ANCIENT LAND-USE MODELLING

Continuity versus emergent locations in central Zakynthos

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In *Zante* I was likewiſe a fortnight, where I ſaw but little of Antiquity: What is Modern, is very flouriſhing, and the Iſland rich and plentiful. Vernons, F., 1676

Cover page: Paleolithic land-use intensity overlain on TPI based landforms

Abstract

This study contributes to the Zakynthos Archaeology Project of central Zakynthos, Greece, identified by the project as Area B. It applies ancient land-use modelling as outlined by Michael C. Barton and colleagues. Their approach have provided a reproducible method by which to create ancient settlement intensity maps for other areas of Zakynthos. Formation processes are isolated and accounted for and a chronological framework is established. The model has resulted in relevant findings pertaining to the archaeological land-use history, but the methods needed to be contextualized to the idiosyncrasies of Zakynthos' archaeology, and limitations came to light. The results are overlain on a geomorphometric landscape.

Artifacts recovered in Area B are greatly fragmented, worn, and multiple periods overlap each other, all attributes associated with dynamic landscapes, a rich land-use history, and seismic activity. Limitations were encountered when addressing erosion and artifact taphonomy.

The resulting models have shown a continuity of land use and emergent locations in Area B, from the Paleolithic to the present. There is an abundance and spread of Paleolithic presence with important locations in the west, on the ridge above Achiouri valley and the area around Palaiokastro, and in the east along three Miocene ridges. One known cave across Palaiokastro may have been used as well as additional caves located outside of Area B. Land use during the Prehistoric is in contrast scarce and made of isolated pockets on the ridge above Achiouri valley and around Palaiokastro, as well as in proximity to the eastern Miocene ridges and foothills. The Historic period shows a re-emergence of land use in Area B, with greater intensity and breadth around Palaiokastro, the foothills, and the ridges. By the Byzantine period, this image is reduced but then increases in aerial spread and intensity from the Venetian period onwards. Again, Palaiokastro is an area of interest but becomes less so in recent times while at the same time, the eastern area of Panagia has increased in land-use intensity. Also, as with other time periods, the ridges are favorable locations from the Venetian period onwards.

Keywords: Land-use modelling; artifact taphonomy; formation processes; geomorphometry; spatial analysis

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SECTION 1 - CONTEXT

1 INTRODUCTION

Zakynthos island, Greece, has been the subject of ongoing archaeological investigations through the cooperation between the Netherlands Institute at Athens and Ephorate of Antiquities at Zakynthos. The Zakynthos Archaeology Project (ZAP) is an interdisciplinary project that aims to relate the distributions of archaeological material to the dynamic landscape of Zakynthos island and is carried out through survey archaeology, archaeological reconnaissance, remote sensing, excavations, and geomorphological and historical research (Avramidis et al., 2017; Avramidis & Kontopoulos, 2009; de Bruijn, 2012; Gouma, van Wijngaarden, & Soetens, 2011; Horn-Lopes, 2010; Kunzel, 2011; Pieters, 2008; Stoker, 2010; Storme, 2008; Tendürüs, van Wijngaarden, & Kars, 2010; von Stein & van Wijngaarden, 2012; van Wijngaarden, Arapogianni, Rink, & Tourloukis, 2005; van Wijngaarden, Avramidis, & Kontopoulos, 2014; van Wijngaarden, Kourtessi-Philippakis, & Pieters, 2013; van Wijngaarden & Pieters, 2017; van Wijngaarden et al., 2008; van Wijngaarden, Sotiriou, Pieters, Abed, & Tendurus, 2007).

Three study areas were selected by the ZAP on Zakynthos (Figure 1) with differing geological, geomorphological, and topographic characteristics. Intensive surveys and previous research on the island have revealed Paleolithic to modern remains ranging from lithic to ceramic artifacts.

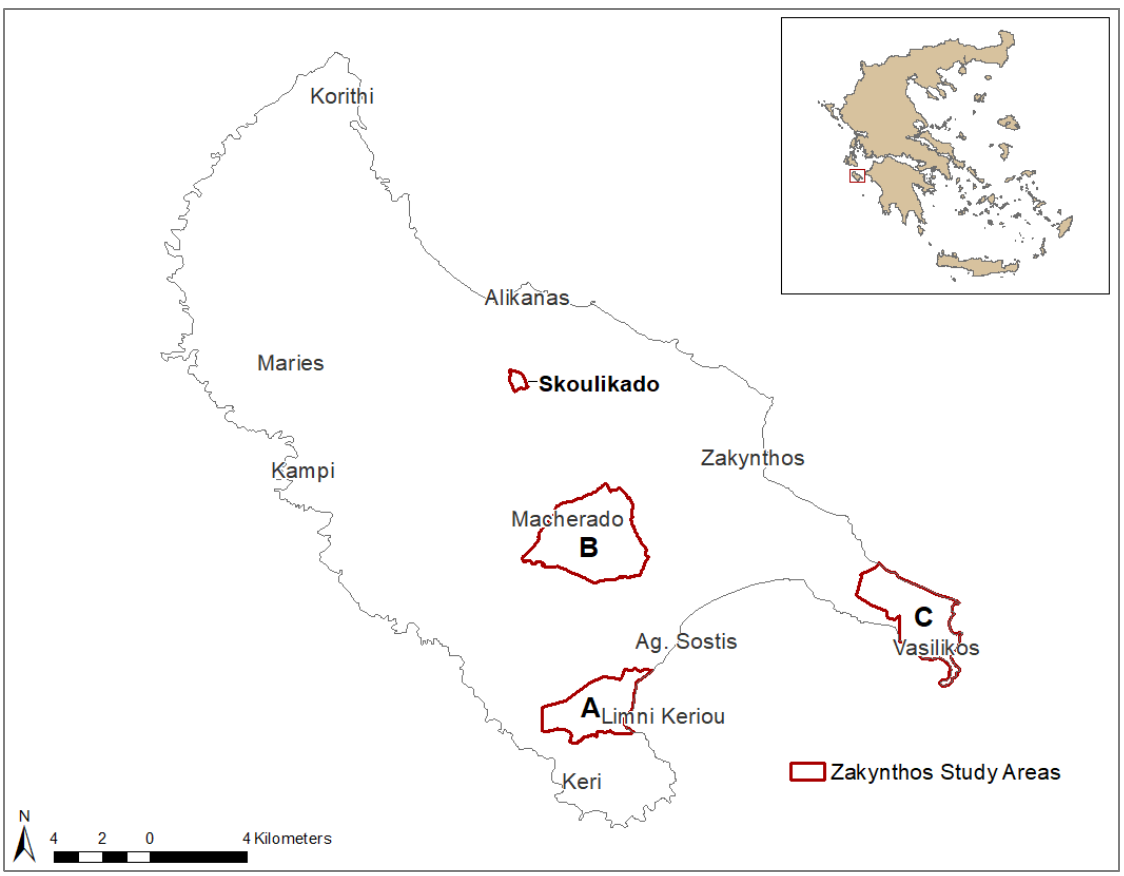

Figure 1 - Three research areas selected by the ZAP on Zakynthos, Greece.

Throughout the survey of the research areas, questions of artifact patterning arise concerning the manner of their distributions and how they relate to each other and the landscape in general (van Wijngaarden et al., 2006). In Area B, the spatial and chronological distributions of surface material recovered through survey archaeology is considered as part of my thesis fieldwork[1].

Survey archaeology is "aimed at studying the spatial distribution of human activities, variations between regions, changes in populations through time, and the relationships between people, land, and resources" (Renfrew & Bahn, 2004, p. 82). The factors that create accumulations of surface artifacts and the ways that they came to be buried and what happened to them after burial are defined as formation processes (Schiffer, 1987). Cultural formation processes are those that are a result of human interference (deliberate or accidental activities) while natural formation processes are those that are non-cultural and that affect the burial and survival or destruction of artifacts (Mandel, Goldberg, & Holliday, 2017; Renfrew & Bahn, 2004; Stein, 2001).

To understand the spatial and chronological distributions of artifacts, and to be able to compare them across and within survey projects, the factors that create them must be identified and accounted for (Barton, Bernabeu, Aura, & Garcia, 1999; Barton, Bernabeu, Aura, Garcia, & La Roca, 2002; Given, 2004; van Leusen, 2002) offer a methodology by which to un-mix the formation processes and apply a chronological framework to them. In so doing, their methodology allows for the interpretation of settlement intensity (or ancient land use) and at the same time, it allows for the comparison of artifact distributions both locally and regionally.

1.1 Research question

The aim of this thesis is to interpret archaeological survey material of the ZAP in Area B in terms of settlement intensity. To do this, I follow the methodology outlined by Barton et al. (2002). Specifically, I investigate:

- The ways in which Barton et al.'s methodology (2002) are applicable for the interpretation of the spatial and chronological distributions of artifact accumulations in Area B.
  Sub-questions are:
  - What insights will this model generate in terms of its applicability to Area B?
  - What idiosyncrasies of Area B need to be accounted for?
  - What limitations (if any) do I encounter when applied to this research area? And in what way will I adjust Barton's method to ZAP's Area B?

[1] Throughout the course of fieldwork in 2007, field-walkers accidently ventured outside the perimeter of Area B. From here onwards, I will use the new perimeter (see Chapter 0 and Figure 19 for more).

1.2 Approaches to Ancient Land use

1.2.1 *Formation Processes*

In survey archaeology, the archaeological record may be represented in the form of artifact density. Given (2004) suggests three main factors that create artifact density: cultural, post-depositional, and methodological amounting to the amalgamation of formation processes and our ensuing collection and interpretation of artifact scatter. Investigating one of these requires isolating it from the rest making sure it is the only cause of variation (Given, 2004; van Leusen, 2002). These factors are defined as formation processes (Mandel et al., 2017; Renfrew & Bahn, 2004; Schiffer, 1987). They affect spatial accumulations of artifacts on the landscape and in sites in various ways, depending on their age, geomorphic environment, climate, sediments and soils, as well as the type and complexity of occupation (Mandel et al., 2017).

Cultural formation processes result from ancient anthropogenic activities and can be identified as original human behavior, or they can be activities that came after the burial of artifacts (Renfrew & Bahn, 2004). Often, cultural formations processes are a result of a series of both. Original human behavior can be, for example, the acquisition of raw materials, manufacturing and use of pottery, and disposal and/or re-use of the pottery. After discard, the pottery can be scattered on fields together with manure, and then plowed, and subsequently, buried (Given, 2004). Actions of people at the time of deposition, but also of today's archaeologists, alter, obscure, or destroy these patterns (Stein, 2001).

Natural formation processes are the non-anthropogenic factors that influence archaeological remains by causing their destruction or preservation (Renfrew & Bahn, 2004; Stein, 2001). The archaeological remains are situated in a dynamic environment involving a combination of chemical, biological, and physical processes (Mandel et al., 2017; Renfrew & Bahn, 2004). These processes can be broken down into those that took place before, during, and/or after occupation of a site (Mandel et al., 2017). For example, several depositional environments are associated with open-air sites and may include alluvial processes that contributed to the initial accumulations through fluvial process but that also displaced the artifacts horizontally and vertically. In these natural settings, artifacts become part of the sediment, migrating and redepositing within the alluvial deposit (Barton et al., 2002; J. Evans & O'Connor, 1999; van Leusen, 2002; Mandel et al., 2017). As a result, they can become sorted within the sediment and their morphology can become smoothed and rounded (Barton et al., 1999; Barton et al., 2002; Mandel et al., 2017).

Not to be overlooked are the archaeological and methodological formation processes. This is related to the assessment of the archaeological record (ex., intensity of survey recording), surface collection policy (ex., minimum sherd size, field-walkers' biases), survey method and analyses (ex., visibility protocols, identification and grouping of chronological periods), and quality control (ex., from data processing to map presentation) (Schiffer, 1987).

Differentiating between the three types of formation processes is relevant in the reconstruction of past human activities (Given, 2004; van Leusen, 2002; Renfrew & Bahn, 2004) since they identify patterns that were created in the past and separate those that were created later, whether a result of anthropogenic or natural processes (Given, 2004; Stein, 2001). Whether the resulting analyses can be compared within the same project and region, or between different projects, is debatable (Given, 2004).

1.2.2 *Previous studies on ancient land use*

There have been various studies aimed at interpreting artifact accumulations in terms of ancient land use by using erosion models as a backdrop, remote sensing, soil changes, a combination of methods, spatial statistics, and more.

Ayala et al. (2005) model present day erosion in Sicily, Italy, using an adaptation of the Universal Soil Loss Equation (USLE), which was then overlaid by archaeology material. They identify the location, intensity, and integrity of surface finds as well as sizes of sites. Together with ancient literary sources and ethnographical studies, they are then able to map the different forms of ancient land use that were most probably practiced at those locations.

The result is two extreme scenarios of land-use patterns, at one end a sedentary population with subsistence farming. At the other end, a pastoral population where sites are located along long-distance routes. Their models do not demonstrate a temporal element but rather indicate the seasonal exploitation for herds on the hillslopes that contributed to the history of landscape development.

Montufo (1997) analyze satellite imagery in southeast Spain to determine ancient rural patterns and the remains of centuriated systems. Data is gathered in several bands which are then filtered to detect large-scale archaeological features, such as land-use patterns. Linear features are analyzed on cartographic maps to provide details of roads, rural tracks, and stone walls. After incorporating land cover data, centuriated patterns and quadriculate land-use patterns are identified.

Sandor et al. (1990) discuss the interaction between ancient agricultural land use and environment based on changes in prehistoric soils in the Mimbres area, New Mexico. Changes in prehistoric soils are deduced based on comparisons to adjacent and uncultivated soils and based on changes in soil color and in phosphorous content. Vegetation changes and erosion due to agriculture are also considered in the analyses, where it was revealed that some cultivated areas devoid of vegetation were a result of either climate change or dam construction.

de Kleijn et al. (2018) simulate past land-use patterns by using the modelling framework Past Land use Scanner (PLUS). They consider economic, socio-cultural, technological, and political factors, as well as spatial and environmental features that are needed to support the population of the Lower-Rhine delta in the first century AD. Their algorithm calculates the amount of land that is expected to be used for different land use types with resulting scenarios being based on food production for the Roman military and inhabitants of 70 CE and 140 CE.

Snitker et al. (2018) apply Bayesian statistical concepts and b-spline interpolations for building relative chronology of surface material for lithic assemblages in Canal de Navarrés, eastern Spain. The Bayes theorem allows for multi-period sites to be simultaneously represented at different probabilities. These estimates result in an outcome based on new data and some knowledge about the likelihood of that outcome.

The above methods each yield unique results yet neither considers specifically formation processes nor the artifact morphology in the assessment of land-use intensity. A study by Barton, Bernabeu, Aura, Garcia, & La Roca (2002) has provided a method by which to accommodate formation processes, the application of which is the aim of this study and this is reviewed below.

1.2.3 *Dynamic landscapes, ancient land use, and artifact taphonomy*

Barton et al. (2002) explore ancient and more recent cultural and natural formation processes and determine to what extent the processes have had on the spatial patterns of archaeological remains. They present a model of prehistoric land-use intensity in the Polop Alto, Spain, and this is based on (1) un-mixing formation processes and (2) establishing a chronological framework to these processes (Figure 2). To this end, they use archaeological survey, photogrammetry, spatial analyses, and distribution and morphology of artifacts.

They begin by isolating the *formation processes* that have shaped the landscape and material culture by attempting to determine to what extent modern land use has influenced artifact density. Because modern land use influences the recognition and perception of surface artifacts, they assert that our assumptions about past human behavior will also be affected. To account for this factor, they categorize modern land use based on visibility into three ordinal descriptions of ‘poor’, ‘fair’, and ‘good’. After calculating artifact density for each survey unit and statistically comparing these values to visibility, they find that even though mean artifact density varied greatly among different visibility values, the difference in mean values was not significant. *T-tests* between survey units and the different visibility values revealed that although some density variability in the Polop Alto is due to differential modern land-use practices, they are overshadowed by variability due to other factors. The results were confirmed using re-visits of the same fields over different years and seasons and found no consistent patterning of retrieved material.

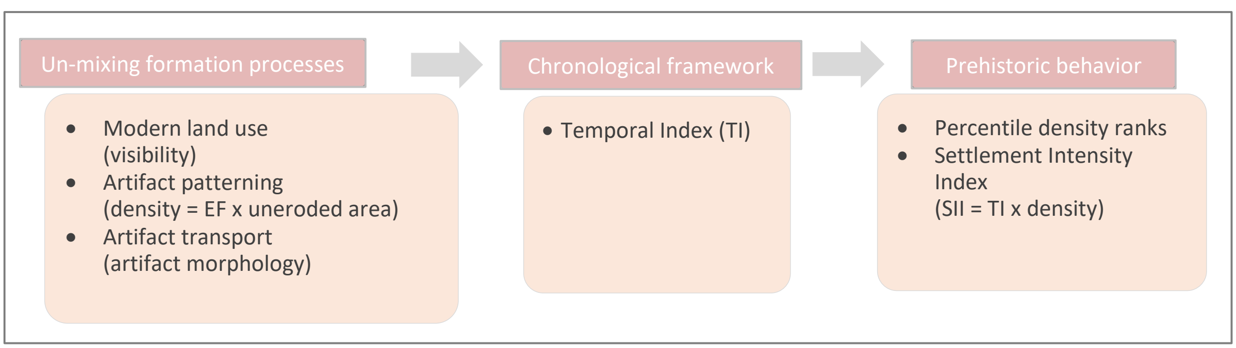

Figure 2 - Method outlined by Barton et al. (1999, 2002) (EF = erosion factor).

Another step in which Barton et al. (2002) isolate formation processes is to identify those that have contributed to artifact transport. Erosion may horizontally divide the accumulations of artifacts or carry them away. In the case of the Polop Alto, cutting and sheet erosion are the primary forms of erosion (Barton et al., 2002) where artifacts are transported along with sediment and then buried and reburied or removed and redeposited elsewhere. By analyzing aerial photographs, they isolate those areas which had been subjected to sheet erosion. Using an image processor, they isolated areas of exposed bright white areas by isolating pixels based on coloration. Then, using a GIS, they traced polygons around the eroded areas and assigned to them an Erosion Factor (EF) (from solid erosion to patches of erosion (1.00, 0.75, 0.50, 0.25)). The overlay between surveyed parcels and the polygons was multiplied by the EF and then subtracted from the total area of surveyed parcel. This resulted in uneroded areas which were then used to calculate artifact density. These density values are later ranked into percentile categories.

Having unmixed the formation processes of modern land use, current erosion, and analyzing the extent to which erosional processes have had on artifact morphology, Barton et al. (1999) and Barton et al. (2002) begin by modelling prehistoric behavior. First, they create and apply a chronological framework to the above processes (Figure 2). Their approach to chronology considers four factors: artifacts may be temporarily meaningful but persist over a long period of time; the presence or absence of an artifact class may be important; it is likely that in an area with a long occupational history, an assemblage will represent a palimpsest of human activities; and dating artifact assemblages is an estimate.

Bearing these considerations in mind, Barton et al. (1999) derive a method of ranking artifact assemblages based on the probability (non-statistical) that they belong to a specific chronological interval. It is meant to measure the presence and absence of an assemblage as well as to assign simple ranks. They define this as Temporal Index (TI) with a range from 0.9 - 0.1. Those with the highest probability of dating are given TI = 0.9, those with the lowest are TI = 0.1. A value of '0' is given when no artifacts are present. These ordinal values are assigned cumulatively exclusive from highest to lowest value. For example, an assemblage is given TI = 0.5 for Neolithic II only if it meets the minimum criteria of having 'Neolithic tools, ceramics, or ground stone' and fails to meet that of TI = 0.7 and TI = 0.9 (Figure 3).

	Temporal Index					
Period	.9	.7	.5	.3	.1	0
Neolithic II	**present**: Late Neol. tools[a] or Late Neol. ceramics	**present**: ceramics or ground stone	**present**: Neol. tools[b], ceramics or ground stone	**present**: blade tech.[c]	**present**: artifacts	**present**: N/A
	absent: N/A	**absent**: backed tools and Early Neol. tools[d]	**absent**: N/A	**absent**: N/A	**absent**: N/A	**absent**: artifacts

Figure 3 - Criteria for assigning TI values to Neolithic II. It is a means of ranking lithics derived from a particular time interval (modified from Barton et al., 1999, fig 2).

The spatial distribution of TI values offers insight into the spatial patterning of land use over time but is by itself insufficient to model land-use patterns through time (Barton et al., 1999; Barton et al., 2002). They can point to locations of past human activities and land use will vary according to the types of activities, number of participants, duration of occupation, and frequency of reoccupation (Barton et al., 2002). For example, concerning lithic material, land-use intensity is proportional to the amount of discarded material, the way in which it was used, and the availability of raw material.

To accommodate for this, Barton et al. (2002) weighted an ordinal derivative of artifact density by TI to produce a Settlement Intensity Index, SII, defined as an estimate 'of the relative intensity of artifact accumulation' (Barton et al., 2002). Survey units are ranked into six percentile groups based on their densities and ranked from lowest to highest (0 artifacts = 0; < 25th percentile = 0.25; 26th – 50th percentile = 0.50; 51st - 75th = 0.75; 75th - 90th = 0.90; 91st - 100th = 1.00). For every survey unit with artifacts > 0, the percentile rank was multiplied by TI (Figure 2).

These newly derived SII values are not comparable across different time periods and as a result, Barton et al. (2002) rank them into quartiles within each chronological period and then compare them spatially. They focus on the upper SII quartile values since the very low values are a result of low TI and density values indicating the possibility of modern land use. Also, the moderate SII values are a result of low and high values indicating either intensive land use at some unknow point in time, or that humans were present and their use of land was minimal. Their final SII maps are rasterized with a cell size equivalent to the area of the smallest survey unit (Figure 4).

To explore the non-cultural sources of the SII patterns, Barton et al. (2002) examine the spatial distribution of artifact transport by chronological period. This part of prehistoric behavior is tied to the formation process gleaned through artifact morphology (Figure 2), which can be a proxy indicating relative age and extent to which the artifacts have been moved. Geomorphologically, artifacts can be viewed as moderately coarse clastic sediment with which their morphology is transformed by the type and duration of transport as well as by the depositional environment Barton et al. (2002). The more time has elapsed since an item was discarded, the more likely it has been moved from its original location; and by being exposed to greater geomorphological processes, the more distance older artifacts would have traveled. They analyze only lithic material since the ceramics were infrequent and highly fragmented (Bernabeu Auban, Barton, Puchol García, & La Roca, 2000) and identify two main types of morphological damage: non-cultural edge damage and surface abrasion. A third type (breakage) is ignored due to the low frequencies of ceramics recovered. These types of damages may result from agricultural practices (ploughing, trampling, land clearance) or colluvial/fluvial transportation. Based on the results of their morphological analyses, they found that the effects of agriculture on artifacts in the Polop Alto was great.

They also compare the frequency of edge damage and surface abrasion of the lithics with the upper quartile SII values and find that post-depositional transport was not sufficient to affect spatial patterning Barton et al., (2002). Another examination of non-cultural formation processes using sheet erosion indicate that they are not the source of the land-use patterns expressed in the SII maps but are rather from a comparatively recent chronological period.

In reviewing previous research regarding ancient land-use modeling, I have found Barton et al.'s (1999) and Barton et al.'s (2002) the most relevant to Area B. They synthesize present land use, dynamic landscapes, artifact morphology, and consider the latter as clasts of sediment. Furthermore, they give attention to the likelihood of various formation processes affecting artifact scatter (as also discussed by various other authors, such as Given (2004) and van Leusen (2002). In this, they have identified to what extent current land use (in terms of visibility) has on the recognition of spatial patterns. They have also determined that while lithic assemblage from earlier time periods indicate more post-depositional processes, they are not sufficient to influence spatial patterning of the artifacts.

This model is uniquely interesting for Area B, and perhaps the other ZAP research areas, because Zakynthos has a rich history of land use, a dynamic landscape, and based on recovered surficial artifacts, a long occupational history. The ZAP has collected much information related to survey and geomorphology, and with some alterations to Barton et al.'s model, I will show the ways in which I have adapted their methodology to suit that of Area B in Zakynthos in Chapter 3.2.

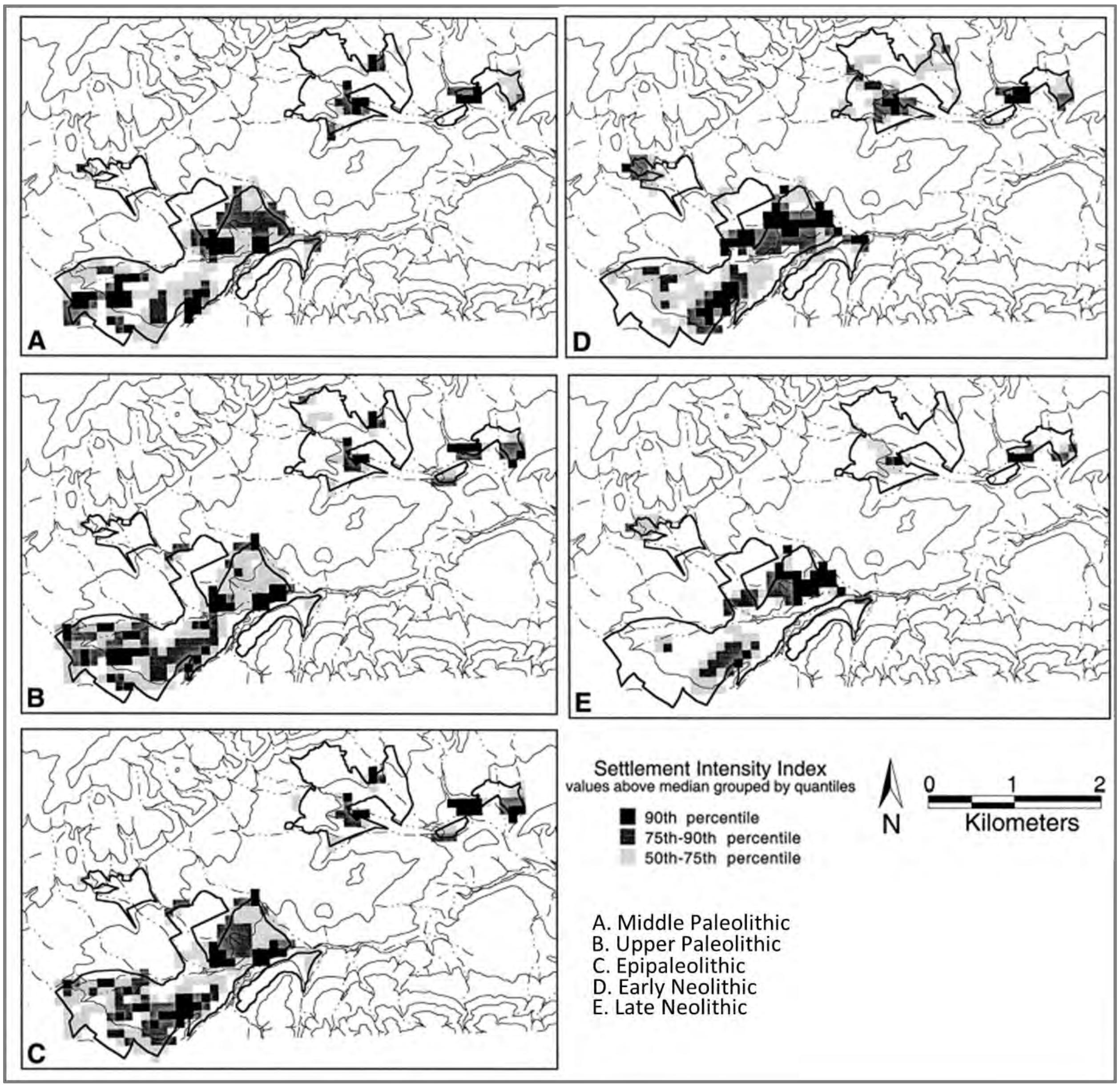

Figure 4 - Settlement Intensity Index maps indicating changing land use through time (adapted from Barton et al., 2002). The Middle and Upper Paleolithic show dispersed land use with a more aggregated land use in the Upper Paleolithic. The Epi-paleolithic shows intensive land use which is focused in fewer but larger locales while the Early Neolithic shows intensive land use centered on few locales. Finally, the Late Neolithic shows residues of activities concentrated in single locales.