Anatolia west of the Euphrates. This distinctive landscape involved a combination of animal husbandry, cereals and tree crops. Climate, terrain and ecology meant that the balance between these different elements varied regionally. For example, although there is evidence that in Roman times tree crops, such as olives, were cultivated in upland valleys in the territory of Sagalassos, (Vermoere et al., 2003), large-scale commercial olive groves were restricted to coastal lowlands, such as around Lake Iznik in northwest Anatolia, land next to the city of Nicaea, and parts of Palestine (see Roberts, 2017). Cultivation of both olive trees and vines in upland areas was aided by climatic conditions that were generally warmer than the long-term average up until 536 CE. Estimates for the upper limits at which olives could be grown in antiquity vary, but they are usually based on a combination of modern practices and ancient literary and archaeological evidence. In the early twenty-first century, large operations tend to be limited to about 800 m, though smaller groups of trees are found up to ca. 1000 m and isolated examples even higher. However, olives produced at these altitudes are of lower abundance and quality than those from lower altitudes (Vermoere et al. 2003). The same pattern occurs with vines, which can be grown at up to 1100-1200 m, while also producing smaller crops of lower quality. Cereal cultivation was dependent on precipitation as well as temperature, and small variations in rain and snowfall had a significant impact on dry-farmed cereal crop yields (Izdebski et al., 2016). Thus even in the twenty-first century, the well-watered Cilician lowlands in the Tarsus sub-province of Adana province produce a cereal yield 50% higher than Karaman on the Anatolian plateau. This must have been especially consequential during the period of dry climate during the fourth and fifth centuries. On the other hand, under conditions of political and economic stability, climatic aridity could be compensated by investment in irrigated agriculture – for example, in the Konya plain prior to ca. 500 CE, where archaeological survey data provides evidence of dense settlement at this time.

6.2 Intermediate period, Ω-phase

Economic prosperity and political security came to an end with the Persian and Arab wars of the seventh century. These conflicts transformed much of Anatolia from a relatively secure region into a borderland between the late Roman Empire and the Arabs. The seventh century brought dramatic changes, visible in the historical, archaeological and pollen records, including the end of the BOP at most sites Following the Byzantine-Arab wars of the seventh century and the loss of Byzantine control of the Levant and Egypt, central Anatolia and the southern coast were subject to Arab raids for more than two centuries. The unity of the Mediterranean as a single trading zone was broken and ceramic material of western Mediterranean origin, though never common before, now appeared only rarely. The seaborne flows of goods changed after the seventh century, when the role of major cities as attractors was diminished, with only Constantinople surviving as a major market. Even with the Byzantine re-conquest of large parts of Anatolia and northern Syria from the tenth century, cities no longer played the same role in society. In terms of causal mechanisms, we are able to eliminate the hypothesis that this 'collapse' of the late Roman socio-ecological system was triggered directly by drought or other climatic change; rather it appears to have been the result of human factors, notably warfare.

Although this period is poorly understood archaeologically, recent projects are beginning to identify ceramic material from the later seventh to ninth centuries, as at Sagalassos in Pisidia, Balboura in Lycia and Sebaste in Cilicia (Armstrong 2007). This recent work, although it still shows a decline in the number of sites, suggests that earlier impressions of an empty countryside in the so-called Dark Ages were rather misleading. The Göksu survey identified small amounts of material from the seventh and eighth centuries where none had been detected before, while at Balboura, the decline in site numbers comes only from the end of the eighth century. Despite their limitations, these ceramic analyses are nevertheless more precise than architectural indications. Many churches were rebuilt after the Late Roman period, but the rebuilding cannot be assigned to any specific period. With our new ability to detect ceramic material from the seventh and eighth centuries, an alternative model of slower reduction in settlement sizes in some regions, rather than a dramatic crash in all cases, might be considered.

This Intermediate period of rural land abandonment nonetheless saw a major reduction in the intensity of the human 'footprint' in Anatolia. Archaeological surveys from south central and southwest Anatolia show a fall in the number of settlements per generation of 70-80% by ca. 800 CE compared to ca. 600 CE, in line with the pollen evidence for the scale of decline in cereal and tree crop production (Table 3). Pollen data suggest that arboriculture was especially hard hit and that livestock grazing may have continued, albeit at a lower level. The pollen evidence for agrarian decline and 're-wilding' of the rural landscape is especially important in light of deficiencies in other sources of data, such as documentary texts, and the lack of archaeological survey data for some regions (e.g. Bithynia). Pollen data suggest that northwest Anatolia was less seriously affected than the other three sub-regions during this time period. This area was, of course, nearest to Constantinople and farthest from the Arab/Byzantine frontier zone. Izdebski

(2013) has suggested that Bithynia maintained a Classical-type rural economy until medieval times. The data presented here give some support to this hypothesis, albeit in modified form. It is clear from sites such as Iznik that there was a real decline in agrarian indicators in this region between ca. 650 and ca. 800 CE. However, the 'interregnum' appears to have been of shorter duration and ended sooner than elsewhere in Anatolia. The economy of this region subsequently recovered to a system similar to the one that had existed previously, with renewed cultivation of cereals and tree crops.

6.3 Middle Byzantine, α-phase

In the tenth century much of the central zone of Anatolia was restored to Byzantine control. Starting in the late eleventh century, there was increasing Turkic settlement throughout Anatolia and the introduction of pastoralism as a significant element in subsistence economies. Archaeologically, this period is marked by green glazed tablewares and the re-modelling of churches on a smaller scale. Whereas some areas, such as Balboura, show evidence of re-occupation only from the late eleventh century, others (e.g. Cappadocia) were taken back into Byzantine agricultural usage from the start of the tenth century onwards. Even if chronologically detailed archaeological survey data are lacking for Cappadocia, other archaeological evidence (e.g. for church building) attests to the importance of the mid-Byzantine 'golden age' in this area (e.g. Ousterhout, 2005). Similarly, textual evidence describes productive and wealthy imperial estates (e.g. 'Drizion') that had only recently become safe from hostile attack, after years of warfare and conflict. A number of Anatolian aristocratic landlords began to invest in expanding their estates around the 960s, a period coinciding with growth in the Byzantine agrarian economy (Haldon et al 2014). This resurgence is also evident in the Nar lake pollen record from

Cappadocia. Pollen data imply that cereal production was higher here by the early eleventh century than it had been in Late Roman times, but that olive and other tree crops were no longer economically significant. This agrarian re-expansion was aided by an ameliorating climate bringing higher precipitation, which would have led to more reliable yields for rain-fed cereal crops.

7. Discussion and conclusions

By using a multi-disciplinary approach, it is possible to triangulate between different data sources – archaeological, textual and palaeoecological – to establish how far they converge. However, this is only possible if the data sources are spatially congruent and if they have a comparable chronological precision and accuracy. For the former, it should be recognized that the majority of pollen cores derive from uplands, some of which were economically marginal, rather than from the cereal-producing lowlands. There are currently no pollen data to match the regional archaeological surveys at Cide and Sinop, for instance, just as there are no archaeological survey data to match the pollen diagrams from sites such as Iznik in Bithynia. There are, however, some areas in Anatolia with good spatial congruence between pollen and archaeological data – notably at Sagalassos (with pollen from Bereket and Gravgaz, among others) and at Balboura (pollen from Gölhisar and Söğüt) – while the archaeological survey at Avkat can be linked to pollen sites such as Ladik, and the Konya survey to the Nar pollen record. For chronology, we have put data sets on common timescales, with century-scale time resolution. While this inevitably leads to the loss of some temporal detail and of sub-centennial events, it allows us to identify *longue durée* trajectories in regional socio-ecological systems on a like-for-like basis.

In different ways, archaeological survey and pollen data both allow generalized trends in human activity to be revealed, thus transcending precisely dated historical events in order to explore broader structures and longer-term social and environmental processes. Both of these data sources focus upon activity beyond a single point of activity (the 'site') to consider broader regional patterns (e.g. rural settlement and land use) and their historical transformation. While aware of the 'false stability' in archaeological survey data, activity at a single locality over several phases can identify 'persistent places', which in turn can be used to infer elements of stability or instability. Comparing data and narratives can be a useful enterprise that provides an insight into broader regional patterns and trends. Throughout the period studied, there were changing markets (the creation of Antioch and Alexandria at the beginning of the Hellenistic period, and of Constantinople in the fourth century CE), as well as changing economic conditions (it was much easier to move goods freely and safely in the fifth century than in the eighth century), and changing tastes. Other reasons for change might have been demographic, reducing the manpower available for intensive crop production. These changes would have different impacts on different ecological zones, different altitudinal zones, and different market connection zones.

In terms of the Adaptive Cycle framework, we can see that the late Roman period – ostensibly one of over-extension (K-phase) – represented a tightly integrated socio-ecological system with strong internal connectivity, for example through trade. Political and military security allowed for long-term investment in the rural economy, notably in tree crops, which take decades to generate an economic return. In the subsequent release (or Ω) phase after 650 CE, there is clear evidence of land abandonment and a major decline in rural population, with crop production and settlement numbers falling by >80%. This decline may have been more gradual in some remote upland areas than elsewhere. The cause of the economic and demographic decline was exogenous and of human (rather than climatic) causation – namely, because Anatolia became a frontier zone between warring Byzantines and Arabs for more than two centuries. Cultivation of tree crops disappeared except for the northwestern and western coastal lowlands, while some upland areas became re-forested. Spatial connectedness in the economic geography of the eastern Mediterranean was reduced, especially in the flow of transformed products such as olive oil (Roberts, 2017). The following α-phase is marked by strong regional differentiation rather than a common pattern of recovery (Figure 6). In northwestern Anatolia the economy returned to a system similar to the one that had existed previously, particularly with respect to the cultivation of tree crops. However, elsewhere in Anatolia, the economy shifted to a new basis reliant on agro-pastoralism.

Here, a number of factors played a part. The long-term trend of climatic cooling since Roman times discouraged re-investment in tree crops in climatically marginal upland areas and instead led to greater reliance on cereal crops, which provided an immediate return on investment. Ecological factors related to different crop potentials thus appear to have conditioned site choice over the course of the first millennium CE. But this shift was not only related to environmental factors. As suggested by a number of studies (Brandes and Haldon 2000; Brandes 2002, p. 316; Haldon 1994; 2016, pp. 259 ff.; Prigent 2006), changes in the emphasis of state fiscal policy also played a crucial role, as the government at Constantinople encouraged the production of grain and livestock to support its military and to supply Constantinople. The memory of recent rural insecurity and the loss of trading connections likely made a further important contribution. For example, transport of bulk agricultural commodities by sea had enabled the intensification of industrial production directed to supplying Constantinople and other coastal urban centers, while the network of Roman roads may have facilitated the emergence of less intensive local systems of production and trade. Over time, these different economic networks had profoundly divergent implications for the resilience of local systems. Thus in areas such as Cappadocia in central Anatolia, the post-disturbance trajectory took the regional socio-ecological system to a new and different state, rather than a return to a previous one. For inner Anatolia, the shock of the Arab wars (=Ω phase) led to a non-reversible change in system state; while in N. Anatolia the partially state-sponsored transport of grain from Paphlagonia and areas to the east to supply Constantinople likewise must have impacted upon regional production patterns and markets. The recovery and post-recovery phases in medieval times therefore had different characteristics in different regions, confirming the prediction of Holling (2001) that during the α-phase numerous new trajectories in Socio-Ecological Systems can emerge, some of them returning to previous conditions and others leading in radically new directions.

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Table 1: Archaeological surveys and site excavations used in this study

	Survey/site	Sub-region	Altitudinal range	References
A	Cide survey	Northern (Black Sea coast)	0 – 200 m	During and Glatz, 2015
B	Sinop survey and excavation	Northern (Black Sea coast)	0 - 1200 m	Doonan 2004; Doonan et al. 2015
C	Avkat survey	Northern (interior)	~1000 m	Elton et al., 2009, 2012; Bikoulis et al. 2015; Haldon et al., in prep.
D	Çadır höyük (excavation)	Northern (interior)	1010 m	Cassis, 2009, 2017; Cassis & Steadman, 2015; Steadman et al., 2013, 2015
E	Konya survey	South Central (interior plateau)	1000 m	Baird, 2003
F	Göksu (GAP) survey, excavations at Kilise Tepe	South Central (lowland-upland transitional)	150 - >1200 m	Postgate and Thomas 2007
G	Sagalassos, survey and excavations	Southwest (upland)	800-1800 m	Vanhaverbeke and Waelkens, 2003
H	Balboura	Southwest (upland)	1100- >2000 m	Coulton 2012

Table 2: List of pollen sites used to create regional land-cover reconstructions

	Total number of pollen samples (AD300-1300)	Elevation (m)	Reference
SW Anatolia			
Bereket (2 cores)	13 + 31	1410	Kaniewski et al. 2007
Gölhisar (2 cores)	7 + 7	930	Eastwood et al. 1999
Gravgaz	27	1215	Vermoere 2004; Bakker et al. 2011
SC Anatolia			
Nar	50	1363	England et al. 2008
N Anatolia			
Kaz	8	500	Bottema et al. 1993/1994
Demiryurt	13	1300	Bottema et al. 1993/1994
Ladik	10	800	Bottema et al. 1993/1994
NW Anatolia			
Iznik	10	85	Ülgen et al., 2012; Miebach et al., 2016
Sapanca	23	31	Leroy et al., 2010
Abant	9	1300	Bottema et al. 1993/1994
Melen	18	125	Bottema et al. 1993/1994

Table 3: Pollen-inferred decline and recovery in agrarian indicators by sub-region. Percentage change is relative to the Late Roman period prior to decline. Values based on mean of adjacent two-century periods.

	N Anatolia	***SC Anatolia***	***NW Anatolia***	***SW Anatolia***	***Mean***
Cereals					
decline	37%	13%	17%	9%	19%
recovery	140%	154%	85%	45%	106%
Tree crops					
decline	14%	17%	24%	7%	15%
recovery	8%	18%	61%	22%	27%
Grazing indicators					
decline	21%	35%	51%	23%	32%
recovery	51%	62%	139%	35%	72%

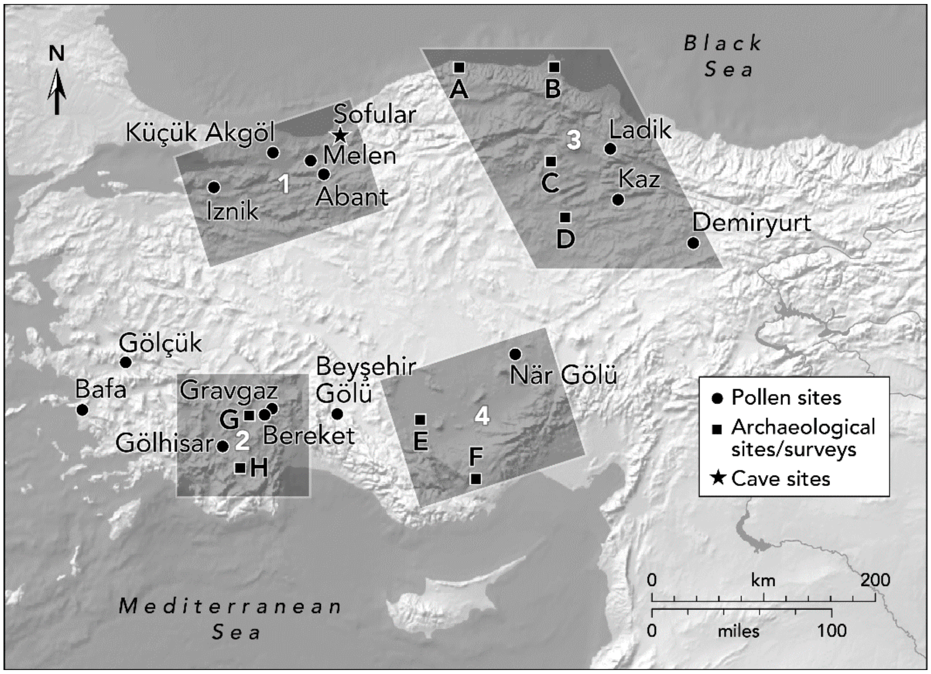

Figure 1: Map of Anatolia with four sub-regions (1= northwest, 2=southwest, 3=northern, 4= south central). For archaeological site key, see table 1; for pollen site key, see table 2

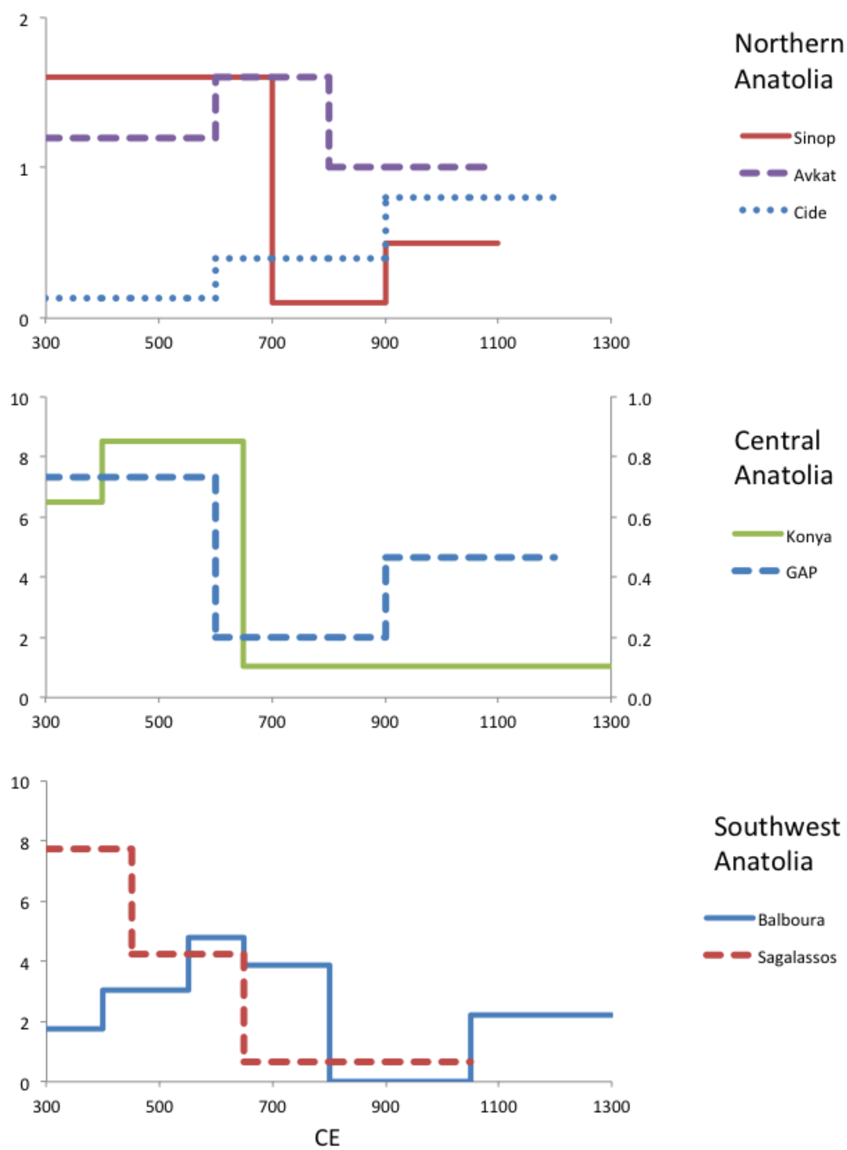

Figure 2: Rural settlement numbers from archaeological surveys in Northern, south central and southwestern Anatolia, by generational interval (viz. numbers of sites per 20 years). For Central Anatolia, Konya = left hand axis, GAP = right hand axis.

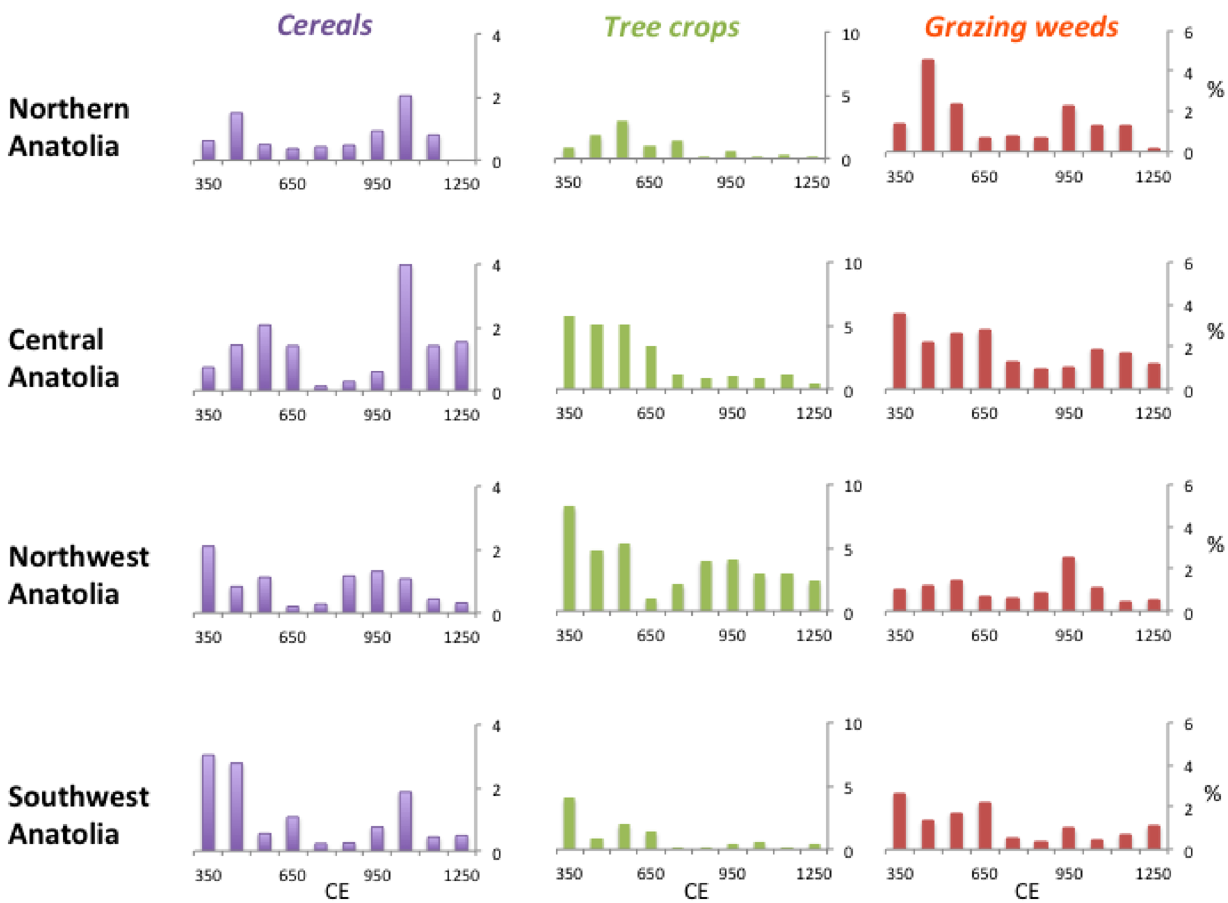

Figure 3: Century-by-century regional means for three agrarian pollen types (cereals, tree crops, grazing indicators), 300-1300 CE. Note that the vertical scales are the same for each land cover type, but differ between types.

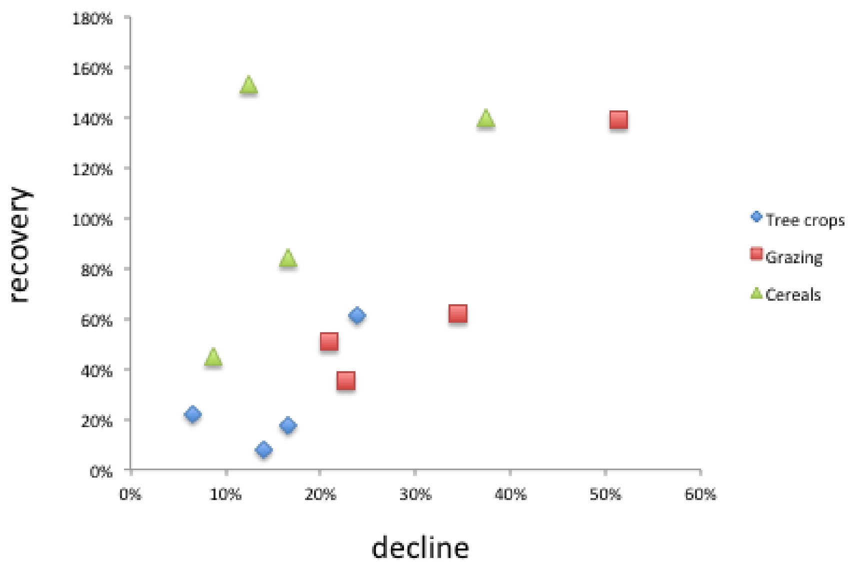

Figure 4: Percentage agrarian decline (x-axis) vs recovery (y-axis), based on pollen data for different sub-regions

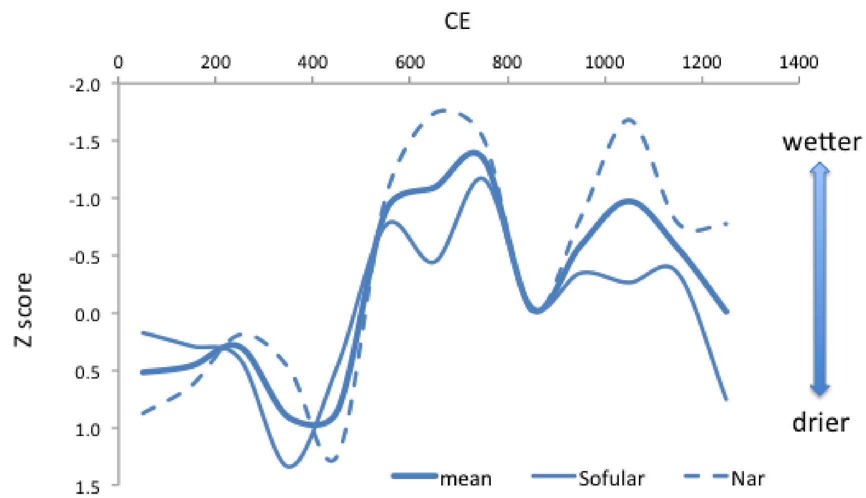

Figure 5: Century-averaged z-scores for hydro-climatic change in northern (Sofular) and central Anatolia (Nar). Wetter climatic conditions are marked by more negative z-scores

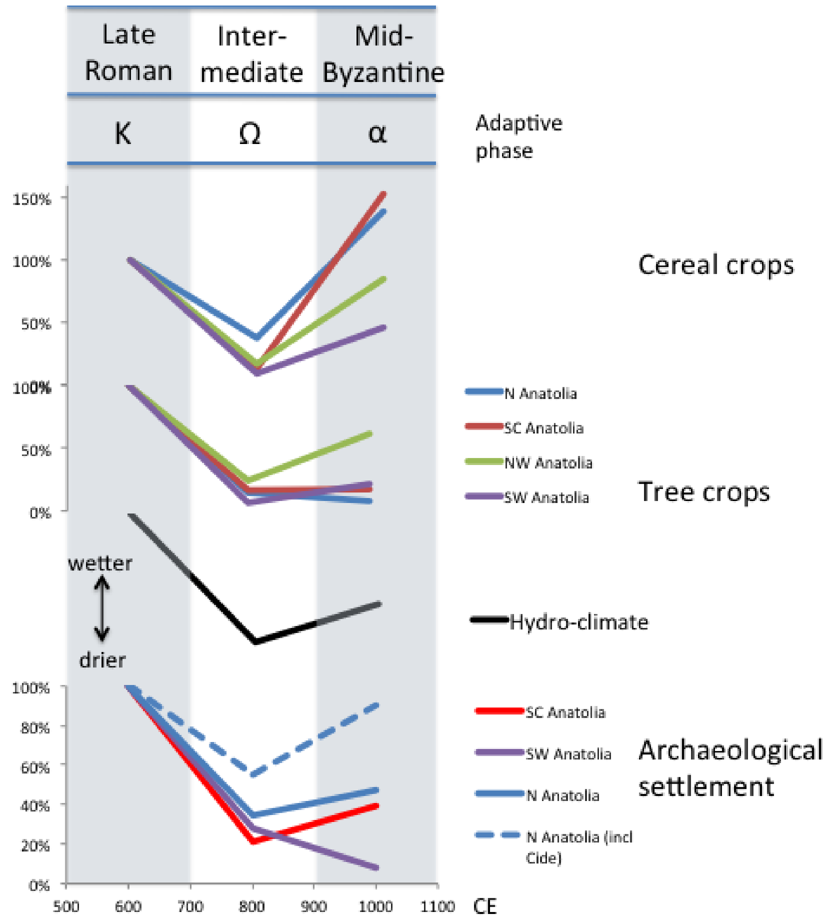

Figure 6: Summary diagram, showing changes in rural settlement, hydro-climate, cereal and tree crops during different phases of the Adaptive Cycle in Anatolia (600-1000 CE). All changes are scaled relative to the Late Roman period prior to rural decline (late sixth century CE).

Compliance with Ethical Standards:

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Literature

Alcock S.E. and Cherry J.F. (eds). (2004). Side-by-side survey: comparative regional studies in the Mediterranean. Oxford University Press, Oxford.

Allcock S.L. (2017). Long-term socio-environmental dynamics and adaptive cycles in Cappadocia, Turkey during the Holocene. Quaternary International 446, 66-82.

Allcock S. and Roberts N. (2014). Changes in regional settlement patterns in Cappadocia (central Turkey) since the Neolithic: a combined site survey perspective. Anatolian Studies 64: 33–57.

Armstrong P. (2009). Trade in the east Mediterranean in the 8th century, in Mango, M.M. (ed). Byzantine trade, 4th-12th centuries: the archaeology of local, regional and international exchange. Ashgate, Burlington VT: 157-178.

Baird D. (2003). Settlement expansion on the Konya Plain, Anatolia: 5th–7th centuries AD. In Bowden W., Lavan L. and Machado, C. (eds). Recent research on the late antique countryside. Late antique archaeology 2. Brill, Leiden, Boston.

Bakker J., Paulissen E., Kaniewski D., Poblome J., De Laet V., Verstraeten G. and Waelkens M. (2013). Climate, people, fire and vegetation: new insights into vegetation dynamics in the Eastern Mediterranean since the 1st century AD. Climate of the Past, 9(1).

Bikoulis P., Elton, H., Haldon J.F. and Newhard J.M.L. (2015). Above as below: application of multiple survey techniques at a Byzantine church at Avkat. In Winther-Jacobsen K. and Summerer L. (eds). Landscape and settlement dynamics in northern Anatolia in the Roman and Byzantine Period. Geographica Historica 32. Franz Steiner Verlag, Stuttgart: 101–117.

Bottema S., Woldring H. and Aytuğ B. (1993/1994). Late Quaternary vegetation history of northern Turkey. Palaeohistoria 35/36: 13–72.

Brandes, W. (2002). Finanzverwaltung in Krisenzeiten. Untersuchungen zur byzantinischen Administration im 6.–9. Jahrhundert. Löwenklau: Frankfurt am Main.

Brandes, W. and Haldon, J. (2000). Towns, Tax and Transformation: state, cities and their hinterlands in the East Roman world, ca. 500-800, in N. Gauthier, ed., Towns and their hinterlands between late Antiquity and the early Middle Ages. Brill: Leiden, pp.141-172.

Büntgen U., Myglan V.S., Ljungqvist F.C., McCormick M., Di Cosmo N., Sigl M., Jungclaus J., Wagner S., Krusic P.J., Esper J. and Kaplan J.O. (2016). Cooling and societal change during the Late Antique Little Ice Age from 536 to around 660 AD. Nature Geoscience 9: 231-236.

Butzer K.W. (2005). Environmental history in the Mediterranean world: cross-disciplinary investigation of cause-and-effect for degradation and soil erosion. Journal of Archaeological Science 32(12): 1773-1800.

Cassis M. (2009). Çadır Höyük: a rural settlement in Byzantine Anatolia. In Vorderstrasse T. and Roodenberg J. (eds). Archaeology of the Countryside in Medieval Anatolia. Nederlands Instituut voor het Nabije Oosten, Leiden: 1-24.

Cassis M. (2017). Çadır Höyük. In Niewöhner, P. (ed.). Archaeology of Byzantine Anatolia. OUP, Oxford: 368-374

Cassis M. and Steadman S. 2015. Çadır Höyük: continuity and change on the Anatolian plateau. In Stull, S. (ed). East to West. Newcastle: 140-154.

Cassis M., Doonan O., Elton H. and Newhard J.M.L. (this volume). Evaluating archaeological evidence for demographics, abandonment, and recovery in Late Antique and Byzantine Anatolia. Human Ecology.

Coulton J.J. (2012). The Balboura survey and settlement in highland southwest Anatolia, 2. BIAA Monographs. British Institute at Ankara, London.

Dean J.R., Jones M.D., Leng M.J., Noble S.R., Metcalfe S.E., Sloane H.J., Sahya D., Eastwood W.J. and Roberts C.N. (2015). Eastern Mediterranean hydroclimate over the late glacial and Holocene, reconstructed from the sediments of Nar lake, central Turkey, using stable isotopes and carbonate mineralogy. Quaternary Science Reviews 124: 162–174.

Doonan O. 2004. Sinop landscapes: exploring connection in the hinterland of a Black Sea port. University of Pennsylvania Museum Publications, Philadelphia.

Doonan O., Bauer A., Casson, A., Conrad, M., Besonen, M., Evren, E. and Domzalski K. (2015). Sinop Regional Archaeological Project: report on the 2010 - 2012 field seasons. In Steadman S and McMahon G. (eds). The archaeology of Anatolia: current work I. Cambridge Scholars Publishing, Newcastle on Tyne: 298-327.

Düring B.S. and Glatz C. (2015). Kinetic landscapes: the Cide Archaeological Project: surveying the Turkish western Black Sea region. De Gruyter Open, Warsaw.

Eastwood W.J., Leng M.J., Roberts N. and Davis B. (2007). Holocene climate change in the eastern Mediterranean region: a comparison of stable isotope and pollen data from Lake Gölhisar, southwest Turkey. Journal of Quaternary Science 22: 327-341.

Eastwood W.J., Roberts N., Lamb H.F. and Tibby J.C. (1999). Holocene environmental change in southwest Turkey: a palaeoecological record of lake and catchment-related changes. Quaternary Science Reviews 18: 671-696.

Elton H., Haldon J.F., Newhard J.M.L. and Bikoulis P. (2012). Avkat Arkeoloji Projesi. In Çorum Kazı ve Araştırmalar Sempozyum, 2:203–218. Çorum Muzesi, Çorum.

Elton, H., Haldon J.F., Newhard, J.M.L. and Lockwood S. (2009). Avkat Archaeological Project, 2007-2008. Araştırma Sonuçları Toplantısı 27 3: 29–50.

England A., Eastwood W.J., Roberts N., Turner R., Haldon J.F. (2008). Historical landscape change in Cappadocia (central Turkey): a palaeoecological investigation of annually-laminated sediments from Nar lake. The Holocene 18: 1229–1245.

Göktürk O. M. et al. (2011). Climate on the southern Black Sea coast during the Holocene. Quaternary Science Reviews 30: 2433–2445.

Haldon, J. (1994). *Synônê*: Re-Considering a Problematic Term of Middle Byzantine Fiscal Administration. Byzantine and Modern Greek Studies 18: 116-153

Haldon, J. (2016). The empire that would not die. The paradox of eastern Roman survival 640-740. Harvard University Press, Cambridge MA.

Haldon J. and Rosen A. (2017) Society and environment in the East Mediterranean ca 300-1800 CE. Problems of resilience, adaptation and transformation. Human Ecology (this volume).

Haldon J., Izdebski A., Roberts N., Fleitmann D., McCormick M., Cassis M., Doonan O.P., Eastwood W.J., Elton H., Ladstätter S., Manning S., Newhard J., Nichol K., Telelis I.G., Xoplaki E. (2014). The climate and environment of Byzantine Anatolia: integrating science, history and archaeology. Journal of Interdisciplinary History 45: 113-161.

Haldon J.F., Elton H. and Newhard J.M.L. (eds). (in prep). Euchaita – Avkat – Beyözü: from late Roman and Byzantine city to Turkish village. Cambridge University Press, Cambridge.

Henning, J. (ed). (2007). Post-Roman Towns, Trade and Settlement in Europe and Byzantium. Vol. 2. Byzantium, Pliska, and the Balkans. Millennium-Studien, 5/2. Berlin/New York: Walter de Gruyter

Holling C. (2001). Understanding the complexity of economic, ecological, and social systems. Ecosystems 4(5), 390 - 405.

Horden, P and Purcell, N. (2000). The corrupting sea: a study of Mediterranean history. Blackwell, Oxford.

Izdebski, A. (2013). A rural economy in transition: Asia Minor from Late Antiquity into the early Middle Ages. Journal of Juristic Papyrology supplement 18. Warsaw: Raphael Taubenschlag Foundation.

Izdebski A. (2016): An environmental-economic history of Miletus's hinterland in Late Antiquity and the Middle Ages. In Niewöhner, P. (ed). Miletus excavations. German Archaeological Institute, Berlin.

Izdebski A., Cassis M., Laparidou S., Mordechai L., Pickett J., White S. and Allcock S. (this volume). Environmental stress and resilience in complex historical societies. Insights from Eastern Mediterranean case studies. Human Ecology

Izdebski A., Pickett J., Roberts N., Waliszewski T. (2016). The environmental, archaeological and historical evidence for regional climatic changes and their societal impacts in the Eastern Mediterranean in Late Antiquity. Quaternary Science Reviews 136: 189-208.

Jones M.D., Roberts N., Leng M.J., Türkeş M. (2006). A high-resolution late Holocene lake isotope record from Turkey and links to North Atlantic and monsoon climate. Geology 34 (5): 361-364.

Kaniewski D., Paulissen E., De Laet V. and Waelkens M. (2007). 3000 years BP high-resolution ecological landscape history inferred from an intramontane basin in the Western Taurus Mountains, Turkey. Quaternary Science Reviews 26: 2201–2218.

Kaniewski D., Van Campo E., Guiot J., Le Burel S., Otto T. et al. (2013). Environmental roots of the Late Bronze Age crisis. PLoS One 8 (8), e71004. http://dx.doi.org/10.1371/journal.pone.0071004

Kuzucuoğlu C., Dörfler W. and Kunesch S. (2011). Mid-Holocene climate change in central Turkey: the Tecer lake record. The Holocene 21: 173–188.

Labuhn I., Finné M., Izdebski A. and Roberts N. (2017, in press) Climatic changes and their impacts in the Mediterranean during the first millennium CE. Late Antique Archaeology

Leroy S.A.G., Schwab M.J. and Costa, P.J.M. (2010). Seismic influence on the last 1500-year infill history of Lake Sapanca (North Anatolian Fault, NW Turkey). Tectonophysics 486: 15–27.

Matthews R. and Glatz C. (2009). At empire's edge: Project Paphlagonia. Regional survey in north-central Anatolia. BIAA Monographs 44. British Institute at Ankara, London.

Mazzoni S., D'Agostino A. and Orsi V. (2010). Survey of the archaeological landscape of Uşaklı/Kuşaklı Höyük (Yozgat). Anatolica 36: 111-163.

Miebach A., Niestrath P., Roeser P. and Litt T. (2016). Impacts of climate and humans on the vegetation in northwestern Turkey: palynological insights from Lake Iznik since the last Glacial. Climate of the Past 12(2): 575-593.

Mitchell, S. (1993). Anatolia: Land, Men, and Gods in Asia Minor. The Celts and the Impact of Roman Rule. Oxford University Press.

Neumann F.H., Kagan E.J., Leroy S.A.G., Baruch U. (2010). Vegetation history and climate fluctuations on a transect along the Dead Sea west shore and their impact on past societies over the last 3500 years. Journal of Arid Environments 74: 756-764.

Omura S. (1998). An archaeological survey of central Anatolia (1995). In Mikasa T. (ed.), Essays on ancient Anatolia in the second millennium BC. Harrassowitz, Wiesbaden: 78–113

Ousterhout R.G. (2005). A Byzantine Settlement in Cappadocia. Dumbarton Oaks, Washington DC

Postgate J.N. and Thomas D.C. (eds). (2007) Excavations at Kilise Tepe, 1994-1998: from Bronze Age to Byzantine in western Cilicia. BIAA Monographs 30. British Institute at Ankara, London-Cambridge.

Potter, D. (2011). Cities in the eastern Roman Empire from Constantine to Heraclius. In Dally, O. and Ratté, C. (eds.) Archaeology and the Cities of Late Antiquity in Asia Minor. Ann Arbor, pp. 247-260.

Prigent, V. (2006). Le rôle des provinces d’Occident dans l’approvisionnement de Constantinople (618–717). Témoignages numismatique et sigillographique. Mélanges de l’École française de Rome. Moyen Âge 118: 269–299

Roberts N. (2017, in press). Re-visiting the Beyşehir Occupation Phase: land-cover change and the rural economy in the eastern Mediterranean during the first millennium AD. Late Antique Archaeology.

Steadman S.R., McMahon G., Ross J.C., Cassis M., Şerifoğlu T.E., Arbuckle B.S., Adcock S.E., Roodenberg S.A., von Baeyer M. and Lauricella A.J., (2015). The 2013 and 2014 excavation seasons at Çadır Höyük on the Anatolian north central plateau. Anatolica 41: 87-123.

Steadman S.R., McMahon G., Ross J.C., Cassis M., Geyer J.D., Arbuckle B. and von Baeyer M. (2013). The 2009 and 2012 seasons of excavation at Çadır Höyük on the Anatolian north central plateau. Anatolica 39:113-167.

Sullivan D. G. (1988). The discovery of Santorini Minoan tephra in western Turkey. Nature 333: 552-554.

Summers G. (2001). Keykavus Kale and associated remains on the Kerkenes Dağ in Cappadocia, central Turkey. Anatolia Antiqua 9: 39-60.

Telelis I.G. (2008). Climatic fluctuations in the eastern Mediterranean and the Middle East AD 300-1500 from Byzantine documentary and proxy physical paleoclimatic evidence - a comparison. Jahrbuch der österreichischen Byzantinistik 58: 167–207.

Ülgen U.B., Franz S.O., Biltekin D., Çağatay M.N., Roeser P.A., Doner L., Thein J. (2012). Climatic and environmental evolution of Lake Iznik (NW Turkey) over the last ~4700 years. Quaternary International 274: 88–101.

Vanhaverbeke H., and Waelkens M. (eds). (2003). The chora of Sagalassos. The evolution of the settlement pattern from prehistoric until recent times. Studies in eastern Mediterranean archaeology 5. Brepols, Turnhout.

Van Zeist W., Woldring H., and Stapert D. (1975). Late Quaternary vegetation and climate of southwestern Turkey. Palaeohistoria 17: 55–143.

Vermoere, M. (2004) Holocene vegetation history in the territory of Sagalassos (southwest Turkey): a palynological approach. Brepols, Turnhout

Vermoere M., Vanhecke, L., Waelkens M. and Smets E. (2003). Modern and ancient olive stands near Sagalassos (south-west Turkey) and reconstruction of the ancient agricultural landscape in two valleys. Global Ecology and Biogeography 12, 3: 217–235

Xoplaki E., Fleitmann D., Luterbacher J., Wagner S., Haldon, J., Zorita E., Telelis I., Toreti A., Izdebski A. (2016). The Medieval Climate Anomaly and Byzantium. A review of the evidence on climatic fluctuations, economic performance and societal change. Quaternary Science Reviews 136: 229-252.

Figures

Table 1: Archaeological surveys and site excavations used in this study

Table 2: List of pollen sites used to create regional land-cover reconstructions

Table 3: Pollen-inferred decline and recovery in agrarian indicators by sub-region. Percentage change is relative to the Late Roman period prior to decline. Values based on mean of adjacent two-century period.

Figure 1: Map of Anatolia with four sub-regions (1= northwest, 2=southwest, 3=northern, 4= south central). For archaeological site key, see table 1; for pollen site key, see table 2

Figure 2: Rural settlement numbers from archaeological surveys in Northern, south central and southwestern Anatolia, by generational interval (viz. numbers of sites per 20 years). For Central Anatolia, Konya = left hand axis, GAP = right hand axis.

Figure 3: Century-by-century regional means for three agrarian pollen types (cereals, tree crops, grazing indicators), 300-1300 CE. Note that the vertical scales are the same for each land cover type, but differ between types.

Figure 4: Percentage agrarian decline (x-axis) vs recovery (y-axis), based on pollen data for different sub-regions

Figure 5: Century-averaged z-scores for hydro-climatic change in northern (Sofular) and central Anatolia (Nar). Wetter climatic conditions are marked by more negative z-scores

Figure 6: Summary diagram, showing changes in rural settlement, hydro-climate, cereal and tree crops during different phases of the Adaptive Cycle in Anatolia (600-1000 CE). All changes are scaled relative to the Late Roman period prior to rural decline (late 6th century CE).