Human-Environment Interactions: The Role of Foragers in the Development of Mobile Pastoralism in Mongolia's Desert-Steppe.

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This dissertation investigates the local settlement history of Mongolia's desert-steppe, affording an opportunity to examine adaptive strategies of mobile people over time (Neolithic-Kitan periods, ca. 8000-800 BP). The study examines land use patterns, mobility strategies, technological organization, and environmental context prior to, during, and after the transition to herding (ca. 4500 BP) to understand the nature of this economic and social change. The study compares how hunters and herders distributed themselves within habitats, detecting differences in how, when, and why people moved, illuminating how people make decisions about existing environmental conditions.

Work was carried out at Ikh Nartiin Chuluu Nature Reserve in southeastern Mongolia and involved a program of systematic survey and artifact analysis. Working within a framework of evolutionary ecology and habitat suitability, this study documents subtle yet important shifts in land use and mobility across the Neolithic-Bronze Age transition (ca. 4500 BP) as people presumably began to take up herding.

Settlement and population patterns indicate an abrupt change in habitat choice across this transition, suggesting that preferences of committed herding societies (i.e., Iron Age and beyond) were firmly established during the Bronze Age as people began to prioritize upland grasslands and productive wintertime vegetation. This shift coincided with the regional onset of dry, cool conditions, a reversal of wetter and cool environments where prior foragers exploited a broad range of habitats, including surrounding low-lying wetlands.

Both Neolithic hunters and Bronze Age herders employed short-term, high residential mobility to target resources, demonstrating that foraging lifeways were amenable to early mobile pastoralists. By the Bronze Age, mobility was more constrained with increased recurrent site use and population consolidation in upland settings. Findings support recent geoarchaeological research that suggests intensified human-environment interactions within the uplands during this period resulted in the enhancement of grassland habitats. Population consolidation may have also increased levels of unpredictability as people vied for scarce resources and contended with increasing rates of interaction and resource depletion, setting the stage for the development of adaptations that came to define mobile pastoralism across Eurasia including high residential mobility, long distance connections, social differentiation, and broadly adopted mortuary traditions.

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Preface

I am grateful for the opportunity here to acknowledge all the people and organizations that supported me in my dissertation research and graduate school experience at the University of Pittsburgh. I want to thank my dissertation committee members Dr. Robert Drennan, Dr. Loukas Barton, Dr. Elizabeth Arkush Dr. Claire Ebert, and Dr. Joshua Wright for their support and thoughtful input throughout the entire project. I feel honored to have worked with each of you and will always be thankful for your generosity and guidance. Though I came to Pitt an experienced professional archaeologist, my time with the Anthropology Department has changed me profoundly. Many faculty members (especially Dr. Mark Berman, Dr. Brian Hanks, and Dr. Tomas Matza) helped me to push the boundaries of what I thought I could accomplish. The experience not only expanded my knowledge of anthropological archaeology, it opened whole new research avenues, introduced the joys of teaching, and challenged me in ways I never expected.

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1.0 Introduction

Pastoralism is a fundamental aspect of Mongolian culture and identity, and its origins and development have long been important research topics. Known primarily throughout parts of Eurasia, Africa, and South America, pastoralism is a migratory subsistence economy in which people make their living by tending herds of domesticated animals (e.g., sheep, goats, cattle, horses, donkeys, llamas, alpacas, camels, yaks, reindeer) to provide meat, milk, wool, hides, dung, and transportation. Pastoral economies are found in a range of environments where climate and topography set limits on agricultural production including deserts, desert-steppes, mountains, and tundra.

Animal domestication, the defining characteristic of pastoralism, was a slow process involving gene-flow between wild and domestic species, and a co-evolutionary or symbiotic relationship with the people who cared for them (Zeder 2011). Though herding economies often involve a suite of other subsistence pursuits and associated tasks (e.g., hunting, fishing, foraging, cultivation, trade, and exchange), the care and management of herd animals is paramount among pastoral societies and plays a vital role shaping individual and group social identities (Marshall and Capriles 2014:250).

Herd size among pastoral groups is dependent on a range of factors, such as access to land/pasture, climate, and political structure, and is often considered an indicator of individual or family wealth (Barnard and Wendrich 2008). Mobility, of course, is an important aspect of pastoral societies with households moving at regular intervals to access water and pasture for herds. Mobility patterns among contemporary groups are wide ranging from days, months, to years, and are dictated by a host of factors including climate, seasonality, resource abundance, and social or political arrangements that influence access/land use rights.

For decades, efforts to understand the origins of herding economies in Eurasia, including Mongolia (Figure 1.1), have been stymied by a "steppe and sown" dichotomy that perpetuates long held stereotypes of farmers and herders and imagines agriculture as a precondition for mobile pastoralism. Early studies on the causes and effects of pastoralism have had a substantial and lasting influence on our understanding of nomadic lifeways (Cribb 1991; Khazanov 1978, 1994; Kradin 2002; Lattimore 1951, 1979; Lees and Bates 1974). Based largely on historic and ethnographic data, early scholars focused primarily on the development of detailed typologies of mobile pastoralists, including their economic and social interactions with agricultural communities (Honeychurch and Makarewicz 2016). Over the past few decades, researchers have critiqued these approaches, citing problems with applicability to prehistoric populations and their ability to address change over time (Honeychurch and Makarewicz 2016). Indeed, recent perspectives have revealed more complex evolutionary processes, highlighting variability in environmental adaptation (e.g., Anthony et al. 2016; Bendrey 2011; Dolukanov 2002), and differences in economy, subsistence, settlement, and social interaction (Frachetti, 2009, 2012; Hermes et al. 2021; Kohl 2008). These studies have helped to dismantle outdated views of pastoralism, expanding our understanding of its development and the role of non-agricultural traditions (e.g., foragers) in the development of food producing economies (Frachetti 2012; Ingold 1980; Popova 2009; S. Rosen 2008). Recent archaeological studies have also provided important perspectives on the nature of pastoral societies as "complex and flexible social constructs, forms of risk management, and as resilient systems" that have developed overt time "to help people to cope with aridity, climatic changes, and environmental extremes" (Marshall and Capriles 2014:249).

In Mongolia, hunter-gatherer economies began to include domesticated animals from western Eurasia ca. 5000-4500 BP (Hermes et al. 2021; Honeychurch et al. 2021; Jeong et al. 2018; Kovalev and Erdenebaatar 2009; Wilkin et al. 2020), well before evidence for the adoption of agricultural practices (Spengler et al. 2016). Regional research has started to generate important insights about the natural and social context of hunters and early herders, highlighting variability in economic transitions across different environmental settings, and expanding our understanding of the range of factors influencing the development of pastoralism in some regions (Clark 2014; Hermes et al. 2021; Honeychurch et al. 2021; Janz 2012; Janz et al. 2017, 2020; Jeong et al. 2018; Taylor et al. 2019, 2020; Wright 2006; Wright et al. 2019). Despite these advances, we still have little information about how foraging societies contributed to the development of herding lifeways, limiting our understanding of temporal and spatial variability and the underlying causes of social change.

This dissertation addresses this information gap by investigating the development of pastoralism in Mongolia's desert-steppe north of the Gobi Desert (Figure 1.2), a region with no evidence of agriculture prior to the development of pastoralism about 4500 years ago. The study employs archaeological data from the Ikh Nartiin Chuluu Nature Reserve (Ikh Nart) in the Dornogovi Aimag (Figure 1.3). Recent efforts here have identified several sites dating to the past 8000 years, including stratified deposits spanning the period when people are thought to have shifted from foraging to herding (ca. 4500-3500 BP). This dissertation aims to provide a detailed look at local settlement history of the desert-steppe, affording an opportunity to examine adaptive strategies of mobile people over time (Neolithic-Kitan periods, ca. 8000-800 BP). Research focuses on land use patterns, mobility strategies, technological organization, and environmental context (both natural and social) prior to, during, and after the transition to herding to understand the nature of this economic and social change, providing comparative insight on the development of pastoralism throughout Eurasia. The study compares how hunters and herders distributed themselves within habitats, detecting differences in how, when, and why people moved, illuminating how people make decisions about existing environmental conditions.

Figure 1.1 Location of Mongolia in Northeast Asia (Worldmapwithcountries.net).

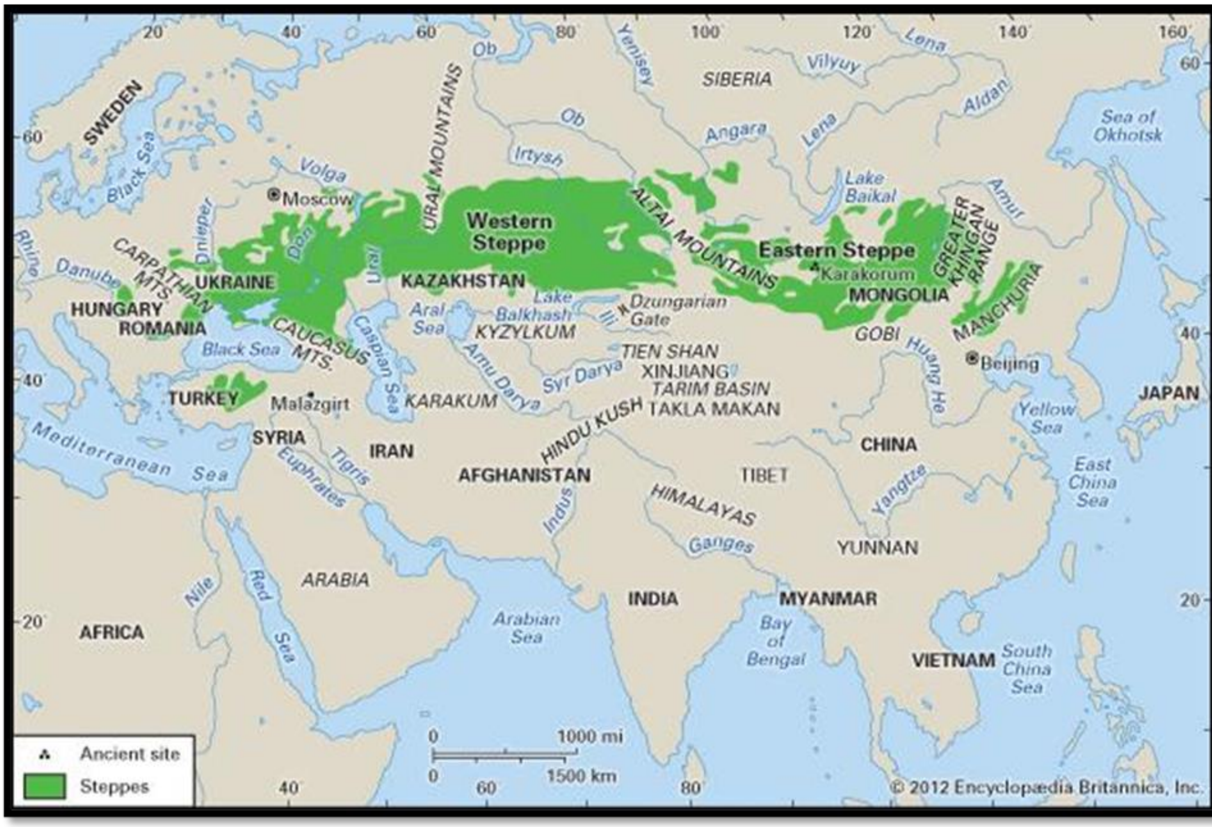


Figure 1.2 Map of the Eurasian Steppe (from McNeill 2022).

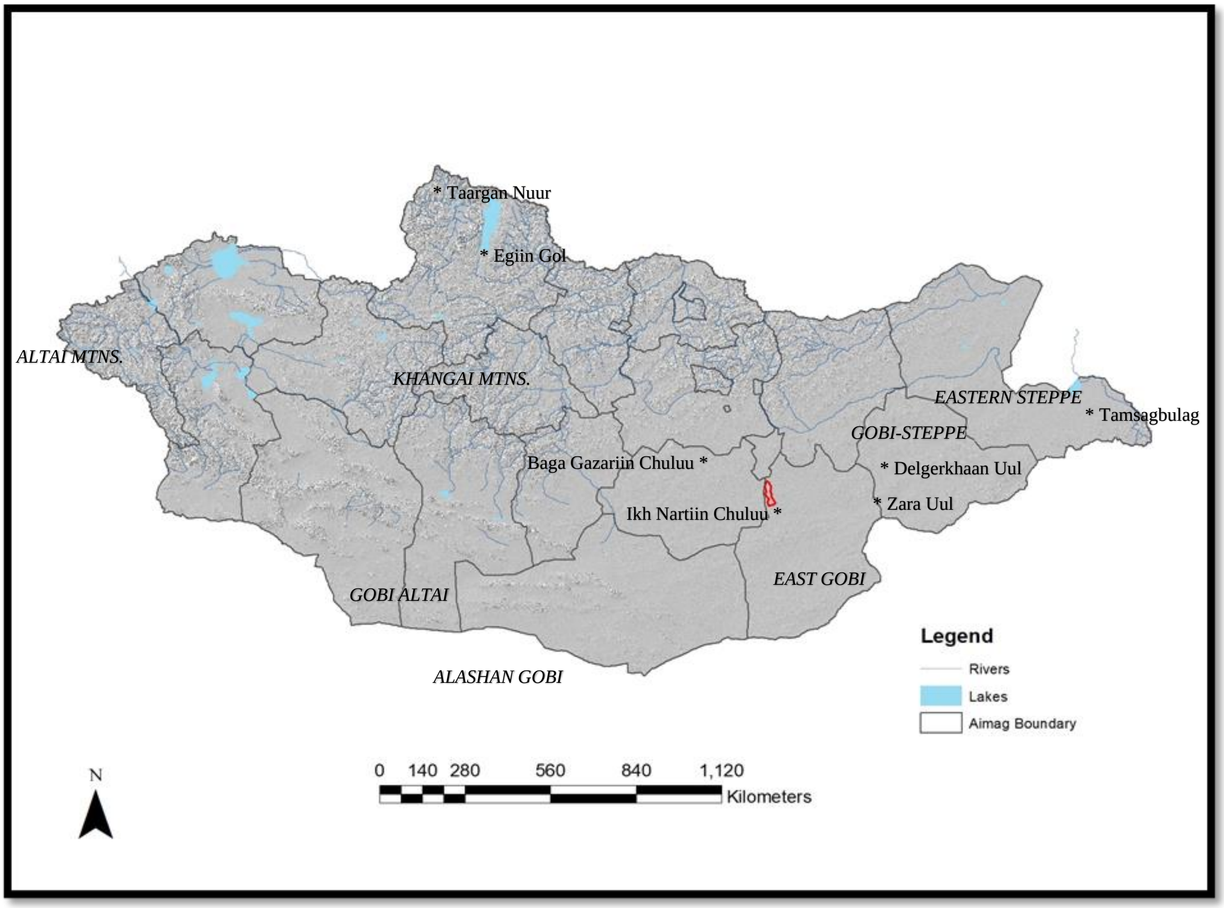


Figure 1.3 Sites and regions referenced in text.

The remaining sections of this chapter provide important background information for this dissertation, including discussions on mobility (Section 1.1), mobile pastoralism (Section 1.2), previous research in Mongolia (Section 1.3), and prior archaeological work at Ikh Nart (Section 1.4). Chapter 2 presents study research questions and provides a discussion of the theoretical frameworks that guide this work. Chapter 3 describes the natural environment of the study area, while Chapters 4 and 5 discuss analytical background and methods, respectively. Chapters 6 and 7 present the results of archaeological survey and artifact analyses. Chapter 8 addresses research questions and Chapter 9 provides a discussion of research significance and directions for future work.

1.1 The Importance of Mobility

The study of mobility and land use has a long history in anthropology, particularly in research focused on forgers (also referred to hunter-gatherers) (e.g., Bamforth 1991; Binford 1980; Kelly 1988, 1995; Torrence 1983). More recently, the study of mobility has expanded to consider relationships between foragers and mobile pastoralists and the variable ways people employ movement in different modes of production (Aldenderfer 2002; Barnard and Wendrich 2008). This research not only improves our understanding of the complexity and flexibility of mobile lifeways, but provides crucial insight to social and economic transformations, including the development of food production.

There are a number of similarities between forager and herder lifeways, including a reliance on vast knowledge of natural surroundings, and an intimate familiarity with animals and plants targeted for subsistence (Ingold 1980). These traits are critical in environments that are considered "marginal" in terms of productivity and proclivity for extreme or unpredictable natural conditions. Other commonalities include low population densities and use of seasonal rounds to procure or produce resources. Both foragers and herders are dependent on plants and animals, and on regular movements to procure food for themselves or provision their animals.

While there are many similarities between hunters and herders, differences in consumption, territoriality, spatial patterning, and migratory behavior can provide important perspectives on economic transformations (Cribb 1991). Comparing the ways in which foragers and herders organize themselves in relationship to resource procurement activities helps us to understand the factors that shape decisions about movement (Binford 1980; Boyd 2006; Close 2000), and ultimately how economies are altered. Mobility is key to understanding these differences and requires us to think more critically about its structure, including distance, frequency, and motivation (Barnard and Wendrich 2008:8; Chang 2008; Rogers 2012).

It is also important to understand differences in how resources are incorporated into movement. For example, both foragers and herders target water, but they do so for different purposes; foragers target for human consumption and production, while herders require water for herds in addition to their own needs. Arguably, this is the most crucial resource for both production modes, though herders may be more tethered to productive water sources than foragers. If so, then in a region where mobile pastoralism developed in place, we might expect to see in the archaeological record a notable change in the range or frequency of residential movements over time, reflecting in part, the rate of resource depletion and group size (humans, animals). Similarly, plants and animals are targeted in diverse ways. Foragers typically rely on a wide variety of plants and animals from various environments, procured in a wide variety of settlement strategies (i.e., movement of an entire group or task specific groups to target resources); duration; frequency; or distance traveled. Pastoralists target grass to feed herds, with other plants and animals being a secondary pursuit. That is, herders target a limited range of environments that dictate how they organize their movements. In areas where patches of pasture are abundant, we may expect to see frequent, short-range movements. In areas where tracts of pasture are less abundant (spaced further apart), we may see increased range of movement (Mearns 1993).

Comparison of temporal and spatial patterning can help us to understand the logic of movement (e.g., to improve access to resources, adjust to abundance, encourage/discourage social interaction), a primary goal of this dissertation. While we may expect variation across different environments, similarities might tell us something important. For example, parallels in mobility across vastly different biotic regimes could indicate the importance of other factors in movement strategies (territoriality, raw material availability, social interaction). Along the same lines, differences in mobility within ecologically similar contexts could signal significant differences in production modes, territoriality, or human migration patterns. Identifying and understanding differences in mobility among foragers and herders is particularly key for understanding cases where herding was adopted by preexisting forager populations.

To summarize, the study of mobility across the transition to food production allows us to better understand the context for a range of behaviors relating to subsistence, material acquisition, and social interaction. Indeed, changes in mobility present different opportunities and constraints, creating novel contexts that shape decisions about what to eat, how to organize movement to acquire resources, and how to interact with others in these pursuits. Understanding these contexts allows us to understand the logic of movement and provides insight to the drivers of social change.

1.2 Mobile Pastoralism

1.2.1 Theoretical Developments

As mentioned, formative studies on mobile pastoralism (Cribb 1991; Khazanov 1978, 1994; Kradin 2002) had a considerable and lasting impact on the study of mobile lifeways across the globe. These prominent works focused largely on the development of detailed typologies of pastoral communities, where interactions with grain-producing societies (and the exchange opportunities they provided) were considered a prerequisite (Honeychurch and Makarewicz 2016). The following section details some of these influential works and identifies some of the important concepts and debates that have shaped recent research of mobile pastoralists including variability in economic and social structures, the role of the natural environment, sustainability of herding practices, and pathways to complex social-political systems.

Khazanov (1978, 1994), one of the most influential theorists on early pastoralism, viewed mobile pastoralism as a set of adaptations to ecological niches that required specific prerequisites including an environment with low potential for agriculture, presence of livestock, availably of saddle and draft animals, and some degree of private property (Khazanov 1978:1). According to Khazanov, these conditions developed on the Eurasian steppe over millennia, beginning around 4000 years ago with the introduction of the saddle and wheeled draft transport from the Near East (Khazanov 1978:1-2). Significant aridification of the region around 2000 BP was viewed as the impetus for transition to pastoralism (Shnitnikov 1957). Based in part on ethnographic accounts of herder communities across the steppe, Khazanov identified five types of pastoral economies, which were differentiated based on periodicity and duration of residential mobility, settlement configuration, and the degree of engagement in agricultural (Khazanov 1978:2-3):

1. Entire populations move, with no fixed routes, staying nowhere for long.
2. Entire populations move year-round, with limited spatial patterning of movements and irregular use of seasonal winter camps.
3. Entire populations roam along routes and established seasonal winter camps.
4. Populations move seasonally along established routes and establish permanent winter camps. Agriculture is practiced alongside herding.
5. Part of the population roams at various times of the year, while remaining group resides in a permanent residential base and engages mostly in agriculture.

Khazanov (1978:3) linked sedentism to internal socio-economic circumstances including the level of poverty among community members, the presence of pressure from high status individuals to obtain agricultural products and wares from nearby communities, unfavorable political climates, restricted access to pastureland, and pressure from agricultural neighbors (see also Finkelstein and Perevolotsky 1990 for similar processes observed in the Middle East). Overall, the economic potential of herding was viewed as limited due to factors such as susceptibility to animal loss, low demand for labor, and fettered development of social classes. These characteristics were regarded as limiting factors in that they obstructed social growth and rendered populations susceptible to influence by agricultural communities (Khazanov 1978:3); the same traits were also thought to promote mutual aid and cooperation, and ultimately provided encouragement to social institutions to carryout economic, military, and political tasks (Khazanov 1978:4-5). Khazanov believed that relations with the outside world were driven primarily by economic concerns (Khazanov 1978:6) and were largely dependent on products, handy crafts, and wares produced by farming communities. While class relations may have been encouraged by sedentism, state formations only developed when nomads were interested in raiding and/or conquering their agricultural neighbors.

Less than a decade later, Khazanov (1984, reprinted in 1994) made significant revisions to his mobility-based typology, shifting focus to the relative proportion of pastoralism to agriculture practiced in an economic system (Khazanov 1994:19-23). He proposed five types of pastoralism:

1. *Pastoral nomadism proper*: characterized by seasonal migrations and the absence of agriculture.
2. *Semi-nomadic pastoralism*: primarily pastoralist, with supplementary agriculture.

3. *Semi-sedentary pastoralism*: predominantly agriculturalist, with shorter (both in time and distance) seasonal migrations.
4. *Herdsman husbandry*: sedentary populations focused primarily on agriculture, with livestock managed year-round by a small segment of the population in distant pastures.
5. *Yaylag* (transhumance): sedentary agriculturalists who move herds between different ecological zones based on seasonal productivity (i.e., moving herd to upland in summer month, and returning to lowland areas in the winter).

While not intended to be an exhaustive list of the all the forms of pastoralism, this taxonomy focused on some of the most common and distinctive forms. Categories were not seen as static; Khazanov (1994:25) recognized that transformations did occur and that these transitions were not necessarily linear in nature. Based on criteria concerning herd composition and size, the nature of ecological zones, the character of pastoral migrations, and the nature of pastoral products and dietary systems, he identified six types of pastoral nomadism: *Northern Eurasian* (polar desert and tundra zones); *Eurasian Steppe* (desert, semi-desert, and deserts of the temperate zones of Eurasia); *Near Eastern*; *Middle Eastern*; *East African*; and *High Inner Asian*. According to Khazanov (1994:89), the origins of mobile pastoralism in each area varied, however, the origins of cultivation and animal husbandry were ultimately linked to the broader Neolithic "revolution" and the emergence of sedentary lifeways and the development of food surpluses. Khazanov viewed these economic and technological conditions as preconditions for the development of a pastoral economy, conditions that rendered a population "potentially capable of and ready for a transition to pastoral nomadism" (Khazanov 1994:117). He proposed that independent development of mobile pastoralism occurred in the Eurasian Steppe, the Near East, and Northern Eurasian regions, though did not discount the possibility of exchange of technologies and ideas with neighboring groups. He further supposed that mobile pastoralism diffused to other areas (Middle Eastern and High Inner Asian types) by way of migration and adoption of traits.

In contrast to Khazanov's economic approach to the origins of pastoralism (1978, 1994), Kradin (2002) examined the development of pastoralism from the perspective of social-political organization, specifically through the lens of world-systems theory. Envisioning a number of possible paths to social-political transformations, Kradin highlighted the cyclical nature of social-political complexity among pastoral groups, having "many times united into large political formations and created great empires that have subsequently disintegrated" (Kradin 2002:369). Kradin identified three levels of integration for pastoralists with categories based on level of political integration (Kradin 2002:370):

1. Acephalous segmentary clan and tribal formations;
2. Secondary tribes and chiefdoms;
3. Nomadic empires and quasi-imperial polities.

For Kradin, movement between the levels was fluid and multidirectional, however, transformations were not thought to correlate with other criteria typically associated with social complexity, including changes in population density, complex technologies, structural differentiation, and functional specialization. Only total population density was thought to track changes in political structure complexity (Kradin 2002:370).

Because Kradin viewed nomadic empires as predicated on conquest and extraction of goods from agricultural societies, he perceived a limit to the development of complexity within pastoral groups, one that is directly related to the level of organization and complexity of the agricultural group in which it is engaged (Kradin 2002:384-385). In other words, within a region, the political structure of the nomadic periphery is directly proportional to the size of the agricultural core.

In *Nomads in Archaeology,* Roger Cribb argued against rigid typological schemes like those purported by Khazanov, advocating a model based on recognition of “nomadic tendencies” and the tremendous variably within groups both in terms of mobility and subsistence practices (Cribb 1991:15-18). Cribb highlighted the dual nature of pastoral nomadism, one that comprises two dimensions (nomadism and pastoralism):

> “Within each of these dimensions, dualisms such as nomadic/sedentary, agricultural/pastoral, the desert and the sown, perpetrate gross distortions of our ability to understand the relationship between the two. Each dimension may be viewed as a continuum, and the relationship between them is best represented in terms of a probability space in which groups or individuals are uniquely located with respect to each axis” (Cribb 1991:16).

Cribb expanded the definition of pastoralism (a mode of production that relies chiefly on herds of domestic stock for subsistence) to include concepts of ownership and mutualism that distinguish pastoralism from other modes that also involve animals, namely hunting and ranching (Cribb 1991:17). While expanding the concept of pastoralism, he refined the concept of nomadism by stressing the importance of the organization of mobility. He contends that nomadism “involves the regular migration of a community together with much of its productive base within a single ecological niche" (Cribb 1991:20). This definition distinguishes mobile pastoralists from other mobile groups such as hunter-gatherers and shifting cultivators.

While Cribb's approach focused on the dichotomy between agriculture and pastoralism and not the relationship between pastoralism and forager subsistence (Clark 2014:3), his ethnographic research did highlight important distinctions between hunter-gathers and mobile pastoralists in terms of consumption/production focus, territoriality, spatial patterning of settlements, the role of risk (Cribb 1991:22). Examination of these differences provided important perspectives on economic transformations involving both modes of subsistence and demonstrated the potential for identifying signatures of early mobile pastoralists (Clark 2014).

As previously outlined, many of the early models for the emergence of pastoralism were based on ethnographic and historic accounts and advanced the idea that the exchange of goods and services between settled agriculturalists and non-settled people was a prerequisite for mobile pastoralism. The resulting mode of production was separate from and peripheral to sedentary farming (Honeychurch and Makarewicz 2016:343). In contrast, archaeological investigations of early pastoralists have emphasized a more complex picture of the development of pastoralism, highlighting the role of hunting, gathering, fishing, and cultivation (Hermes et al. 2021; Ingold 1980; Kiryushin and Kiryushin 2005; S. Rosen 2008; Semibratov and Stepanova 2006). For example, in his seminal work *Hunters, Pastoralists, and Ranchers* Ingold (1980) argues against the dichotomy of food gathering and food production, suggesting instead that gathering and pastoralism are similar in terms of their economic production (both requiring development of capabilities for production). Both modes are equally dependent on plants and animals, the difference being the "productive relations that link animals and men" including taming, herding and breeding (Ingold 1980:82) and their respective social structures (Ingold 1980:143).

Steven Rosen's work in the southern Levant (2003) focuses on the importance of non-pastoral activities in multi-resource mobile systems. He highlights the tremendous amount of variability among mobile pastoralists, but also emphasizes the utility of rethinking limited dichotomies that have influenced our thinking about pastoralism and mobility. His work at the Camel Site in central Negev desert documented an Early Bronze Age (ca. 5000-4700 BP) occupation characterized by multi-resource nomadism. Despite a relatively ephemeral archaeological record, Rosen was able to glean aspects of a short-term occupation characterized by a system of mixed subsistence and an economy that included hunting (projectile points), seed processing (milling equipment), and herding (grass phytoliths and spherulites in pen enclosures). While there is little to no evidence for agricultural activities or connections with agricultural communities, there is evidence for engagement within a broader economic system including opportunistic low-intensity production of shell beads, ground stone milling slabs, and copper for export to neighboring communities. The high level of interaction within a broader economic system and the incorporation of a wide variety of non-pastoral activities illustrate the flexible nature of adaptations, including development of exchange opportunities that did not require external reliance (Honeychurch and Makarewicz 2016:346).

A sharpened focus on the relationship between hunter-gatherers and pastoral nomads is presented in Barnard and Wendrich's (2008) *The Archaeology of Mobility*. This collection of essays demonstrates important shifts in our understanding of resource production modes, supplying ample evidence for multi-resource nomadism or herder-hunter strategies (Wendrich and Barnard 2008). As the title suggests, the concept of mobility is used to explore variability in the ways people employ movement within resources procurement strategies. By simply defining mobility in terms of moment (length of time), motion (patterned movement over time), motivation (resources, cultural identity, social or economic circumscription), and segment (parts of population that engages in movement) the authors dispose of static classificatory schemes and overly deterministic or simplistic models of climate driven human adaption, and instead emphasize the flexible nature of mobility and the role of social organization and agency in settlement strategies (Barnard and Wendrich 2008:8):

> "Humans will adapt their lifestyles to changing circumstances, or proactively decide on changing their way of life, either as a group, as a specific part of a group, or as individual. No firm delineation can be made between settled and mobile existence. At the same time, we should not imagine the relation between settled and mobile life as a point or range on a scale between 'completely settled' and 'completely mobile'. The decision to move location occasionally, regularly, or frequently is in most cases opportunistic" (Barnard and Wendrich 2008:11).

Many of the essays in the volume draw upon methods employed by prehistorians, especially in hunter-gatherer studies focused on understanding why people move. Several important concepts are put forth that demonstrate a profound shift in our understanding of mobile lifeways and a refocus on broader, interdisciplinary, and less deterministic approaches. Useful themes include the importance of multi-site occupations and landscape analysis (Bernbeck 2008), climate, weather, and ecological reconstructions (Shishlina et al. 2008), social learning (Milne 2008), and the importance of analogical reasoning and ethnographic studies.

1.2.2 The Eurasian Record

The theoretical shifts in the study of pastoralism over the past few decades are evident in regional research across the Eurasian steppe. Employing a mobility-based typology focused on the relative importance of agriculture, Khazanov (1994:90) proposed that food production entered the Eurasian steppe from the Balkans between 7000 and 8000 years ago but took several thousands of years to take hold. While traces of food production and pastoralism are found throughout the region by ca. 5000 BP, "true nomadic pastoralism" did not take hold until after 4000 BP. According to Khazanov (1994:92-94), early pastoralists and food producers of the steppe did not meet the criteria for pure nomadism, which are based on herd composition and settlement configuration. Instead, true nomadism did not occur until the appearance of horse riding, which occurred sometime around 3500 BP. He proposed that between 5000 and 3000 BP pastoral groups of the steppe developed characteristics that would later set the stage for the transformation to nomadic pastoralism (i.e., mobile life ways, stock animals, wheeled vehicles, and horsemanship); the potential of such preconditions, however, was not realized until ca. 3000-4000 BP, when the first evidence of explicit riding and nomadism occurs (Khazanov 1994:94). This period, according to Khazanov, was marked by significant climate shifts (aridification, Butzer and Twidale 1966 and Starkel 1966) and changing political environments including the rise of sedentary states in the Black Sea area and Middle Asia (Khazanov 1994:95). Other models backed by archaeological evidence (Anthony 2007) have pushed back an increased reliance on domesticated cattle, sheep, and horses (for riding and wagons) to ca. 6000-5000 BP, linking the eastward expansion of pastoralism across the steppe to environment change and the growing need for pasture.

In contrast to models based on environmental adaptation and linear paths of expansion, Wright (2006) highlights variability in economic transitions across Eurasia and emphasizes the role of elites in the gradual process of adoption and adaptation of pastoralism. Wright argues that while dates for the development of agro-pastoralism throughout the region are very similar (4700 BP in the circum-Pontic region; 4600-4000 BP for the Uralic Steppe; and 5100 BP for the Altai), each signifies a long process of development where the evidence from precursor populations (foragers) overlaps with that of the first mobile pastoralists with no signs of population replacement (Hermes et al. 2021; Wright 2006:45). In northern Mongolia, data from Egiin Gol suggests a similar pathway to pastoralism around 4600 BP (Wright 2006:290-294). In addition, Late Bronze Age sites (ca. 3000-2500 BP) identified in the Targan Nuur region of northern Mongolia are consistent with those observed at Egiin Gol (Clark 2014; Honeychurch 2004; Taylor et al. 2020; Wright 2006), lending support to the hypothesis that a mixed forager-herder orientation was an important and consistent subsistence strategy and may have played a role in the local adoption of mobile pastoralism.

A recent model proposed by Frachetti (2012) also deviates significantly from a linear and deterministic view of mobile pastoralism suggesting that it developed along different trajectories in portions of the Eurasian steppe around 6000-5000 BP. Each developed within unique ecological and social environments, producing a distinctive set of characteristics and interactions with neighboring communities (Frachetti 2012:5). In other words, regional technological and ideological developments were the foundation for a unique political economy across the steppe ca. 4000-3000 BP. Building on themes of regional diversity explored by Barnard and Wendrich (2008), Frachetti's model investigates interactions between distinct nomadic populations across the steppe. More specifically, it examines how these relationships assisted nomads in becoming "key-players" within institutional developments of "core civilizations", while at the same time allowed for autonomy and the preservation of mobile life. Based on a review of data from western, central, and eastern portions of the Eurasian steppe, Frachetti (2012:20) proposes a multi-centered and regionally diverse process of development. In the western steppe, he suggests that mobile pastoralists primarily procured domesticated animals from neighboring agro-pastoralists ca. 7000-6000 BP, while other populations were shaped by interactions with local hunter-gatherers, and did not employ domestic animals until after 6000 BP. In north central regions, herding was adopted later ca. 4500-4000 BP. Mountain-adapted groups along the In the Inner Asian Mountain Corridor appear to have adopted domestic animals as the result of interactions with agro-pastoral neighbors around 5000 BP. According to Frachetti (2012:20), growing interaction among these groups fostered economic and technological innovations that facilitated their ability to increase trade in commodities and raw materials, and to expanded opportunities for participation in large scale networks.

In recent years, research on the spread of pastoralism across Eurasia has focused the Afanasievo cultural horizon that emerged in the Altai Mountains around 5500-4500 BP (Allentoft et al. 2015; Hermes et al. 2021; Honeychurch et al. 2021; Jeong et al. 2020). An array of projects involving radiocarbon dating, faunal analyses, isotopic studies, paleogenomic research and material studies from burial and settlement contexts have provided insight to the origins and distribution of Afanasievo people and traditions (Hermes et al. 2019, 2021; Honeychurch et al. 2021; Jeong et al. 2020). Importantly, these studies have documented a high degree of variability in material culture, burial practices, subsistence, animal management practices, and settlement strategies. While there is still much debate about Afanasievo origins, researchers believe its emergence occurred after western steppe herder populations reached the Altai Mountains (Hermes et al. 2021; Poliakov et al. 2019). Complex interactions with extant foraging societies across the Afanasievo core region are thought to have initiated transformations of subsistence (animal domestication), technology (metallurgy), and mortuary practices (monument construction) that set the stage for the spread of herding practices across the eastern steppe (Honeychurch et al. 2021:14-16).

1.2.3 Social Complexity and Eurasian Steppe Pastoralists

In addition to scholarship on the origins of mobile pastoralism, the development of social complexity and inequality among Eurasian mobile herding communities has been an important research focus, building on recent trends in identifying alternative pathways to complexity. Alongside the biophysical environment, the social context of mobile lifeways (e.g., wealth differentiation, degrees of social interaction, territoriality, exchange, conflict) is an essential component to understanding how economic systems transformed.

While many pastoral societies are characterized by relatively egalitarian social systems where kin relationships largely shape herding lifeways (i.e., when and where to move), more stratified systems are recognized across most contexts where pastoralism occurs, structures that, in some cases, developed thousands of years ago. Central Asia, for example is widely known for ancient pastoral empires (see Frachetti 2012) that involved raiding, warfare, and high degrees of social differentiation.

Recent research across the Eurasian steppe (e.g., Drennan et al. 2011; Frachetti 2009, 2012) suggests that Bronze Age pastoralists do not fit easily into explanations of social complexity that typically focus on the role of surplus, central political authority, and specialized production in the development of institutional forces (Chapman 2003; Earle 1977). As such, studies over the past two decades have embraced frameworks of social complexity that focus on other elements of social change including systems of interaction, core-periphery relationships, and shifting patterns of growth and continuity (Frachetti 2009; Koryakova 2009). Past research has been highly influenced by world-systems theory, a macro-scale approach to world history and social change that developed in the discipline of sociology in the 1970s (Wallerstein 1974). World-systems theory emerged in Eurasian studies during this time as a vehicle for organizing the vast and seemingly interconnected region that stretches from China to Western Europe (Koryakova 2002; Kradin 2002). While often characterized as marginal, Eurasia is ecologically diverse covering expansive areas of steppe, forest, and desert terrain that supported a range of subsistence pursuits ranging from foraging to food production for millennia. Despite the tremendous natural and cultural variability across Eurasia, broad commonalities in subsistence, material culture, technology, and settlement mobility have come to define the region. The widespread occurrence of these traits has largely been explained by world system theory (Kradin 2002) and related core/periphery models that posit a unidirectional flow of material goods/ideas from the former to the later (Hanks 2010). Core groups are often perceived as being more “complex”, while peripheral groups are considered dependent. On a regional scale, Bronze Age mobile herders of the Central steppe are viewed as peripheral to southwest Asia (i.e., Middle East, Near East), with developments in food production and technology moving from west to east through diffusion or acculturation. On a local scale, the model has been central in explaining the “chiefdom-like” organization of the Middle Bronze Age Urals where large fortified Sintashta sites contrast with smaller, less complex communities with distinct, uneven levels of metal production (Koryakova 2009).

In recent years researchers have moved away from world-system and core/periphery models citing their static, unidirectional nature, and their inability to capture the complex and dynamic nature of exchange, conflict, and relations of force. Further, these approaches have often resulted in an underappreciation of the role of so-called “peripheral groups”, and a perpetuation of cultural stereotypes (Frachetti 2009, 2012; Hanks 2010; Honeychurch and Makarewicz 2016; Szynkiewicz 2005). With this, a number of alternative approaches have developed. In Kohl's (2008) "shared social fields" framework, interactions are conceived as web-like, where materials and ideas are diffused and modified by other groups caught up in these same developments. Kohl posits that unidirectional relationships promoted in core/periphery models mask important aspects of unequal systems of exchange including patterns of reciprocity, changing spheres of interaction, and instances where different activities had different cores (Anthony and Brown 2007; Frachetti 2012; Frachetti et al. 2010; Hanks 2010; Koryakova 2009).

Similarly, Frachetti's (2009, 2012) "non-uniform institutional complexity" proposes a dynamic explanation of interaction that focuses on how groups are both influenced by and interact with other communities in a variety of ways resulting in a diversity of social-political and organizational adaptations. In this framework, aspects of pastoral systems including trade networks and conventions of monument construction are viewed as "institutions" shared across wide areas, while other manifestations of culture such as burial practices and pottery motifs are not. Interactions among groups may sometimes be unequal or asymmetrical, however, one group is not significantly dominant over the other. Frachetti's model of non-uniform complexity is particularly useful for identifying different levels of social integration that resulted in a variety of socio-political organizations, mobility patterns, and connections to other groups (Frachetti 2009).

Along the same lines, a comparative analysis of archaeological patterns from the Eurasian steppe by Drennan and colleagues (2011) also focused on structural variability, demonstrating a number of pathways to complexity. The authors identify central problems in the way that complex societies are typically defined, based on highly specific/ rigid typologies that mask variability in the ways that small communities transform into larger, more complex organizations (Drennan et al. 2011:150). Instead, the authors propose that early complex societies be viewed as a process (i.e., “chiefdomization”), not a structural type, with analyses focused on comparisons of developments and traits along a spectrum of possible variation (e.g., finance type, level of hierarchy, corporate versus network organization).

1.3 Research in Mongolia

1.3.1 Culture History

Despite the distinctive nature of Neolithic, Bronze Age, Iron Age, and Medieval period archaeology in Mongolia, precise chronological ordering has eluded researchers. This is due in part to a high degree of material variably between regions, few radiocarbon dates, and a research emphasis that prioritizes monuments and burials over residential sites. As such, chronologies are typically very coarse grained, and constructed primarily on the basis of similarities between monuments, burial practices, and ceramic styles, with only very broad associations with social, economic, and political change over time. The following section provides a broad outline of the history of people in Mongolia (Table1.1).

Table 1.1 Regional Chronology.

Approximate Date Range	Period Name	Janz 2012
50,000-19,000 BP	Upper Paleolithic	-
19,000-13,5000 BP	Early Epipaleolithic	-
13,500-8000 BP	Late Epipaleolithic/	Oasis 1
8000-5500 BP	Neolithic	Oasis 2
5500-4500 BP	Early Bronze Age	Oasis 2/3
4500-3000 BP	Bronze Age	Oasis 3
3000-23000 BP	Iron Age (early/Middle)	-
2300-1600 BP	Xiongnu (Late iron Age)	-
6th-8th c. AD	Turkic	-
10th-12th c. AD	Kitan	-
13th-15th c. AD	Mongol Empire	-

According to current evidence, Mongolia was first inhabited in the Late Pleistocene, ca. 125,000 years ago by highly mobile hunter-gatherers (Olsen 2004). The Upper Paleolithic (ca. 50,000-19,000 BP) is better understood than earlier periods, with numerous investigations carried out in the eastern portion of Mongolia (e.g., Izuho et al. 2009; Tsolbaatar et al. 2010) as well as the in the north along the Selenge River system (Gladyshev et al. 2012; Zwyns et al. 2014). Subsistence/settlement strategies and lithic tool industries are notably similar to patterns noted across northeast Asia prior to the commencement of the Last Glacial Maximum (LGM) ca. 26,000-19,000 BP (Wright 2021). Divergent settlement trends are apparent by the end of the LGM that ushered in a period of warmer and wetter conditions across the region. In the north, forager populations settled along lakes and rivers, employing high levels of residential mobility to target abundant woodland and grassland habitats (Janz et al. 2017; Weber and Bettinger 2010). In drier areas to the south and east, people were less mobile, with occupations centered on wetland habitats; short-term logistical forays were used to exploit surrounding resources, a pattern that continued until the adoption of domestic animals (Janz et al. 2021).

The first pottery in the region comes from areas to the east of Lake Baikal, dating to the mid to late Epipaleolithic (ca. 15,000-8000 BP) (McKenzie 2009; Razgildeeva et al. 2013; Wright

2006). Within Mongolia, the earliest ceramics come from the Gobi region, dating to about 7900 years ago (Odsuren et al. 2015); however, unlike Western Asia, it was not accompanied by the introduction of domesticated plants and animals (Wright 2006).

An Epipaleolithic hunter-gatherer economy persisted into the Neolithic from ca. 8000-6000 BP, marked by the widespread use of microlithic technology (Wright 2006:154). The Neolithic in Mongolia (ca. 8000-5500 BP) is characterized by shifts in material culture, settlement and subsistence strategies including the use of ground-stone tools, an expansion of flaked stone technology, increased sedentism, and the introduction of domesticated plants and animals. The earliest data on multi-resource economies in Mongolia come from the east (Tamsagbulag, Dornod Aimag), where sites dating to ca. 8400-7300 cal. BP suggest the coexistence of farming, herding, hunting, and fishing (Derevianko and Dorj 1992; Sériadès 2006), though the evidence for domestication is unclear. More recent examination of lithic and faunal remains from this site, along with other Neolithic age occupations on the eastern Mongolian Plateau reveal a high degree of variation in adaptations pertaining to sedentism, technology, and diet, highlighting the importance of ecological and cultural contexts in shaping responses to climate change (Zhao et al. 2021:60).

In western and central Mongolia, a mixed hunting-herding economy (one that likely included ruminant dairy consumption) is attributed to Afanasievo-like cultures from the Altai-Sayan mountains entering the region ca. 5000-4500 BP (Honeychurch et al. 2021; Jeong et al. 2018; Kovalev and Erdenebaatar 2009; Wilkin et al. 2020); these groups are widely understood to be responsible for the spread of pastoralism (i.e., domesticated sheep/goat and cattle) across the eastern steppe (Honeychurch et al. 2021; Janz et al. 2017; Jeong et al. 2018; Taylor et al. 2019). The remains of horses have been found in some Afanasievo-like burials and habitation sites, though it has not yet been established if they represent wild or domesticated animals (Fitzhugh and

Bayarsaikhan 2011). In northern Mongolia, the evidence for domestication is a bit later, with foraging and fishing economies likely persisting regionally until nearly 3000 BP, (Losey et al. 2016, 2017; Taylor et al. 2020); evidence for domestication (i.e., sheep, cattle, horses) is widespread by the Late Bronze Age (ca. 3200 BP, Taylor et al. 2019).

Researchers generally agree that the transition to pastoral economies in Mongolia occurred sometime after the Neolithic-Bronze Age transition (ca. 4500-4000 BP), but its development is not well understood. By around 4000 BP, the eastern steppe witnessed wide-ranging transformations in material culture and exchange (Janz et al. 2020), corresponding with periods of increasing social interaction and significant changes in economic and political systems. Toward the end of the Bronze Age (ca. 3600-3000 BP), these transformations were quite distinct, marked by widespread adoption of herding practices (Janz et al. 2020) and monumental stone constructions (e.g., khirigsuurs and deer stones) that dominate the landscapes of central and western Mongolia (Allard and Erdenebaatar 2005). It is during this period that we also see the first potential evidence for horse domestication (Fitzhugh 2009; Taylor et al. 2015, 2016, 2017), including remains from burial contexts in northern provinces (Fitzhugh and Bayarsaikhan 2011). Recent research assimilating data from habitation contexts in western and northern Mongolia with archaeofauna datasets across Eurasia confirm that widespread economic use of horses (e.g., food, transport, and riding) was not established until the end of the second millennium BCE (ca. 3200 BP), a development that dramatically transformed Bronze Age economic and social structures, most notably the displacement of hunter-gatherer lifeways (Taylor et al. 2019, 2020):

> “Although pastoralism was apparently practiced in Mongolia from ca. 3000 BCE, it appears that only after the innovation of mounted riding, associated changes to the

ecological parameters of pastoralism, and the fluorescence of horse-based nomadic culture in Mongolia were hunting and gathering displaced as the dominant economic strategy in some northern regions. Innovations in horse transport – first the chariot, followed by mounted horseback riding – may have stimulated widespread transformations in Bronze Age pastoral economies, and help explain large scale population dispersals between east and west across Eurasia" (Taylor et al. 2020:13).

Also around 3400 BP, intensification of herding practices (i.e., dairying, Janz et al. 2020; Wilken et al. 2020) and monument construction (e.g., Ulaanzuukh and Tevsh burials) emerged in southeastern Mongolia (Honeychurch 2015; Kovalev and Erdenebaatar 2009), developments that coincided with the growth of craft production and exchange that resulted in the circulation wealth items (e.g., lapidary beads, fine-ware ceramics). Janz and colleagues (2020) hypothesize that it was wealth accumulation through exchange that stimulated investment and eventual commitment to a pastoral economy by foraging communities. Taylor and collaborators (2020) link the growth of pastoral traditions in the eastern and desert-steppe regions of the Eastern Steppe to the addition of horses to earlier economies focused on sheep and cattle (Taylor et al. 2020:11), triggering a shift in land use patterns, specifically, a move from "localized transhumance" to one that was more diverse and wide ranging. Based on Bayesian modeling of radiocarbon dates and burial positioning across the Eastern Steppe, Taylor and associates (2019:15) suggest a connection between the spread of prone burial traditions such as Ulaanzuukh and Tevsh and the introduction of horses into the pastoral economy.

Around 3000 BP early Iron Age cultures appeared across Inner Asia bringing about significant changes in technology (metal arrows and horse-riding equipment); mortuary practices

(Slab Grave, Sagly/Uyuk, and Pazyruk traditions); mobility (increased long-distance interaction); and subsistence (intensification of grains to supplement domestic animal diet) (Honeychurch 2015). By the middle Iron Age (ca. 2300-1600 BP), Xiongnu groups represent the first steppe empire in Mongolia (Wright 2006), marking a period of rapid and sustained transformation of the social-political landscape (Brosseder and Miller 2011; Di Cosmo 2002; Honeychurch 2015). The Xiongnu are widely regarded as the first nomadic empire (Hanks 2010; Rogers 2012), with foundations established in prior Late Bronze Age social transformations (Taylor et al. 2019). The core of the Xiongnu domain stretched across central and eastern Mongolia, however their influence extended to western Mongolia, northern China, and eastern Baikal. The scale of monumental construction by Xiongnu people increased significantly over time, focused on elaborate, labor-intensive tombs.

The decline of Xiongnu cultures by ca. 1600-900 BP marks the beginning of the Medieval Era. In Mongolia, Türkic groups (mid-6th century to mid-8th century) reflect the widespread influence of Altai Göktürkic tribes (Golden 1992) as well as impact from a brief military invasion by the Chinese Tang dynasty (659-882 AD). The Late Medieval Period in Mongolia is marked by Khitan populations from northeast China who dominated all of Mongolia through military force between the 10th and 12th centuries AD (Kradin and Ivliev 2008). The Mongol Empire commenced by the 13th century AD, originating among the forests and rivers of northeastern Mongolia, and successfully dominating pastoral communities across the Eurasian steppe as well as sedentary agricultural populations in surrounding regions. The Mongols are widely known for highly successful military actions that fostered the establishment of slavery, the creation of elaborate trade networks, and dedication to the development and exchange of knowledge and technology (Allsen 2015)

1.3.2 Studies on Hunters and Early Herders

Only a handful of systematic settlement studies have been carried out in Mongolia; most focused on northern and central steppe environments (Clark 2014; Honeychurch et al. 2007; Houle 2010; Wright 2006, Wright et al. 2019), with an emphasis on the development of complex sociopolitical organizations that appeared during the Late Bronze Age and Iron Age. While these studies have expanded our understanding of the evolution of Eurasian pastoralism, little attention has been paid to the earliest herders, leaving large gaps in our understanding of their origins and development. Recent archaeology across Eurasia has highlighted the varied and complex nature of pastoralism, suggesting that in many places the material remains of pre-existing foragers overlap with those of the first mobile pastoralists, with no signs of population replacement (Hermes et al. 2021; Janz et al. 2017; Jeong et al. 2018; Wright 2006). Based on these works, there is some indication that the development of mobile pastoralism in some regions likely involved interactions with or transformations of extant foraging groups. Transitions were not uniform but included a broad range of adaptations involving a unique combination of subsistence, technology, and settlement strategies (Clark 2014; Hermes et al. 2021; Honeychurch et al. 2021; Jeong et al. 2018; Losey et al. 2017; Nomokonova et al. 2010, 2015; Taylor et al. 2019; Weber et al. 2013; Wright 2006:45; Wright et al. 2019). In the central and northern steppes, mobile herding is thought to have been the primary economic focus as late as 4000 BP (Wright 2006), though forager lifeways are thought to have persisted in some parts of Siberia and northeastern Asia into the Late Holocene (Losey et al. 2017; Nomokonova et al. 2010, 2015; Weber and Bettinger 2010; Weber et al. 2013) and even into present times (Plattet 2016; Jordan 2001, 2016).

As noted, the earliest data on mixed economies in Mongolia comes from the east, where sites dating to ca. 8400-7300 cal BP suggest the coexistence of farming, herding, hunting, and fishing (Derevianko and Dorj 1992; Séfériadès 2003; Wright 2006; Zhao et al. 2021). Wright (2006) contends that the growing body of evidence pointing to the importance of forager strategies supports ethnographically based concepts about the origins of Eurasian pastoral lifeways (Ingold 1983, 1990; Vajnshtejn 1978). Wright observes that several shared characteristics of foragers and herders, such as short term, seasonal movements, and the need for predictable resources, illustrate the compatibility of divergent food gathering and producing economies (Wright 2006:294). While these studies provide important insight on the role of mobile multi-resource subsistence strategies on the Mongolian steppe, the records of other regions remain elusive, limiting our understanding of relationships with surrounding agricultural, pastoral, and forger groups in the western steppes and northern China. Desert and desert-steppe regions of Mongolia have received far less attention, though a growing number of systematic surveys in the desert-steppe are expanding our understanding of mobile pastoralism beyond the better studied regions of the country and deepening our awareness of the relationship between mobile foragers and pastoralists (Schneider et al. 2021; Tserendagva and Schneider 2014, 2015; Wright et al. 2007, 2019). For example, survey of Baga Gazaryn Chuluu (BGC) in the Dundgovi aimag provided the first large scale (140 km^2) systemic study of desert-steppe land use, documenting occupation spanning the past 10,000 years (Wright et al. 2007). Eneolithic (prior to ca. 3500 BP) forager groups are reflected in sparse/dispersed scatters of flaked and ground stone tools, and poorly fired ceramics found in close proximity to reliable water sources. Settlement trends are similar throughout the remainder of the Bronze and Early Iron Age (ca. 3500-2400 BP) (Wright et al. 2007), but with an increasing co-occurrence with monuments/burials signifying increased social complexity. The ongoing Dornod Mongol Survey in southeastern Mongolia (Wright et al. 2019) documents the development of the distinctive Ulaanzuukh mortuary tradition (prone burials, short walls constructed with layered flat slabs), suggesting that the earliest Bronze Age people were distinguishable from earlier traditions not by metal use and domestication, but by monument building traditions that reflect the ways in which people "negotiated" changes in the natural and cultural environment that occurred between 3000-and 4000 years ago (Wright 2021; Wright et al. 2019:4). By the early Iron Age and Xiongnu Periods (ca. 2400-1700 BP), we see the development and establishment of mobile pastoralism, characterized by a herding economy, wide ranging trade networks, high levels of residential mobility facilitated by domesticated horses, social hierarchy, and shared mortuary and monument traditions (Honeychurch 2015; Houle 2010; Makarewicz 2011, 2017; Taylor et al. 2019; Wright 2006). Settlement trends reflect these social changes including a shift away from drainages to areas with more extensive pasturelands.

Aside from the small number of studies in desert-steppe contexts, much of what we know about the material record of this region comes from numerous artifact collections amassed during investigations across Mongolia and China in the 1920s and 1930s (Maringer 1950, 1963; Nelson 1926a, 1926b); collections include materials from over 500 sites spanning all occupation periods from the Paleolithic to modern times. Dissertation research by Lisa Janz (2012) focused on materials from nearly 100 of these collections to create baseline chronologies for the Gobi Desert. Her work focused on four areas of the Gobi including the Gobi–Altai, the Alashan Gobi, the East Gobi, and the Gobi-Steppe (Figure 1.3). In conjunction with several new radiocarbon dates, her analysis largely provides the basis for what is known about this region today; her work not only deepened our understanding of pastoralism beyond the steppe, but it has also provided a robust dataset from which to examine the relationship between foragers and herders and implications for later social developments. Her study documented the gradual, in situ development of food production during the Neolithic-Bronze Age transition, about 3000-4000 years ago (Janz 2012).

According to Janz, the shift occurred here later than in other parts of northeast Asia and was contemporary with regional aridification and decimation of local wetland habitats. In addition to providing the first glimpse of Neolithic and Bronze Age settlement trends, her work resulted in the development of a coherent regional chronology. Based on her 2012 study, Janz proposed the following chronology for terminal Pleistocene and Holocene occupations in Mongolia's desert and desert-steppe regions (Janz 2012:213-215): Oasis 1 (Late Epi-Paleolithic 13,500 to 8000 BP); Oasis 2 (Neolithic from 8000 to 6000 BP); and Oasis 3 (Neolithic-Bronze Age transition ca. 5000-3000 BP). An important aspect of Janz's study is an assessment of early-middle Holocene settlement and subsistence practices and their relationship to evidence for aridification that occurred around 4500 BP. Prior to this time, the climate was characterized by high effective moisture and rich "oasis" ecological niches associated with riverine, lacustrine, and interdental wetland environments, areas that likely proved a range of resources including reeds, tubers, waterfowl, and small aquatic animals. According to Janz, early Holocene foragers (Oasis 2) targeted these resources through use of long-term seasonal residential camps augmented by logistical encampments and task sites targeting surrounding areas: adjacent upland landforms would have been prime hunting grounds for medium and large mammals (e.g., ibex and argali sheep), while lowlands would have supported a broad range of faunal resources such as wild species of camel, horse, marmots, antelope, fox, ostrich, and hare. An assortment of plant foods such as Allium, grass and legumes, and berries would have probably been found across all zones within the desert steppe (Janz 2012).

Tool kits from this period indicate a focus on a broad range of wild plant and animal resources with assemblages characterized by flaked stone tools made from high quality cryptocrystalline silicates (micro blades/cores, expedients cores, flake scrapers, unifacial points), polished stone tools (adzes), large formal milling equipment (slabs, mortars, pestles), and a few types of low-fired ceramics (Janz 2012; Janz et al. 2017). Desert and desert-steppe forager adaptations during Oasis 2 were markedly different from contemporary communities in neighboring parts of Northeast Asia (Janz 2012:342), including those practicing incipient agriculture in north China (Lu 1999), mixed foraging and agricultural communities in northeast China (Jia 2007; Lu 1998;), and by 6000 BP, established agricultural economies in northwest China that incorporated a range of domesticated plant and animal species (Bettinger et al. 2010; Janz 2012.).

After about 5000 BP (Oasis 3), prevalent aridification appears to have resulted in the reduction of lakes and wetlands (Jiang et al. 2006), significantly altering vegetation patterns (Janz 2012:288-293). Despite these conditions, local occupants seem to have intensified use of remaining wetland environments, employing frequent residential moves to target dwindling resources. Non-wetland resources were exploited more frequently than in previous times and were targeted though an expanded use of smaller field camps and task sites in upland regions. Residential sites of this period are found in a broader range of environmental contexts compared to Oasis 2. Some are associated with Bronze Age burials and monuments (Janz et al. 2017:60), however a focus on oasis environments continues during most of this period. Tool kits associated with Oasis 3 are generally similar to Oasis 2, with continued focus on micro-blade technology. Some technological shifts are noted, however, including specialized biface technology, a decrease in ground stone tools, and an expansion and improvement of ceramic technology. Among the Alashan Gobi sites, there are statistically significant differences in Oasis 2 and 3 assemblages, noting a decrease microblade core size, and use of informal core types over time, suggesting a decrease in the availability of access to quality raw material (Janz et al. 2017:58).

Janz links these changes to a growing focus on a herding economy (Janz 2012:288-293), though the mechanism for introduction (e.g., contact with agro-pastoralists from northern China or steppe populations to the west), or details on how the new economic activities were organized remains unknown. According to Janz, the emphasis on oasis environments evident in Oasis 2 and 3 persisted throughout the Bronze Age and did not change significantly until the beginning of the Iron Age (ca 3000 BP) (Janz et al. 2017:57-64), linked possibly to increased aridification or intensification of herding practices. The apparent continuity in land use strategies (oasis focus) and technology (micro-blades) contrasts with evidence for significant and abrupt Bronze Age social change, most notably the appearance of distinct monuments and burials, suggesting that the regional development of herding was a gradual process of adoption by extant forager groups within a context of regional changes in social organization and subsistence (Janz et al. 2017:61).

A paucity of sites dating to the Iron Age among the Gobi sites suggest a decline in population accompanied increasingly arid conditions, however, could be attributed to increased mobility and limited use of stone tools that likely accompanied the establishment of mobile pastoralism. That said, Iron Age sites of the Gobi are located in a range of ecological contexts, marking a notable shift in focus from wetland resources to those needed to support a growing commitment to mobile pastoralism (Janz et al. 2017:63-64).

1.4 Archaeological Research at Ikh Nartiin Chuluu Nature Reserve

1.4.1 Initial Random Sample Survey

Since 2011, archaeological work carried out at Ikh Nart has added to the growing body of research conducted in the Mongolian desert-steppe, providing a unique opportunity to evaluate and build upon previous regional studies (Janz 2012; Janz et al. 2021; Wright et al. 2007, 2019). Much of this work has been in support of a cultural resource management plan for Ikh Nart (Schneider et al. 2021; Tserendagva and Schneider 2014, 2015;). To date, survey of about 1% of the 67,687-hectare park has documented over 140 archaeological sites spanning the last 8000 years. The first survey program (2011-2014) included examination of 23 randomly selected survey blocks (Figure 1.3) and identified sites in a range of contexts including drainages, springs, ancient lakes/playas, and rocky canyons (Schneider et al. 2021). Thirteen of the blocks were situated in the northern section of the park, 10 were in the south. Just over half of the survey blocks examined (*n*=13) contain archaeological remains (e.g., habitation sites, burial features), with notable differences observed in the northern and southern park areas. The northern is dominated by a NE/SW trending granitic batholith and an extensive drainage system that empties into an ancient lakebed (Choyr Basin) to the northwest. Over three-quarters of the northern survey blocks examined (*n*=10) contain archaeological sites. This contrasts with the southern areas characterized by flatlands and low basalt hills, where less than a third (*n*=3) of the survey blocks contain cultural remains. A GIS analysis of these data reveals that Neolithic occupation sites tend to be located near important water sources such as prominent drainages and wetlands, whereas Bronze Age and later occupations are located further from these contexts suggesting that other factors played a role in settlement selection (Farquhar et al. 2017).

1.4.2 Pilot Study: Systematic Survey

Comparison of local environments was further examined in 2018 during a dissertation pilot survey designed to identify land use strategies and demographic trends. The survey included examination of 39 2-hectare blocks selected across four areas of the park: the ancient lakebed of Choyr Basin in the north; an upland/granitic batholith immediately south; and the lowlands further south (Figure 1.4). The study involved a distributional or “non-site” survey approach to identifying variable and overlapping artifact patterning (Drennan et al. 2015). In contrast to previous survey work, the pilot study documented only minor differences in the proportion of survey blocks with archaeological remains across different environmental zones (between 30% and 48% of survey blocks in each zone). That said, sites located in the upland areas had higher artifact densities than those in adjacent areas; average artifact density among upland sites is 1.7 items/m^2 compared to 0.8 item/m^2 in sites located on the northern ancient lakebed and in the southern lowlands. Further, the upland regions were more extensively occupied than other areas, with archaeological remains covering about 17% of area examined, compared to 2.5 % and 4.9% in lakebed and lowland areas, respectively.

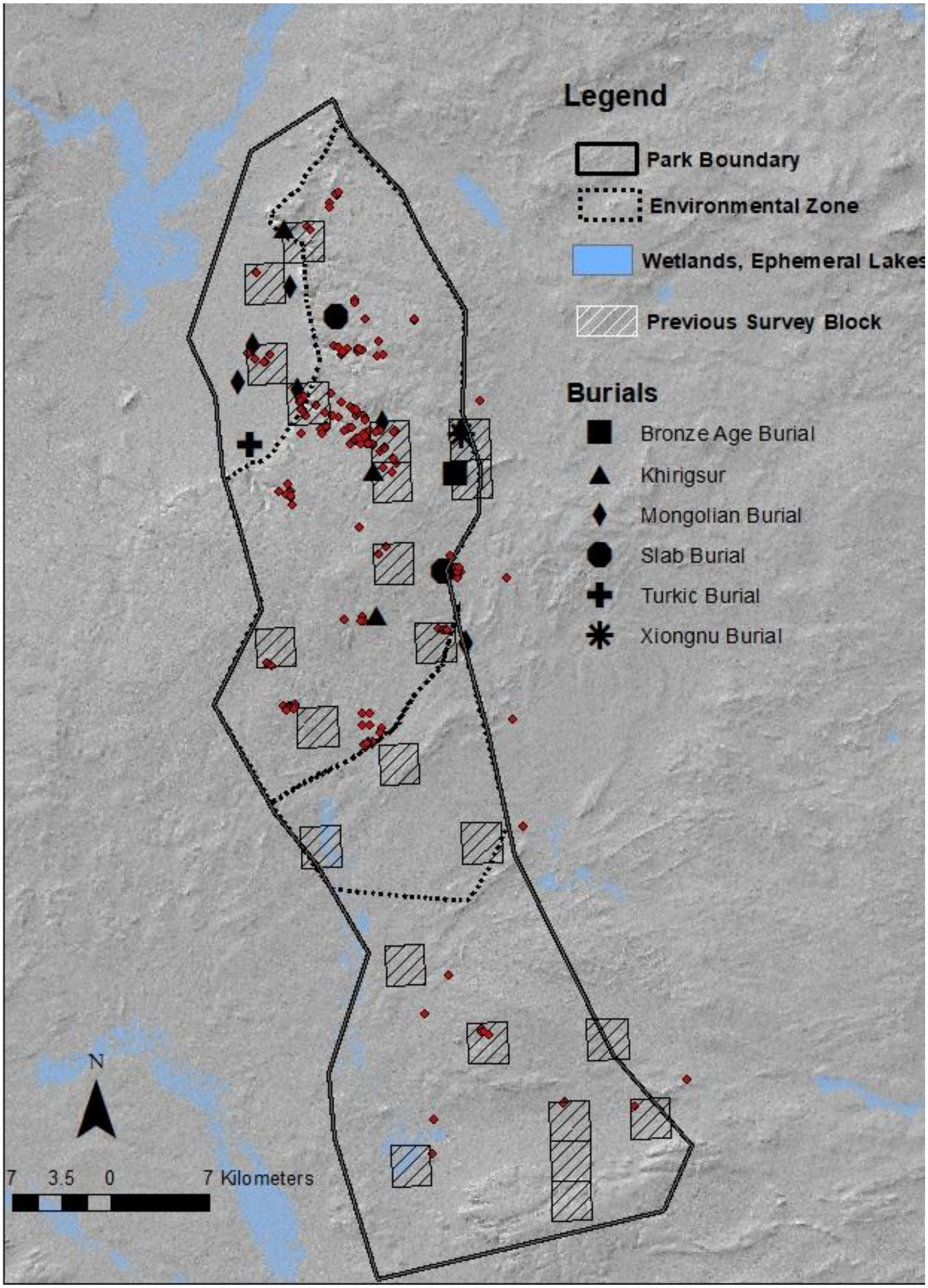


Figure 1.4 Previous survey areas, archaeological sites, and burials at Ikh Nart Nature Reserve, Mongolia.

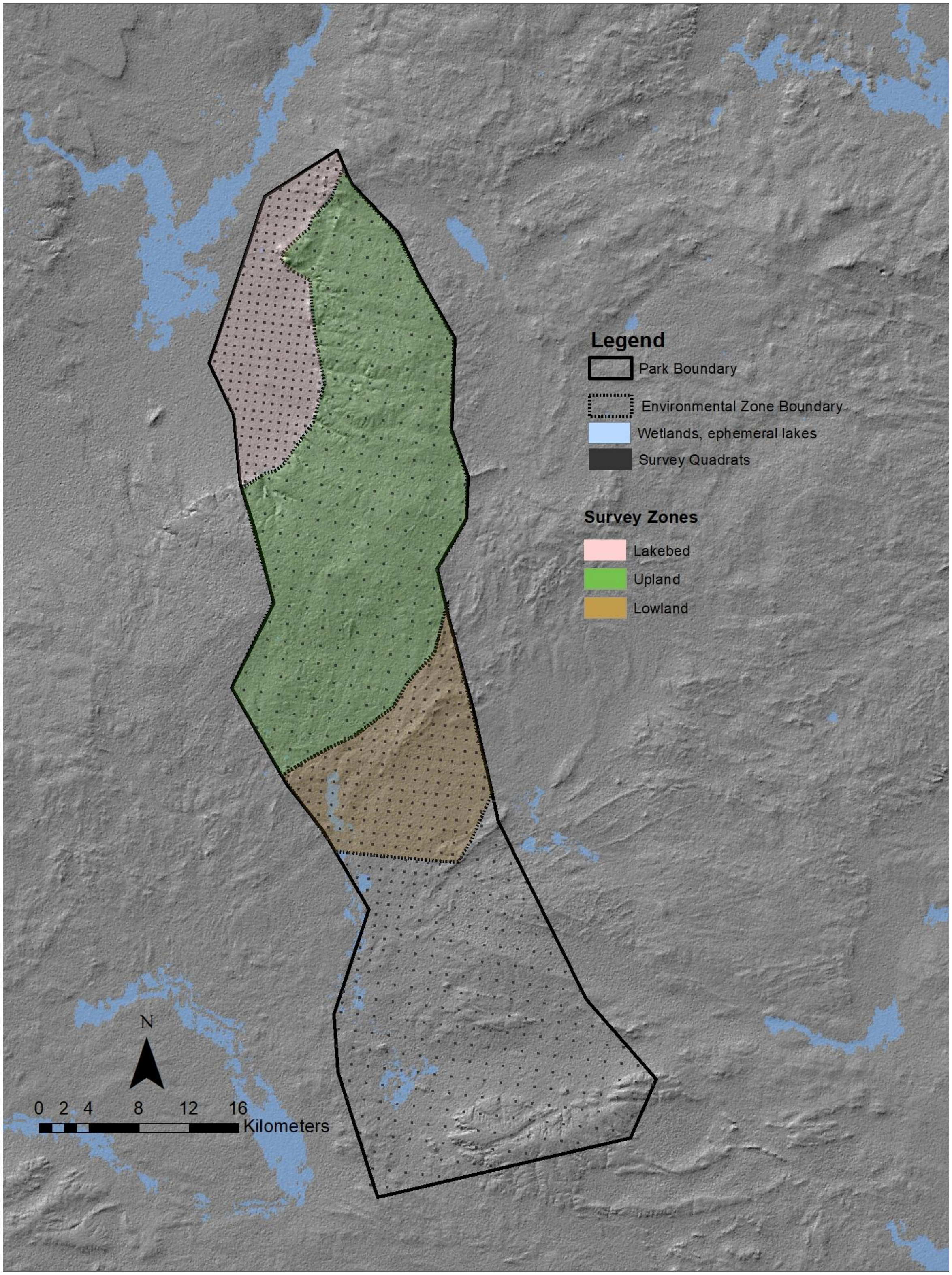


Figure 1.5 Survey areas for 2018 pilot study, Ikh Nart Nature Reserve, Mongolia.

1.4.3 Excavations

In addition to archaeological survey, the team has carried out several seasons of subsurface investigation. Beginning in 2014, Dr. Arlene Rosen (University of Texas, Austin) initiated a geoarchaeological assessment of select areas, several of which contain sediment profiles that reveal how the local landscape, hydrology, and environment have changed over the last ~8000 years. Specifically, the sequence includes the development of shallow-water saline ponds, eventual replacement by wetland marshes, and finally a period of aridification, increased colluvial action (eroding of nearby hillslopes), and the establishment of steppe grasses after 4300 cal. BP. Rosen links changes in landscape and resource availability to climatic change from the middle to the late Holocene, along with the ever-increasing human impact on the landscape (Rosen et al. 2019). On-going work is focused on defining these relationships better through more systematic research including sediment sampling, OSL and radiocarbon dating, and phytolith analyses.

Other important on-going work at Ikh Nart includes archaeological investigations at several sites within the park, including a complex of cultural deposits located at Burgasny Enger, a spring-fed valley that has attracted human groups to it since the Neolithic (ca. 8000 BP). In 2016, Rosen and Farquhar identified rare *in situ* archaeological deposits at IKH-09 dating to the period in which societies presumably shifted their economies from foraging to herding (ca. 4000 BP). To date, the team has excavated about 9 m^3, including seven 2x2 m test excavation units (TEUs) excavated in 5 cm levels and dry screened through 1/8" mesh. Efforts produced a broad range of materials including numerous lithics (chipped stone micro-blades, bifacial tools, manufacturing debris: *n*=4,461), earthenware ceramics (*n*=20), metal production debris, faunal remains, macro-and micro-botanical remains (e.g., seeds, wood, phytoliths). In addition, investigations have revealed intact occupation surfaces from ca. 10 cm to 30 cm in depth including a possible house structure defined by a circle of dark charcoal staining and an accumulation of stone tools and manufacturing debris, ceramic sherds, and mammal bone (Figure 1.5). Stratigraphic units exposed are differentiated by sediment composition, compaction, color, and texture, possibly demarcating separate occupation episodes (Figure 1.6). Vertical distribution of lithic materials from one excavation unit (TEU 7) indicates some similarities and differences between the occupation episodes, possibly linked to the nature of on-site activities, intensity of occupation, and settlement structure (Table 1.2). Level 20-25 cmbs, for example, is distinct from the level above (15-20 cmbs), having lower artifact density, yet a higher flake to tool ratio, and a higher proportion of retouched tools, suggesting a short-term occupation focused on the manufacture of more formalized tools (retouched micro-blades) for use in other locales. A more intensive occupation is evident in the upper level, with activities focused on manufacture of a slightly broader range of expedient tools that were used and discarded on site. Despite these differences, the overall size of micro-blades produced (based on average width) does not change significantly, suggesting manufacturing techniques or possibly procurement strategies did not change over time, though this would need to be verified through additional technological analysis. Ultimately, understanding how lithic assemblage attributes relate to subsistence/settlement strategies will require a more in-depth analysis of the vertical and horizontal distribution of these materials across the site, as well as their association with other artifact and ecofact classes (ceramic, bone, and plant remains).

Analysis of IKH-09 ecofacts (i.e., faunal, phytoliths, macrobotanicals) is ongoing; forthcoming data will no doubt contextualize artifact patterning by providing direct evidence for plant and animal use, distinguish use or activity areas, and proxy data for environmental reconstruction.

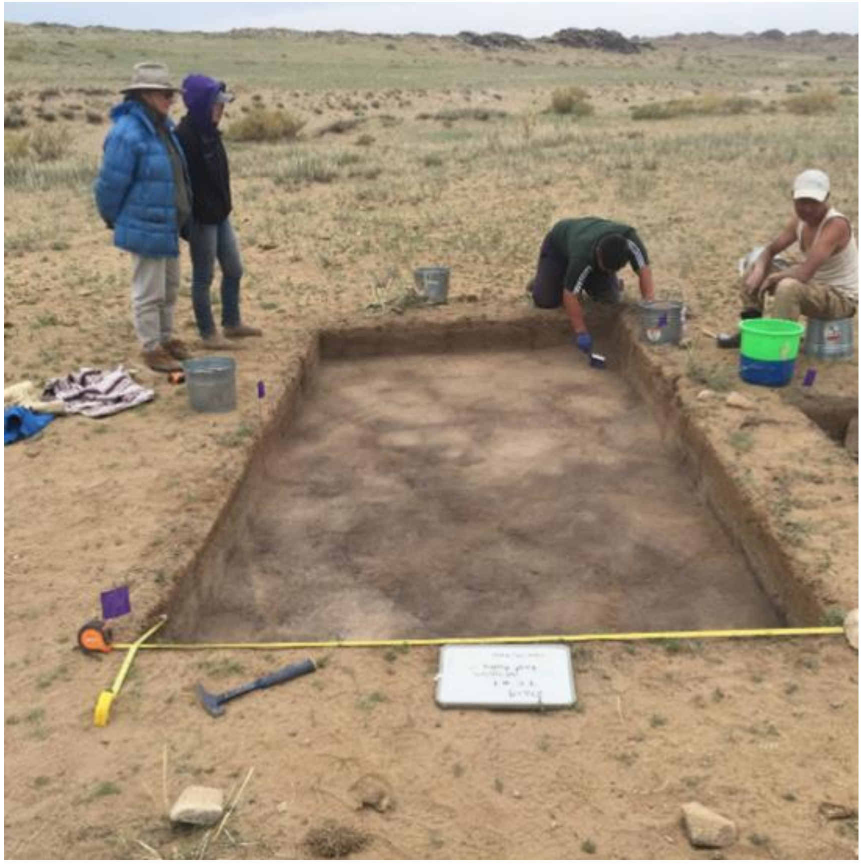


Figure 1.6 Excavations at Burgasny Enger (2017), Ikh Nart Nature Reserve, Mongolia.

Figure 1.7 Stratified deposit at Burgasny Enger (2017), Ikh Nart Nature Reserve, Mongolia.

Table 1.2 **Analysis of Flaked Stone Tools and Debitage From IKH-09 (TEU 7).**

Depth (cmbs)	**Stratum/Description**	**Lithic Count**	**Lithic Density (items/m^3)**	**Flake: Tool Ratio**	**Tool Assemblage Diversity (Simpsons Index of Diversity*)**	**Microblade: Average width (cm)**	**Proportion of Tools with Retouch**
10-15	Stratum 2: 10YR 4/2 silty fine sand.	133	665	2.3:1	0.1 (low diversity)	6.9	13.3%
15-20	Stratum 2: 10YR 4/2 silty fine sand.	224	1,120	1.7:1	0.1 (low diversity)	6.4	11.2%
20-25	Stratum 3: 10YR 3/2 gritty silt.	136	680	3.1:1	0.00 (no diversity)	6.8	17.8%
25-30	Stratum 4: 10YR 3/1 silt mottled with 10YR 5/2 fine sand.	201	1,000	2.1:1	0.05 (very low diversity)	6.2	13.1%

*1-D

2.0 Research Design

2.1 Research Focus and Questions

In the desert and desert-steppe environments of the Gobi southeast of Ikh Nart, Neolithic age foragers and early herders of the Bronze Age appear to have prioritized the same environments, including resource rich wetlands and dune fields (Janz 2012; Janz et al. 2017). Despite increasingly arid conditions and presumably diminishing wetland resources during the Bronze Age, people continued to prioritize "oasis" resources using similar settlement and technological strategies. According to Janz, the continuation of foraging strategies through the early stages of pastoralism indicates the gradual, in-situ development of herding as opposed to a more abrupt shift in organizational strategies of "oasis-dwellers" (Janz et al. 2017:61).

Land use and technological stability (e.g., lithic tool tradition) in the face of social change across the Gobi is indeed intriguing and warrants further examination in other settings to understand variability in the ways that herding developed and the role of foraging among early adopters. The existing and potential archaeological datasets at Ikh Nart make it an excellent place to carry out such work, offering the opportunity to employ a systematic and multiscale approach.

At the local level, geoarchaeological work has identified a complex of possibly coeval sites at Burgasny Enger suggesting intensive use of wetland environments ca. 4000 years ago. Landscape scale data from the random sample survey are somewhat contradictory, suggesting that Bronze Age occupations are more likely to be found away from wetland areas, indicating differences in land use over time. Given that Bronze Age sites likely represent the earliest herders in the region, access to adequate forage for animals may explain the pattern. A closer examination of both local and landscape data (and how they relate) can help to document this patterning, and together provide a robust way to investigate land use trends across the transition from foraging to herding.

The present study employs data from surface and subsurface contexts at Ikh Nart to investigate how settlement priorities changed over time, with the goal of understanding the context in which herding was eventually developed. Research focuses on patterns of mobility across this economic and social transition spanning the Neolithic and Bronze Age (ca. 7000-2500 BP) to understand how hunters and herders distributed themselves within and between habitats, identifying changes in how, when, and why people moved. Mobility is indeed critical to both foraging and herding modes of production; it provides not only important insight to how settlement strategies changed with the addition of domestic animals, but also contextualizes other aspects of social life including patterns of social interaction, access to material wealth, prestige, production, and ritual. Tracking mobility strategies over time allows us to address broader questions about how, where, and why mobile pastoralism developed. Based on this, the following questions guided the research: (1) Where did people live before, during and after the transition to a herding economy (i.e., Neolithic; Early to Middle and Bronze Age; Iron Age, and beyond)? (2) Are there distinct differences in how these areas were exploited over time (e.g., different mobility strategies)? (3) What impact, if any, does the adoption of herding have on foraging lifeways? Was the transformation to herding the product of gradual *in situ* development, suggesting conservation of existing forager lifeways, or was it a more rapid replacement/reorganization of a foraging economy either by extant foragers or new herding groups? (4) How do patterns correspond to associated environmental change, both natural (e.g., climate) and social (e.g., population growth, increased evidence for social difference, interaction)?

2.2 Theoretical Framework

Understanding the developmental sequence at Ikh Nart requires that we refine both site and landscape level datasets, and also find ways to link them to provide a better understanding of land use change. The current dissertation accomplishes this though systematic archaeological survey combined with a study of lithic materials and their context.

2.2.1 Technological Organization

Lithic analysis is critical yet under-utilized approach to understanding human behavior, with analyses typically focused on determining functional, morphological, and stylistic attributes to address issues of chronology, cultural taxonomy, and site function. Here, technological characteristics are viewed as a sort of "static index of economic organization" (Shott 1986:15). Other approaches to lithic studies (i.e., organizational studies) have focused on the spatial and temporal juxtaposition of tool manufacture, use, reuse, and discard within a cultural system (e.g., Nelson 1991, Perry and Kelly 1987). Results have demonstrated their utility in understanding not only their relationship with functional tasks, but to behavioral variables such as settlement and resource procurement, in other words, how people interact with their landscape. Studies offer insight into the constraints imposed by the natural and social environment and illuminate the forces that shape how people made and used tools in the past (Bamforth 1991). Organizational studies over the past few decades have focused on issues including the maintenance of social boundaries, resource procurement, cultural preferences, and settlement organization to explain variation in technological systems (e.g., Binford 1980; Kelly 1988; Torrence 1983; Wobst 1977). The validity of organizational approaches has been supported in numerous studies, where it has been demonstrated that it is not enough to identify variability in artifact assemblages, it is necessary to understand the nature of differences (Andrefsky 1991, 1994; Bamforth 1991; Bousman 1993; Kelly 1988; Lurie 1989; Nelson 1991; Parry and Kelly 1987; Shott 1986; Torrence 1983).

A number of studies involving stone-tool using pastoral groups demonstrates the utility of stone tools in identifying and interpreting economic and organizational strategies of discrete herding traditions (Goldstein 2019; Rosen 1997; Seitsonen et al. 2018). Along these lines, the current study focuses on lithics recovered from new survey and previously excavated contexts at Ikh Nart to understand the organizational parameters associated with the transition from foraging to food production. Analysis of lithic tools from habitation settings of hunters and early herders, in concert with analysis and dating of other existing materials from excavated contexts (e.g., ceramics metal, faunal, plants) help to clarify the occupation sequence, but also sheds light on changes in how resources were exploited, illuminating the context in which herding practices were introduced. Refining and linking site and landscape datasets not only illustrates the nature of local processes, but provide the basis for comparison with surrounding regions, illustrating the variable ways herding economies developed.

2.2.2 Behavioral Optimization Models

This study aims to provide a detailed look at local settlement history of the desert-steppe, affording an opportunity to examine adaptive strategies of mobile people over time (Neolithic-Kitan periods, ca. 8000-800 BP). This includes the Neolithic-Bronze Age transition (ca. 4500 BP), a period when people are thought to have shifted from foraging to herding. Working within the framework of evolutionary ecology, specifically the concepts of behavioral optimization (Bird and O’Connell 2006; Smith and Winterhalder 1992b) and habitat suitability (Fretwell and Lucas 1970) this study examines which places were favored by people over time, and how settlement priorities may have shifted (or stayed the same). The study also focuses on identifying patterns of mobility to compare how human populations distributed themselves within habitats, detecting differences in how, when, and why people moved, decisions which relied heavily upon environmental conditions. Understanding the development of food production requires an in-depth look at how land use and mobility articulate with other factors such as population dynamics, climate, and changes in subsistence and technology. Documenting the links between these factors allows archaeologists to explore the processes impacting food production, and more broadly, provides important insight to mechanisms for social change.

The current study employs models rooted in evolutionary ecology to understand settlement trends and their relationship to the development of a herding economy in Mongolia's desert-steppe. These models focus on the logic of individual decision making to formulate testable hypotheses about past processes that explain the variability in human behavior, providing a systematic way to explore broad patterns of social development (Bird and O'Connell 2006; Smith and Winterhalder 1992b). Specifically, the study uses a model known as the Ideal Free Distribution (IFD) to interrogate the nature and context of settlement change by foragers and early herders. The IFD is a simple optimality model rooted in behavioral ecology that predicts how and when individuals distribute themselves across habitats in relationship with their perceived suitability (Fretwell and Lucas 1970). While initially employed in studies of animal behavior, the IFD has been incorporated into research anchored in Human Behavioral Ecology (HBE), an outgrowth of evolutionary biology with an interest in understanding how the environment (both natural and social) shapes the behavior of organisms with similar genetic composition (Borgerhoff Mulder and Schacht 2012). HBE provides a conceptual framework that links natural selection and hypotheses about human behavior and its material consequences. Applications of the IFD over the past two decades has led to advances in our understanding of a range of phenomena including the origins of agriculture (Kennett and Winterhalder 2006; McClure et al. 2006) and the emergence of inequality (Codding and Bird 2015; Prufer et al. 2017). Because the IFD focuses on population dynamics and habitat suitability, it guides our examination of how the distribution of resources affects the distribution of individuals. Optimality models are designed to make predictions about behavior; they specify a decision necessary for a specific context relative to a particular goal and currency. Models predict strategies that allow individuals to attain goals at the lowest cost. These approaches necessarily reduce behavior to simple components for study, allowing one to look more carefully at the nature of specific interactions (Borgerhoff Mulder and Schacht 2012).

The central premise of the IFD is that habitats are defined by a limited number of resources, and can be ranked in terms of suitability, including the resources that they possess and fitness those resources provide (Kennett 2005; Kennett and Winterhalder 2008; Winterhalder et al. 2010). Habitat suitability decreases as more people vie to exploit those resources. Because individuals tend to maximize habitat suitability, incoming populations will occupy habitats with the suitability until it declines to a level that matches the next best habitat. If the assumptions underlying the basic model hold (e.g., individuals have complete information about all habitats, and are “free” to make the most optimal choice), IFD predicts that the most suitable habitats will be occupied first; that these habitats will always have the highest densities of people; and that lower ranked habitats will fill gradually as the ratio of people to habitats increases (either by in-migration or internal growth).Recognizing that there are instances in which increasing population densities may improve rather than diminish habitat suitability (the Allee effect), a variation of IFD takes into account initial improvements to suitably made by founding groups who leverage large population size by implementing group-dependent technologies that improve habitats (Kennett et al. 2009; Kennett and Winterhalder 2008) (Figure 2.1)

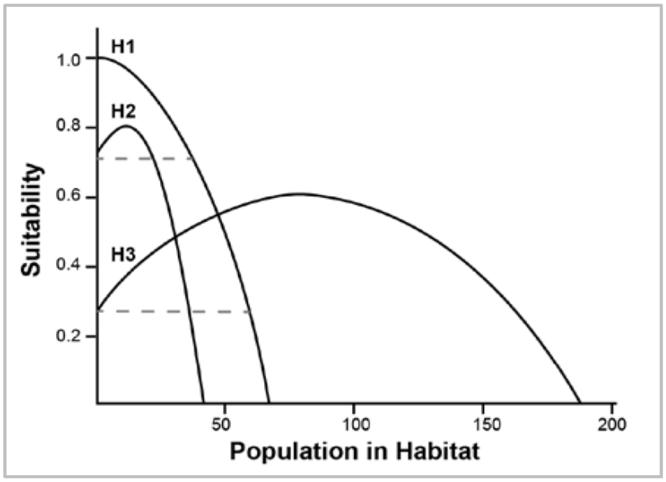


Figure 2.1 Example of Ideal Free Distribution. Shows predicted suitability in three habitats (H1,H2, H3, increasing in rank) as a function of density in each habitat. Suitability in H1 declines with population growth; H2 and H3 are charaterized byan Alee effect (After Kennett and Winterhalder 2008:Figure 2).

Observed deviations from expected IFD patterns have been modeled using Ideal Despotic Distribution (IDD) which considers situations in which individuals are no longer "free" to select the most suitable habitat, taking into consideration other factors beyond habitat suitability that may shape human behavior such as resource competition, hierarchy, and territoriality (Codding and Jones 2013; Kennett et al. 2009; Kennett and Winterhalder 2008; McClure et al. 2006; Moritz et al. 2014; Prufer et al. 2017).

Other studies have employed the IFD to identify and explain major shifts in land use preferences, linking the reordering of habitat selection to historical events such as an influx of new people with fundamentally different adaptations (Hildebrandt and Ruby 2016). The current study employs the IFD in this way, as a means to track trends in settlement location, mobility, population, subsistence, and technology across various contexts to identify settlement priorities over time.

For foragers, we may hypothesize that the most important locations (i.e., most suitable habitats) are those close to reliable water sources and those that provide protection from sun and wind. Early pastoralists would also have favored some of these locations, but would have prioritized areas with forage for herds, especially winter-season vegetation. In other words, areas with abundant and reliable pasture would be the most suitable zones for herders. Proximity to large mammal habitats might have been a stronger organizing factor for hunter-gatherers than herding communities; though, early herding communities may have continued to target these resources to a similar degree.

An assessment of habit in-filling as modeled by the IFD provides an opportunity to track population settlement trends; along with data on mobility, subsistence, and technology from well dated contexts, these data allow us to assess the impact of herding on foraging lifeways. For example, we can gauge whether the transition was the result of gradual in-situ processes associated with extant foraging populations, or an abrupt reordering of economies and associated lifeways. Based on the expectations of the IFD, a gradual and in-situ development of herding practices will be indicated when the habitat priorities of foragers are maintained as herding is introduced. Here, we should expect that the preferred habitats of foragers will be occupied first, with subsequent populations settling in secondary habitats. Continuity of settlements across the initial transition to herding may indicate conservation of foraging lifeways; artifact patterning and settlement strategy indicators will provide corroborating evidence. Conversely, a more abrupt replacement/reorganization of a foraging economy with one more committed to food production (through adoption or population replacement) will be signaled when population in-filling patterns do not correlate with established habit suitability of earlier foragers. A shift in habitat use in the absence of population pressure may signal a reordering of habitat preference to reflect changing economic priorities. These patterns may also signal that movement was no longer predicated solely on access to forage and water but came to reflect concerns over access to goods that increase wealth or status.

In addition to the IFD, my study incorporates other concepts from behavioral ecology including Optimal Foraging Theory (OFT) (Kelly 1995; Smith and Winterhalder 1992a) and Niche Construction Theory (NCT) (e.g., O'Brien and Laland 2012; Zeder 2012, 2016) to identify the underlying causes and consequences of the transition to food production. OFT models focus on resource intensification (e.g., Stiner et al. 2000; Stiner and Munro 2002), patch choice (e.g., Bettinger and Grote 2016; Hawkes et al. 1982), and technological investment (e.g., Bettinger et al. 2015) to identify cost-benefit relationships that structure human behavior aimed at optimizing reproductive fitness. Behavior is often viewed as a response to environmental stress or demographic pressures. NCT, by contrast, views ecologically rich environments as contexts that promote investment in technological innovation to alter the natural environment for greater productivity (Zeder 2008, 2012). NCT predicts that broad spectrum diversification is likely to occur in resource rich environments rather than marginal environments. While these models view human-environment interactions in fundamentally different ways, numerous researchers (Bliege Bird et al. 2008, 2013; Broughton et al. 2010; Gremillion et al. 2014) have posit that the two approaches are not necessarily in opposition to one another, but "share a commitment to evolutionary explanation even though they emphasize different processes, questions, and types of causation" (Gremillion et al. 2014:6176). A more in-depth discussion of these concepts in relationship to the development of herding is contained in Chapter 8 (Section 8.3.1.3)

3.0 Natural Environment

3.1 Ikh Nartiin Chuluu Nature Reserve Setting

The country of Mongolia is situated on the Mongolian Plateau, an extensive northeastern highland of the larger Central Asian Plateau. The Mongolian Plateau is bounded by the Sayan and Khentii mountains of Southern Siberia to the north, the Greater Hinggan Mountains of Inner Mongolia to the east, Northern China's Yin Mountains to the south, and in the west, the Altai Mountains, which mark the convergence of Mongolia, Russia, China, and Kazakhstan (X. Zhang et al. 2009). Extensive steppe, desert-steppe, and desert regions characterize the plateau interior.

The dissertation study area is contained within the boundary of Ikh Nartiin Chluluu Nature Reserve (Ikh Nart), located in Mongolia's desert-steppe, a transitional zone situated between the semi-arid steppe of eastern Mongolia and the Gobi Desert to the south. The park encompassess 67,687 hectares, positioned in the northwest part of Dornogovi aimag, including portions of Dalanjargalan and Airag soums. The reserve consists of a mosaic of landscapes including rocky outcrops, riparian corridors, and expansive desert-steppe grasslands that support an exceptionally diverse range of plant and animal life. Elevation ranges from 1072 m to 1291 m above mean sea level (Mongolian Ministry of Nature, Environment, and Tourism 2014).

The Mongolian government established the park as a protected area in 1996, a measure to ensure preservation of the area's "ecological balance and natural condition" and to support scientific studies focused "natural processes, mitigation of potential threats to endangered species" and to encourage sustainable growth of local herding and tourism economies (Mongolian Ministry of Nature, Environment, and Tourism 2014). In collaboration with the Denver Zoological

Foundation, and with support from the United Nations Development Program and the Global Environment Facility, park managers and researchers carried out several biological studies that provided the foundation for a science-based management plan for Ikh Nart. Of particular concern to park managers and the scientific community is the protection of Argali sheep populations that inhabit the rocky upland zones of the central and extreme southern portions of the park (Mongolian Ministry of Nature, Environment, and Tourism 2014).

Today, over 100 herding families inhabit the park or target its pastures for their animals. Herding groups derive from two territories, Bichigt Bagh (Dalanjagalan soum) in the north, and Nart Bagh (Airag soum) in the south. Herders practice transhumance, moving between summer and winter camps on an annual basis seeking pasture for their livestock including sheep, goats, horses, cattle, and camels. Movements range in distance from 50-100 km (Mongolian Ministry of Nature, Environment, and Tourism 2014). Winter encampments within the park cluster in the rocky uplands which provide protection from harsh winter winds. A few winter camps have also been noted in the Choyr Basin to the north, as well as the southern portion of the park, in the vicinity of the Khezuu Teeg Mountains. The uplands are also attractive to herders in the summer, providing ample water sources, pasture, and shade within the canyons. The lake basin also attracts families in summer months, with encampments observed along the contact with the upland zone. Herder camps are rare in lowland areas to the south, no doubt due to relatively low pasture productivity (less than 100 kg/ha compared to 200-300 kg/ha in the rocky uplands and edges of the Choyr Basin (Mongolian Ministry of Nature, Environment, and Tourism 2014: Maps 4 and 19).

3.2 Geology and Soils

The park is characterized by three main geologic features, each supporting a unique array of plant, animal and water resources that have attracted people for thousands of years. The first and most distinctive feature of the area are the high outcrops of the upland Nartiin granite formation, a Mesozoic age granitic massif that forms a SW/NE trending band across much of the northern and central regions of the reserve (Daoudene et al. 2012). Interspersed among the granite formations are bands of sedimentary and metamorphic rock. The area is marked by a series of high bluffs, eroded canyons, and arroyos. Small streams are distributed across this landscape, some feeding into larger ephemeral drainages that empty into surrounding low-lying areas. Cryptocrystalline and quartzite cobbles (suitable for stone tool manufacture) are found in some of these drainages. In years with abundant rainfall, underground water associated with sedimentary and metamorphic rock formations feed numerous natural springs and seasonal ponds, an important source of water for upland dwelling human and animal populations.

To the south, high rocky outcrops give way to lowlands, including low sandstone rock interspersed with outcrops of quartzite and basalt rock; cryptocrystalline cobbles occur within drainages and are embedded in desert pavements formed on alluvial fans (Schneider et al. 2021). Portions of the Khezuu Teeg Mountains mark the southernmost boundary of the Reserve. The area was likely an important source for raw material for stone tool production.

In the park's northwest area (and extending beyond) is Choyr Basin, an ancient lakebed filled with unmetamorphosed, non-lithified continental fluvial sediments, including alternating layers of conglomerates and sandstone, overlain by sandstones, mud-stones and shales (Daoudene et al. 2012). The thickness of sedimentation is variable, with loose, dunelike accumulations at the mouths of major streams that drain the adjacent Nartiin formation. The basin is dotted with ephemeral streams, small lakes, ponds, and wetlands. Lake Jirgalanta lies just beyond the park's northwest boundary.

The study area falls within the desert-steppe soil region, comprising Gobi Brown and light brown soils across all environment zones. In the uplands, soils are developed in sediments deposited through alluvial and colluvial action. Soil composition in the uplands is described as rocky, clayey, and sandy, with the lowlands characterized as saline (Mongolian Ministry of Nature, Environment, and Tourism 2014; Rosen et al. 2019).

3.3 Vegetation and Wildlife

Ikh Nart is situated at the convergence of grassland and semi-desert steppe regions of the Gobi-steppe ecosystem, providing a remarkably high level of biodiversity. In the rocky uplands, vegetation cover is predominantly low-density shrub (*Amygdalus pedunculata*, *Spiraea aquilegifolia)* and forb-dominant short grass steppe (*Allium polyrrhizum, Stipa gobica*). Lowlands to the south are dominated by high-density shrub (*Caragana pygmaea*, *Atraphaxis frutescens*), interspersed with semi-shrub steppe (*Reaumuria soongorica, Salsola passerine*). Within the Choyr Basin, saline soils support semi-shrub steppe and tall grasses (*Achnatherum splendens*). Forest cover is limited to valleys and prominent drainages (primarily those that drain into Choyr Basin) and include small, scattered stands of Siberian Elm (*Ulmus pumila*) and willow (*Salix ledeubouriana*). Across all areas, species of sage brush are abundant (*Artemisia ruthifolia, Artemisia frigida*). In relatively wet years, several species of flowers are present across all zones, including lily (*Lilium pumilum*), iris (*Iris tenuifolia*), and columbine (*Aqilegia viridiflora*). Drought resistant fox tail (*Setaria viridis*) and golden rod (*Caragana leucophloea*) are common in years with low rainfall (Jackson et al. 2006; Mongolian Ministry of Nature, Environment, and Tourism 2014).

The area's distinctive natural setting is home to a wide variety of wildlife including at least 34 species of mammals (rodents, bats, lagomorphs, ungulates); over 150 species of birds (including year-round residents, and nesting and non-nesting migratory birds); 20 species of reptiles and amphibians; three types of vipers; and an unquantified number of insect species (Mongolian Ministry of Nature, Environment, and Tourism 2014). Among the large mammal populations are several endangered species including Argali sheep (*Ovis ammon*), ibex (*Capra sibirica*), black-tailed gazelle (*Gazella subgutturosa*), and the Asian wild ass (*Equus hemionus*).

3.4 Climate

3.4.1 Modern Conditions

Situated between dry steppe and desert zones, the climate is best described as semi-arid. Annual precipitation is low, with an average of 100-200 mm (Mongolian Ministry of Nature, Environment, and Tourism 2014), occurring mostly in spring and summer months (May-September). Summers are typically hot and wet with temperatures reaching as high as 43°C (109°F). Fall and winter extend from October through April, with the coldest temperatures occurring in January (-40°C/-40°F). Snow cover is typically less than 10 cm in depth, with full coverage most likely between December and February. Year-round, winds are from the northwest or north.

3.4.2 Regional Paleoclimate

Today's semi-arid climate is a relatively recent development, likely the product of a weakened East Asian Monsoonal System that impacted eastern and southern Mongolia and northern China during the middle and late Holocene (Feng et al. 2007; Rosen et al. 2019). Prior to this era, significant shifts in climate (i.e., temperature and precipitation) produced profound changes in landscape and vegetation, no doubt impacting adaptive strategies of human populations as far back as the Late Glacial Maximum (Janz et al. 2017).

Regional research pertaining to Late Pleistocene and Holocene climate is limited, largely focused on adjacent areas including northern China and Inner Mongolia (Feng et al. 2007; H. Zhang et al. 2000; but see An et al. 2008 for a synthesis of paleoenvironmental data across Mongolia and adjacent regions). Areas further south, including central China (e.g., Cai et al. 2010) and the Qinghai-Tibetan Plateau (e.g., Thompson et al. 1997) expand our understanding of broad regional trends.

The record for northern China is based on a suite of studies involving pollen, lake cores, sediments, and hydrological systems, that together illustrate dynamic climate shifts since the close of Pleistocene (ca. 11,700 years ago) (An et al. 2008; Rosen et al. 2019; Wen et al. 2010; H. Zhang et al. 2000; J. Zhang et al. 2011). Oxygen isotopes derived from speleothems (i.e., stalactites or stalagmites) from caves in China attest to alternating cold and dry conditions across the region at the close of the Pleistocene, transitioning to a warmer and wetter setting by the middle Holocene about 8000 years ago (J. Zhang et al. 2011). This trend is also evidenced by high lake levels throughout the Gobi-Altai region by about 8000 years ago (Komatsu et al. 2001; Lehmkuhl and Lang 2001; Wright and Janz 2012), though in the Gobi Desert region comparatively low rainfall likely promoted unstable lacustrine environments (Chen et al. 2008; Wright and Janz 2012). A drying phase commenced by about 6000 years ago and intensified by about 4000 BP (Feng et al. 2007; Janz et al. 2021; Rosen 2008; H. Zhang et al. 2000). This dry interval is evidenced by lower lake levels across the Mongolian Plateau, with aridity generally increasing from north to south (An et al. 2008). Sand/peat sequences from Midiwan in northern China also indicate that arid conditions may have commenced in some parts of the Mongolian Plateau, including southern Mongolia, as early as 7500 BP (An et al. 2008:285).

More broadly, increased aridity after 5000 BP is confirmed across the region by oxygen isotope data derived from a stalagmite from Jiuxian Cave in Shaanxi Province of central China (Cai et al. 2010) (Figures 3.1 and 3.2). The authors interpret δ18O of speleothem calcite as a proxy for the amount of summer monsoon precipitation; they document less negative values of δ18O around 4500 BP suggesting a decrease in the amount of precipitation during this period, though wet and dry conditions appear to be highly variable as illustrated by frequent and wide-ranging shifts in δ18O values between 7000 and 4000 BP. According to Cai et al. (2010:28), the increase in δ18O values (i.e., decreased precipitation) occurred earlier in lower latitudes including as early as 7000 at Dongge Cave, 5300 BP at Heshang Cave, and 4700 BP at Sanbao Cave.

Further west, oxygen isotope data derived the Guliya Ice Caps on the Qinghai-Tibetan Plateau provide additional evince for regional aridification dating to the middle and late Holocene (Thompson et al. 1997). The timeline for this core was established through correlation between atmospheric CH4 levels and stadial/interstadial events inferred from δ18O values in polar cores (see Thompson et al. 1997, page 1822 for an explanation of this justification). The authors interpret δ18O values as a proxy for atmospheric temperature over northern Tibet, with a positive relationship between δ18O values and temperature. They found a significant decrease in δ18O values during Younger Dryas (ca. 12,900-11,700 BP), with values subsequently increasing into the Holocene. A significant decrease (i.e., cooler conditions) is noted by the middle Holocene (about 6000 years ago). The trend begins to reverse by about 3200 BP, indicating a trend to warmer conditions around 3000 years in the Gobi, likely due to a weakening East Asian Monsoonal system (Feng et al. 2007; Janz et al. 2021; Lee et al. 2013; Rosen et al. 2019; Wen et al. 2017).

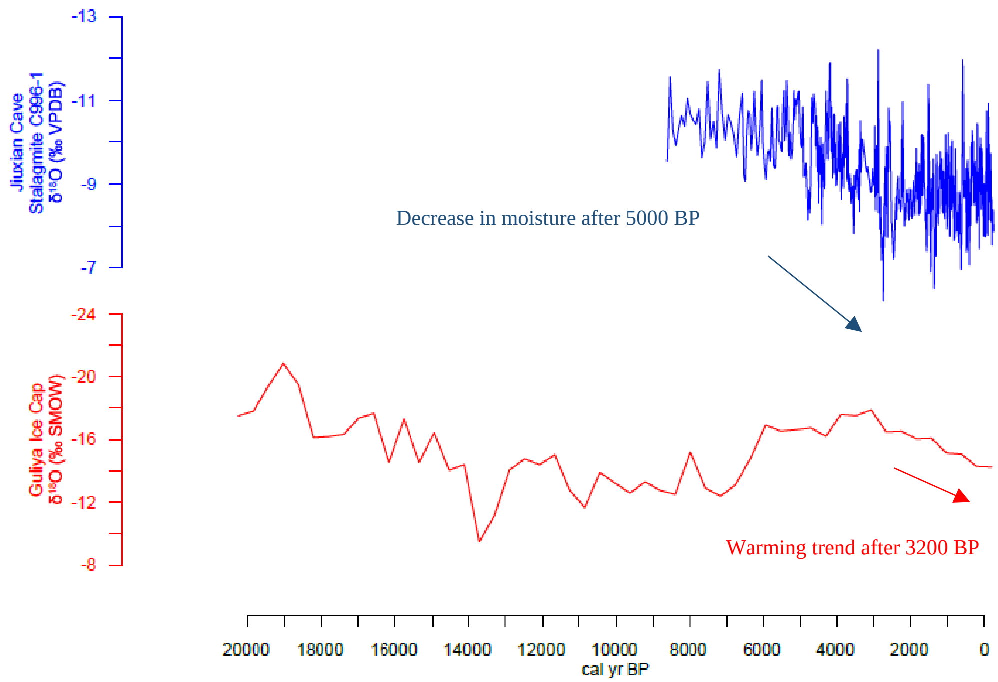


Figure 3.1. Comparision of climate proxies (0-20,000 BP Timescale). Blue: δ^{18}O record of stalagmite from Jiuxian Cave (Cai et al. 2010); Red: δ^{18}O record of ice core from Guliya Ice Cap (Thompson et al. 1997).

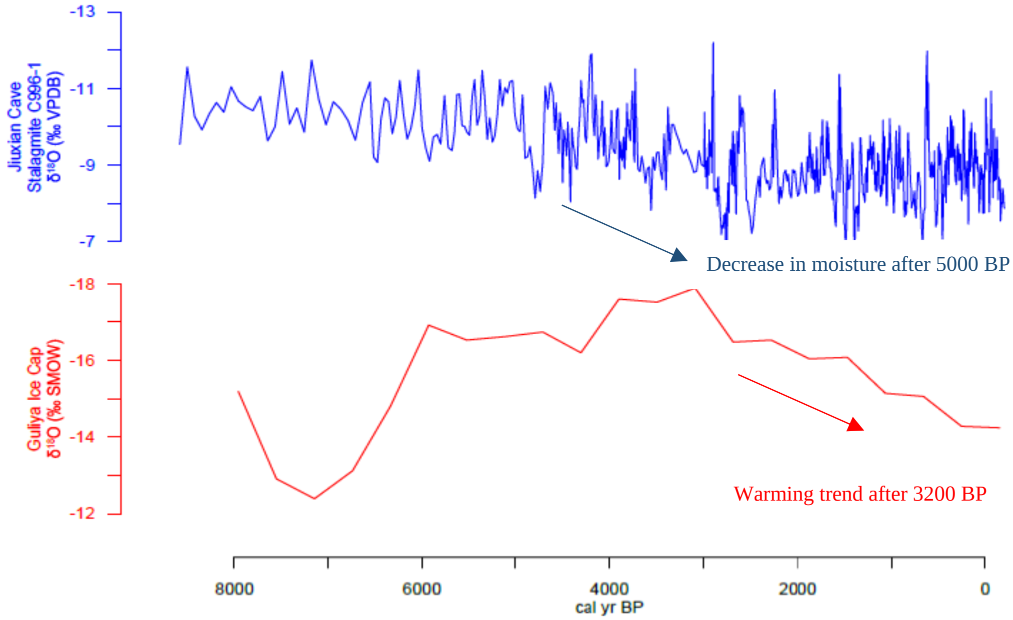


Figure 3.2 Comparision of climate proxies (0-8000 BP Timescale) . Blue: $\delta^{18}O$ record of stalagmite from Jiuxian Cave (Cai et al. 2010); Red: $\delta^{18}O$ record of ice core from Guliya Ice Cap (Thompson et al. 1997).

4.0 Analytical Background

4.1 Lithic Technology

Flaked stone tools recovered from survey and excavation contexts were subject to in-depth analyses to compare technology and to assess settlement strategies of mobile people over time. The manufacture, use, and discard of lithic tools are dynamic aspects of cultural systems linked to other factors such as mobility, subsistence, and access to raw material (Andrefsky 1998). As such, differences between lithic tool-using foragers and herders in terms of settlement and subsistence should be marked by parallel changes in toolkits. Alterations may include the introduction of new technology tto accommodate subsistence shifts; changes in labor investment to meet on-site/off-site needs; adjustments in tool production to accommodate craft production; and shifts in tool manufacture and discard patterns that reveal differences raw material acquisition (e.g., Kelly 1988; Nelson 1991; S. Rosen 1997; Torrence 1983). The current analysis employs technological organization frameworks to examine linkages between lithic technology and settlement strategies of foragers and herders (Section 4.1.2).

4.1.1 Regional Research on Lithic Technology

Lithic artifacts recovered from the study are typical of those associated with the Asian microblade tradition that spans the Epipaleolithic, Neolithic, and Bronze Age of Mongolia's northern region (Price 2000; Wright 2006) and desert/desert-steppes (Chen 1984; Fairservis 1993; Janz 2012; Janz et al. 2017). Microblade technology typically involves the production of small, narrow blades or bladelets from elongated prepared cores of cryptocrystalline material. The resulting finished tools are characteristically standardized in size and shape, used as insets for composite hunting tools (Elston and Brantingham 2002; Kuhn and Elston 2002:2) and in some contexts, specialized manufacturing (Yi et al. 2013).

Across Northeast Asia (Siberia, Mongolia, China, Korea, Japan), microlithic technology was an important component of forager tool kits beginning sometime during the Late Pleistocene, likely originating in southern Siberia (Derevianko and Markin 1998; Yi et al. 2016; though see Gómez Coutouly 2018). After the Last Glacial Maximum (ca. 26,000-19,000 years ago), the microblade industry came to dominate stone tool assemblages across the region, replacing an earlier large core/blade tradition with a manufacturing trajectory focused on the production of microblade cores (i.e., wedge, boat, conical, subconical) and retouched flake tools made from high quality tool stone (i.e., chert, jasper, chalcedony). Microblade technology continued to be a mainstay after the Pleistocene/ Holocene transition (Gladyshev et al. 2010; Janz 2012; Lu 1998), persisting in many regions until or even after the availability of metal for tool use (Chung 1984; Goebel et al. 2000; Lu 1998; Rosen 1997; Seong 1998).

The development of microlithic technology in Northeast Asia parallels trends across Europe, Africa, and other parts of Asia that saw the "microlithization" of stone tool technology during the later stages of the Pleistocene (Kuhn and Elston 2002). Research has generally focused on the timing of the spread of microblade technology, and the development of regional typologies in key areas including Siberia (e.g., Goebel 2002; Goebel and Aksenov 1995; Goebel et al. 2000; Kuzmin 2007; Kuzmin and Orlova 2000), Peninsular Asia (Korea and Japan) (Kuzmin and Keates 2021; Seong 1998), Mongolia, and the South Gobi Desert and Northern China plain (Bettinger et al. 1994; Chen 1984; Fairservis 1993; Nain et al. 2014; Yi et al. 2013; Yue et al. 2021). Regional assemblages display strong commonalities and are generally considered a cohesive technology, though as Wright (2006) points out, analyses are often based on typologies built on a consolidation of data across large regions (rather than site contexts) not modes of production, which inevitably perpetuate the idea of continuity over space and time (Wright 2006:26).

Aside from issues of when and how microlithic technology spread across and beyond Northeast Asia, several researchers have focused *why* this technology developed, contributing a great deal to our understanding of the drivers of human behavior change. As an example, Elston and Brantingham (2002) view the growth of microlithic technology (specifically inset weaponry and edge shaped microblade cores) after the LGM as a risk minimization stagy to manage increasing seasonality and resource variance (specifically large game) associated with warming across the region (Elston and Brantingham 2002:112-113). In this manner, the spread of this technology is viewed not as "a unique solution to particular tasks", but as a way to add efficiency or reliability to forager hunting toolkits in the face of growing uncertainty (Kuhn and Elston 2002:5). Goebel (2002) specifically links the 'microblade adaptation'' with high residential mobility required to target large prey.

Employing data from north central China, Yi and colleagues (2013) challenged the widely held view that microblades were used primarily as hunting implements, positing that by the Younger Dryas (ca. 12,900–11,600 cal BP) microblades were more commonly used as knives, possibly to prepare animal skins for the production of clothing; here, microblade technology is considered a specialized adaptation of highly mobile groups facing the increasing harsh, cold, and dry conditions that characterized this interval (Yi et al. 2013:213). This "microblade adaptation" is markedly different from other lithic industries noted for the LGM in northern China, where small populations relied on expedient bipolar reduction techniques suited for conditions where tool stone was abundant but relatively low in quality (Barton et al. 2007)

Across Northeast Asia, microblade technology persisted beyond the Pleistocene /Holocene transition, even as new technologies to target lower ranked resources were added to the forager tool kit (e.g., ceramics, ground stone tools). The tool tradition endured in areas where agriculture was either late in development or unfeasible (Elston and Brantingham 2002:113), with assemblages becoming more diverse over time (e.g., range of retouched tools, flaked based projectile points, blades) (Chen 1984; Derevianko et al. 2003; Fairservis 1993). Research by Wright (2006) and Janz (2012; see also Janz et al. 2017) have incorporated typological studies across the region to order sites across Mongolia's northern and desert/steppe environments, providing a basis from which to identify and interpret variation in human behavior (e.g., site activities, intensity of occupation, land use trends) across the transition to food production. These regional chronologies are further discussed in Chapter 5 (Section 5.1.2.1).

4.1.2 Technological Organization

For over four decades, technological studies have mirrored trends in hunter-gatherer subsistence research, specifically the positioning of human behavior within an economic framework (Lurie 1989). The role of settlement strategies has been a primary focus, with research centered on understanding the impact of different types and magnitudes of mobility on lithic assemblages. The economic nature of lithic technology is indeed apparent when one considers how tool choice affects efficiency, imparts costs, and offers alternative means to satisfying needs (Lurie 1989:47; Surovell 2009:9-13). Numerous studies have examined the association between lithic technology and mobility, each considering a specific aspect or set of attributes concerning tool manufacture (e.g., manufacturing efficiency; tool design and function; and assemblage diversity). The following discussion presents pertinent concepts concerning technological organization and settlement mobility, based in part on (and abstracted from) the author's examination of technological and settlement trends of Early to Late Holocene hunter-gatherers along California's south-central coast (Farquhar 2003). The concepts presented are foundational to the study methods provided in Chapter 5.

4.1.2.1 Energy Expenditure and Efficiency

The connection between tool manufacturing efficiency and settlement organization was first proposed by Torrence (1983) who focused on the ways in which mobility limits technological choice by imposing transport costs. Noting that technology cannot increase indefinitely to meet changing functional demands, she posited that tool inventories may be an appropriate proxy for understanding mobility constraints. Along these lines, Torrence predicted an inverse relationship between mobility and assemblage size, proposing that as residential mobility increases, the size of tool inventories will decline.

Other early economic models include those developed by Lurie (1989), who sought to understand tool manufacturing behavior across differing settlement contexts. Her study examined technological strategies of Middle Archaic hunter-gathers of the North American Illinois River Valley as they shifted from a residentially mobile pattern to a more sedentary, arrangement. Her study revealed a correlation between mobility and the presence of exotic raw material, thermal alteration, and the amount of energy expended in tool manufacture. She observed that later sedentary populations expended more energy in tool production including a focus on complex tool forms (hafted bifaces) and reliance on thermal alteration techniques to improve tool stone workability (Lurie 1989:55).

Following Binford (1980), Bousman (1993) investigated the relationship between mobility, tool production costs, and assemblage variability. He proposed that toolkits from forager-type systems (those that involve residential mobility) are characterized by increased tool use-life and low production and maintenance costs, reflecting the needs of time minimizers. Collectors (whose movements are logistical or tethered to a residential base) are resource maximizers who engender higher production and maintenance costs and prioritize effectiveness in tool design. Bousman hypothesized that forager toolkits will have more multi-purpose tools, while collector toolkits will have greater tool diversity, including tools designed for specific purposes.

4.1.2.2 Tool Design and Assemblage Diversity

Several studies have focused on aspects of tool design to understand movement, observing that residentially mobile populations tend to craft tools that improve transportability; implements are smaller, lighter, and more portable than those made by sedentary groups (Keeley 1982). Kuhn (1994) also examined transport efficiency using formal optimization models to predict the kinds of tools that would be selected by highly mobile people. Assuming that mobile people design tool kits to maximize durability and functional versatility (Kuhn 1994:426), Kuhn predicted that mobile people would prioritize tools over cores, with the former retaining more usable flake edge per unit mass. Surovell's modeling of tool kit design (2009:142-176) found that Kuhn's predictions worked for some tool classes (e.g., bifaces), however, for others (e.g., flake tools), functional considerations were paramount over transportability. Other organizational studies focus on broader assemblage-wide characteristics such as tool-kit diversity. As an example, Oswalt (1976) hypothesized that mobility restricts not only assemblage size but also constrains the range of tool types contained therein. As such, increased residential mobility is expected to result in a reduction of tool classes employed.

Other research has focused on the ways in which individual tool design and overall assemblage diversity are interconnected, offering insight to the nature of assemblage variation. For example, Shott (1986) linked tool design and assemblage diversity with settlement, reasoning that in systems where logistical mobility is employed, tasks are relatively specialized (or location dependent), compared to residentially mobile systems where people are generally doing the same thing at different locations. Based on this, Shott hypothesized that functionally specific items are more likely to be found in collector contexts. Further, Shott postulates that a decrease in residential mobility would result in reduced carrying costs, allowing for the production of diverse toolkits. Increased residential mobility would therefor result in a decrease in assemblage diversity and an increase in individual tool versatility and flexibility. He emphasizes that diversity and mean complexity are related to mobility parameters in different ways. Technological diversity is related to mobility frequency, while mean complexity is connected to mobility magnitude (i.e., distance moved).

4.1.2.3 Tool Function

The topic of tool function has developed over time, contributing significantly to our understanding of the connection between technology and mobility. Traditionally, functional studies (those not rooted in organizational approach) operate under the assumption that tool form and function are directly linked; in other words, the types of artifacts present provide direct evidence for the kinds of activities carried out at that location. Researchers have long recognized the faulty basis of the form/function correlation (Frison 1968; Semenov 1964; Shott 1986); the idea that morphological tool classes contain items that were used for a variety of purposes was foundational to later behavioral models focused on explaining technological change. Kelly's (1988) seminal work on the role of bifaces in Nevada's Carson Sink, for example, was successful in demonstrating the interconnectedness of tool function and settlement strategies. He proposed that the morphological category "biface" subsumes three different "kinds" of bifacial tools including: bifaces used as cores; bifaces used as long-life tools; and bifaces as the by-product of the shaping process (e.g., projectile points or drills) (Kelly 1988:719). He submits that bifaces are integrated into hunter-gatherer systems in different ways according to situational tool needs and raw-material availability; as such, the role of bifaces within a particular environmental context can signal a group's settlement arrangement (Kelly 1988:719).

4.1.3 Settlement Structure

An important aim of the current study is to understand settlement strategies of foragers and early herders as a way to investigate the way food production came about in Mongolia's desert-steppe region. Comparing the ways in which foragers and herders map on to resources helps us to understand the factors that shape decisions about movement, and ultimately how economies are transformed. As discussed Chapter 2, mobility is key to understanding these differences, and requires us to think more critically about its structure, including *distance*, *frequency*, and *motivation* (Barnard and Wendrich 2008:8; Chang 2008; Rogers 2012).

Binford's forager/collector model (1980) was one of the first to directly address the issue of mobility in hunter-gatherer societies; it is also an early example of middle-range theory in anthropological archaeology that attempts to bridge the gap between the tangible archaeological record and dynamic human behavior (Binford 1979). The model provides a framework from which to distinguish movements of foragers and early herders but is also a lens through which we can interpret technological trends to understand how people make decisions about changing environments.

A key aspect of Binford's (1980) forager-collector model is the linkage between the organization of camp movements and food procurement activities, specifically the different types of mobility employed in procurement pursuits (i.e., logistical versus residential mobility). Residential mobility involves the movement of an entire group between residences, while logistical mobility entails movement of individuals or small task-specific groups between residential sites and distant resource locations. Generally, forager arrangements are associated with high residential mobility (low logistical mobility), where groups "map on" to resources (i.e., consumers move to products) (Table 4.1). Collectors, in contrast, move residences less frequently, not necessarily defined by food getting activities. Logistical mobility is employed to procure and transport food and other resources to people in more permanent residential locales (Table 4.1).

This framework is arguably one of the more important and most widely applied models in North American hunter-gatherer studies, though practical applications have been attempted in virtually every geographic region, and even transcending modes of production (Aldenderfer 2009). The forager/collector dichotomy, alongside other middle range subsistence-settlement models (e.g., Bettinger's 1999 Traveler/Processor Model) provide insight to the utility of small-scale data from artifact assemblages to inform interpretations of regional scale patterns, and importantly, how the two can be combined within a broad theoretical framework to explain process of social change. Despite questions about their overall utility and lack of articulation with general theory (Bettinger et al. 2015:81-86), these models have proven to be effective heuristic devices for understanding the context of important shifts in hunter-gather lifeways, namely the development of sedentism.

Table 4.1 Characteristics of Foragers and Collectors (based on Binford 1980).

	Mobility Strategy	Environmental Characteristics	Archaeological Site Types
Foragers	High residential mobility. Maps on to resources. Little investment in logistical strategies.	Homogenous distribution of resources. Long growing seasons: • year-round; • non-aggregated resources.	Residential Base: • locus out of which foraging party originates; • hub of subsistence activities; • redundancy in use; • high archaeological visibility. Location: low bulk extractive tasks • little evidence for use, exhaustion of and abandonment of tools; • low archaeological visibility.
Collectors	High logistical mobility to procure resources: • frequent, lengthy forays by task groups. Low residential mobility: • not necessarily defined by food resource. Use of storage for at least part of the year: • solves temporary incongruity of availability of resources.	Incongruent distribution of critical resources; Relatively short growing season: • aggregated resources.	Residential Base: (see Forager): Location: (see Forager) Field Camp: • temporary operational center for task group; • differentiated according to target resource/task. Station: • special purpose task group for information gathering. Cache: • temporary storage sites to handle high bulk, surplus items.

For example, Bettinger employs both large- and small-scale datasets to understand how this change came about in the Inyo-Mono region of the North American Great Basin, avoiding well-worn arguments about the role of climate and resource availability on social change in “marginal” environments. The strength in Bettinger’s model is the use of robust artifact and ecofact assemblages derived from a variety of excavation projects that were carried out in what may now be considered the heyday of cultural resource management (CRM) archaeology in the United

States. These robust datasets allowed for ambitious analytical programs designed to answer broad questions about social processes, not merely to provide inventories of artifact types. A problematic aspect of these models, though, is the very coarse-grained approach to settlement demography, based largely on patterns of site density, site (or assemblage) size, and frequencies of radiocarbon dates or time-sensitive artifacts. Since the inception of CRM in western North America, survey programs and settlement studies have been "site" focused, while non-site approaches (like the one taken for the current study) are rare (but see Ebert 1992). One positive outcome of this approach, though, has been the development of well-thought-out site typologies that take into account the wide range of behaviors that result in unique archaeological signatures, as well as the variety of physical and social contexts in which they occur. This has allowed us to move beyond merely assessing site function or identifying specific settlement "types" (i.e., forager vs collector, traveler vs processor) to developing a deeper understanding of spatial differentiation and the implications for social change.

For the current study, the importance of these types of models is not so much their ability to identify variability in foraging lifeways, but their explanatory nature that allows for application to other mobile economies beyond hunter-gatherers (Aldenderfer 2009). What are the conditions under which a particular mobility strategy would be employed? What makes people move from place to place, and why do they "settle down"? Expanding Binford's model, Kelly examines multiple factors to explain settlement patterns of highly mobile populations. Central-place modeling (Orians and Pearson 1979) involving ethnographic data on foraging societies indicates that the relationship between daily foraging tasks and larger group movement is shaped by apparent costs associated with both activities (Bettinger et al. 2015:10; Kelly 1995:137), though other factors likely come into play such as resource return rates, intensity of resource use, storage strategies, and perceived risk (Morgan 2012; Tushingham and Bettinger 2013; Zeanah 1996, 2000, 2002).

In characterizing variance between mobility strategies, central place models frame decisions about group movement as a constant trade-off between the costs and benefits of group movement compared to individual logistical movements,. Neither strategy is inherently more efficient, unless one considers temporal and spatial distribution of resources, both on a local and a regional level. Kelly (1995) suggests that sedentism is advantageous in circumstances of local abundance coupled with regional scarcity; put another way, abundance of a resource is less important than the evenness of distribution across a landscape (i.e., patchiness). Central-place modeling of foraging returns and traveling distance predicts that foragers within evenly distributed resources will remain mobile, as long as there are places to move (Kelly 1995:151).

In considering mobility among pastoralists, it is essential to understand differences in how resources are incorporated into movement. For example, as discussed in Chapter 2, both hunters and herders target water, but for different purposes; hunters target for human consumption, while herders must balance their needs with those of the animals in their care. While access to water is critical for both production modes, pastoralists are likely more tethered to ample or more productive water sources than foragers. If this is the case, then in a region where mobile pastoralism developed in place we might expect to see in the archaeological record a notable reduction in the range or frequency of residential movements over time, reflecting in part, the rate of resource depletion (or patchiness of resources).

Similarly, plants and animals are targeted in different ways. Foragers typically rely on a wide variety of plants and animals, procured in a wide variety of strategies (logistical versus residential movements, short-term versus long-term occupation). Pastoralists, though, target graze to feed herds, with other plants and animals a secondary concern. Here, a limited range of environments are targeted by herders, impacting movement strategies. In areas where pasture is abundant, we may expect to see frequent, short-range movements; in less productive areas (or areas with very patchy distribution), we may expect an increase in the range of movement (Mearns 1993).

Population density is also a critical constraint, but not in a straight forward way. As Kelley points out (1995:151), as population density grows, so does the cost of movement (e.g., displacement of other groups, possibility of increased conflict). Where resource are plentiful, mobile groups who experience rapid population growth could face constraints in residential mobility.

4.1.3.1 Site Function

An important distinction between foragers and collectors is the range of site types employed in each strategy. A foraging strategy is likely to involve only residential bases and "locations" (Table 4.1), whereas collectors make use of a wider range of site types (e.g., field camps, residential bases, locations, caches, and stations). It should be cautioned however, that field camps and residential bases will have relatively high archaeological visibility, with locations, caches, and stations more difficult to detect.

Given the low visibility of many of the site types in the forager/collector spectrum, classification of residential sites is both important and problematic. Significant effort has been devoted to distinguishing residential sites of foragers and collectors with efforts focusing on site structure, assemblage diversity, material density, and faunal remains. Length of occupation is often considered a key component of a settlement strategy (e.g., Surovell 2009:58-98), however it should be remembered that as originally conceived, the difference between residential bases is not length of stay, but how people organized their food-getting activities.

This concept is key to the current study. If, as proposed, differences in mobility strategies are largely related to camp organization in relation to resource acquisition, then toolkits derived from residential bases are fundamental to distinguishing divergent settlement arrangements (high versus low residential mobility; long-range versus short-range movements). For the purposes of this study, residential bases are distinguished from non-residential sites (i.e., task sites, locations) based on two lines of evidence: 1) artifacts associated with residential activities including cooking or food preparation (ceramics, ground stone, fire-affected rock, hearths); and/or 2) artifacts indicating a range of on-site tasks such as manufacturing (e.g., flake tools, drills, knives, slag), lithic reduction (e.g., non-microblade cores, hammerstones, waste flakes), and hunting (e.g., projectile points). A list of all sites and their assigned function (residential versus non-residential) is in Appendix 1.

4.2 Ceramics

Ceramics, like lithics, are typically used to define "site" boundaries or serve as indicators for the location of buried deposits. As such, researchers sometimes overlook the potential for these durable materials to provide insight into past lifeways. Owing to their association with specific time periods, ceramics from hunter-gatherer and herder contexts in the desert-steppe provide an opportunity to better understand the nature of forager and pastoral households including investment strategies (e.g., Eerkens 2003, 2008), subsistence pursuits (e.g., Craig et al. 2013;

Farrell et al. 2014), specialized activities (e.g., Sturm et al. 2016; Thoms 2009; Vitelli 1989), and social organization (e.g., Eerkens 2004; Taché and Craig 2015).

Given this dissertation's focus on lithic technology, ceramics had a limited role in addressing research questions; specifically, ceramics were used to date artifact assemblages, assess site function (residential versus non-residential), and evaluate technological investment, namely the production of highly decorative or specialized receptacles (e.g., Eerkens 2008:319-320). A discussion of the research potential of future ceramic analyses is located in Chapter 9. The following section provides a brief outline of the development of ceramic use across the region and a description of period assemblages from south-eastern Mongolia.

Ceramic use in Northeast Asia dates to about 20,000 years ago (Wang and Sebilaud 2019), when pottery was used as part of the hunter-gatherer toolkit (e.g., cooking technology) to target mixed forest environments across the southern China (ca. 20,000 BP), Japan (ca. 16,700 cal BP), and the Russia Far East (ca. 15,900 cal BP) (Kuzmin 2017; Wu et al. 2012). Widespread use beyond these areas including Siberia, northern China, and Mongolia occurred after 9000 BP, when they were part of a Neolithic toolkit that also included polished stone, milling equipment, and bifacial technology (Janz 2012:160).

The earliest pottery of the desert and desert-steppe dates to about 9600 BP (Oasis 1), though ceramic use became more common after 8000 BP (Oasis 2). Early Neolithic wares are characterized by grey clay with "heavy sand temper, thick walls, and low-fired paste" (Janz 2012:169; Janz et al. 2017). Vessels were manufactured by hand or through the "belt" method. Organic temper is also common, resulting in blackened pastes. Decoration is similar to specimens from the Lake Baikal region dating to ca. 8500 BP, which are characterized by "net-impressed, corded, textile impressed" motifs (Janz 2012:169). As across all parts of Northeast Asia, ceramic use in the desert and desert-steppe regions by Oasis 3 (5000-3000 BP) expanded to include high-temperature firing methods for producing thin, fine red wares. A wide range of decoration and surface treatments also appeared, including string-paddled, incised geometric designs, channel wear, stamped, roller stamped, molded rims, and raised bands (Janz 2012:188-190; Janz et al. 2017:15-16).

Metal Age ceramics from the region are distinctive from Neolithic Age. For example, Late Bronze Age pottery is typically more coarse-grained, with pastes composed of black and brown clays with fine and coarse sand (Erdenbaatar 2002; Olzbayar 2016). By the Iron Age a wide array of forms were manufactured, with plain burnished surfaces with a limited range of appliqué decorations compared to earlier periods (Wright 2011).

Within the desert and desert-steppe environs, ceramics attributed to the Xiongnu Period (2300-1600 BP) are rare but are comparable to those from the Xiongnu core, including northern and central Mongolia and southern Siberia (Wright n.d.; Wright et al. 2007). Wares are typically thick (7-12 mm) and coarse with many inclusions, (Wright n.d.:3); they range in quality from thick, fine grey wares to thin utilitarian vessels made of friable red-brown clay. Xiongnu pottery is distinctive in decoration, described as having vertical “scrape polish” with wavey lines (Wright n.d.:4) or having “flat-combed designs” (Olzbayar 2016; Tseveendorj and Batsaikhan 1994). Within the Xiongnu “heartland” a wide range of forms are represented including simple wide mouth jars and flat rim bowels, to “fancy” large jars (for alcohol), strainer jars (for processing dairy) and beakers (Wright n.d.:2-10). Some vessels exhibit turning marks, indicating use of wheel thrown techniques (Olzbayar 2016:15; Tseveendorj et al. 2003; Wright n.d:12-15). Xiongnu ceramic assemblages from the Gobi tend to contain fewer utilitarian forms, with only limited use of scrape-polish decoration (Wright n.d.:2-10).

Turkic Period pottery (6th-8th c. AD) is reminiscent of Xiongnu wares characterized largely by simple rim forms. There is, however, a marked decrease in assemblage variably across different regions of Inner Asia, with variation in form tied to differences in subsistence pursuits (Wright n.d.:11). Assemblages include grey and red-brown wares bearing distinctive stamped decorations reflecting a range of designs such as arcs, diamonds, herringbone, and chevrons (Wright n.d.:12-15). A unique wave pattern is also characteristic. Kitan wares (10th-12th c. AD) are the first to show signs of standardization in terms of vessel thickness and decoration. They are typically wheel-turned and fired at high temperatures, exhibiting a fine grey paste (Makino 2007; Wright n.d.: 26). Extensive angular punctate designs covering much of the vessel body are the dominant decorative feature.

5.0 Study Methods

5.1 Regional Settlement Study

5.1.1 Distributional Survey methods

To accomplish project goals this study employed a distributional or "non-site" survey approach to identify variable and overlapping artifact patterning that characterizes these large, open, contiguous landscapes. A stratified systematic survey was conducted over a period of eight weeks in 2018 and 2019.

The survey targeted three environmental zones within Ikh Nart, differentiated by landform, hydrology, and vegetation community. The *lakebed* zone (6825 ha) is in the northernmost portion of the park and incorporates an ancient lakebed-drainage-dune field system; the area supports a mosaic of grasses and riparian plant species (Figure 5.1). An *upland* zone is situated just south of the lakebed (27,281 ha) and involves areas within a NE/SW trending granitic batholith that supports a cover of scrub vegetation (Figure 5.2). The upland zone is characterized by series of deeply cut steam beds and springs that drain into the adjacent ancient lakebed. Immediately south of the uplands is a *lowland* zone that includes flatlands that support open grasslands and seasonal wetlands (10,585 ha) (Figure 5.3). A fourth environmental zone is characterized by low basalt hills and hilly grasslands in the south (22,286 ha), but due to time and labor constraints was not investigated.

Figure 5.1 View north from upland environmental zone to lakebed (Choyer Basin).

Figure 5.2 View of upland environmental zone.

Figure 5.3 View of lowland environmental zone.

The study involved inspection of 592 2.07-ha survey quadrats systematically selected across each environmental zone, for a total of 1,225.44 ha (See Section 6.1 for a map and table summary of survey quadrats by zone). Two survey teams composed of 4-6 trained volunteers walked contiguous transects across each survey quadrat, maintaining a 20 m spacing between crew members. Travel to survey blocks was expedited by 4-wheel drive vans and local drivers with knowledge of the Ikh Nart area. When artifact scatters were encountered (more than 2 items within 10 m diameter), all ceramic, lithic, and metal items were collected and returned to the field lab for analysis.

Upon discovery, each identified artifact scatter was divided into one or more collection units, each measuring about 25x25 m. Each collection unit was assigned a sequential number and mapped using GPS (ArcGIS Collector). Scatters that extended beyond the survey quadrat were also recorded, though artifacts outside the quadrat were not collected for analysis. Systematic artifact collection was carried out in any collection unit where artifact density was greater than 0.5 items/m2. Each systematic artifact collection (numbered sequentially for each collection unit) entailed collection of all materials identified within a delineated circle with a radius of 1.78 m (10 m^2). If fewer than 41 items were recovered, another circle was delineated and collected within the collection unit. This process continued up to three more times. If fewer than 41 artifacts were recovered after completing 5 circles, general collection of artifacts across the collection unit was carried out to supplement the systematic collections. Any collection unit with less than 0.5 items/m^2 was also subject to general artifact collection until 41 items were collected, or 15 minutes had elapsed. The minimum sample size of 41 items produces proportional estimates of different material classes with error ranges of no more than ±10% (at 80% confidence). An inventory of all collection units is on file at the University of Pittsburgh's Comparative Archaeology Database (http://www.cadb.pitt.edu).

5.1.2 Analysis Parameters

5.1.2.1 Chronological Assessments

A comprehensive chronology of lithic scatters across the study area is made difficult by several factors including the small, diffused nature of most sites and a paucity of temporally diagnostic artifacts or datable material. Lithic artifacts recovered from the study are typical of those associated with the East Asian microblade tradition that spans the Epipaleolithic, Neolithic, Bronze and Iron Age of Mongolia's northern steppe (Wright 2006) and desert/desert-steppe regions (Janz 2012; Janz et al. 2017). Efforts to distinguish lithic traditions before and after the transition to herding have been stymied by persistent technological strategies centered largely on the production of microblades and retouched tools. Despite broadly homogenous stone tool typologies across the shift to food production, researchers have identified some degree of temporal variation (Janz 2012:202; Wright 2006:155) (Tables 5.1 and 5.2). Among lithic collections from Egiin Gol in northern Mongolia, for example, Wright (2006:146-159) distinguished five chronological groups spanning the Early Upper Paleolithic to post-Neolithic eras (Table 5.1). Characteristics of Periods I-III demonstrate the growing importance of microblade or bladelet technology as larger blade traditions disappear. Wright notes a growing formality of hunter-gather toolkits over time, likely associated with increased residential mobility, a trend also observed in southern Siberia (Goebel 2002). Here, Neolithic assemblages (pre-pottery and later) differ only slightly from Epipaleolithic collections, with microblades being more ubiquitous across all site contexts. By the metal ages and the presumed ascendance of herding, lithic assemblages are characterized by an abundance of expedient forms (e.g., simple or unmodified flake tools).

Table 5.1 Chronological Divisions of Lithics from Northern Mongolia (Wright 2006).

Phase	Approximate Age	Characteristics
I Early Upper Paleolithic	ca. 27,000 BP	Large blade industry, few formal tools.
II Pre-Microlithic Upper Paleolithic	ca. 15,000 BP	Large blade industry with more formal tools including microblades.
III Aceramic Microlithic	>8000 BP	Bladelets dominate, end scrapers, adzes, small bifacial points.
IV Microlithic, Neolithic	8000-3000 BP	Continued dominance of microblades/cores.
V Post-Neolithic	<3000 BP	Microblade technology mixed with expedient tools.

Table 5.2 Chronological Divisions of Lithics from the Gobi and Desert-Steppe (Janz 2012).

Phase	Approximate Age	Characteristics
Early Epipaleolithic	19,000-13,500 BP	Large pebble tools; cores (Levallois, flake, microblade); scrapers; unifacial points.
Oasis 1 (Late Epipaleolithic/Early Neolithic)	13,500-8000 BP	Pebble tools; informal grinding stones; pottery; bone tools; flake cores; microblade cores (boat, wedge, conical, cylindrical); microblade insets; end scrapers.
Oasis 2 (Neolithic)	8000-5000 BP	Large formal tools; formal grinding stones; pottery; bone tools; bifacial cores; flake cores; microblade cores (wedge, conical. cylindrical); unifacial points; perforators, awls; end scrapers; perforators; shouldered projectile points; adz/axes; hoes.
Oasis 3 (Late Neolithic/Early Bronze Age)	5000-3000 BP	Informal grinding tools; pottery; bone tools; bifacial cores; flake cores; microblade cores (wedge, conical, cylindrical, barrel); end scrapers; perforators; expanded base drills; bifacial points; projectile points (straight, stemmed, convex bases); adz/axes; grooved slabs.

Janz's (2012) extensive research on dated surface lithic assemblages from the Gobi and surrounding desert-steppe environs also identified homogenous and persistent technological trends, generally overlapping with those identified by Wright (2006). Her Oasis 1 phase (13,000-8000 BP) is similar to Wright's Phase III (Aceramic Microlith), a time when microblade technology is thought to have replaced large blade and pebble tool traditions. Janz's Oasis scheme highlights shifts in core technology including an emphasis on "Levallois" forms across the Paleolithic, and a preponderance of "boat" and "wedge" shaped microblade cores during the start of the Epipaleolithic. Oasis 2 (8000-5000 BP) and Oasis 3 (5000-3000 BP) broadly track with Wright's Phase IV (Pottery Neolithic). According to Janz, early Holocene foragers of Oasis 1 and 2 targeted wild plant and animal resources by way of long-term seasonal residential camps centered on dune/wetland environments augmented by logistical use of surrounding ecological zones. Associated assemblages are characterized by flaked stone tools made from high quality cryptocrystalline silicates, including microblade cores (boat, wedge, conical and cylindrical shaped), expedient cores, flake scrapers, and unifacial points; other diagnostic forms include polished stone tools (adzes), large formal milling equipment (slabs, mortars, pestles), and a few types of low-fired ceramics (Janz 2012; Janz et al. 2017). During Oasis 2 (8000 BP) boat shaped cores are less frequent.

After about 5000 BP (Oasis 3), widespread regional aridification appears to have resulted in the reduction of lakes and wetlands, significantly altering vegetation patterns (Janz 2012:288-293), though hunters and presumably early herders seem to have intensified use of remaining wetland environments, employing frequent residential moves to target dwindling resources. Non-wetland resources in upland areas were exploited more frequently than in previous times and were targeted by way of small field camps and task sites. Residential sites of this period are found in a broader range of environmental contexts compared to Oasis 2. Oasis 3 toolkits are comparable to those of Oasis 2, with continued focus on microblade technology. Some important technological shifts are noted, however, including specialized biface technology, a reduction in the use of ground stone tools, and an expansion of ceramic technology. Among the Alashan Gobi sites, statistically significant differences in Oasis 2 and 3 assemblages are noted, including a decrease in microblade core size, and increased use of informal core types, possibly signaling a decrease in the availability of quality raw material (Janz et al. 2017:58). Markers that distinguish Neolithic age forager populations (Oasis 1 and 2) from the mixed economies of the Neolithic-Bronze Age transition and later parts of the Bronze Age (Oasis 3) include a small number of distinct forms including expanded base drills; curved bifacial knives; projectile points with bases that are straight, stemmed, or convex shaped; “barrel” shaped microblade cores; and end scrapers made on microblades (Janz 2012: 202).

5.1.2.2 Population Proxies

An important aim of the current study is to understand how populations distributed themselves across the three broad environmental zones over time to compare land use strategies of hunters and herders. The study employs the area-density index as a relative population estimate based on the distribution of archaeological materials that facilitates an estimation of the intensity of human utilization of the landscape across space and time, as well as an approximation of relative group size (Drennan et al. 2015:34). This index is a continuous-scale population proxy based on the idea that more people in one location for a longer period will result in debris scatters that are either larger in extent or in density (Drennan et al. 2015:37). The index is a relative measure and therefore does not necessitate the use of some universal or culturally specific constant for the amount of garbage produced (per person/year.) For mobile populations where mobility can affect rate of accumulation, the area-density index is an excellent method for identifying changes in accumulation rates (i.e., change in size of local population, duration or frequency of occupation), illustrating important differences in how habitats were used over time. Based on ceramic and lithic typologies described previously, collection units within each survey quadrat were ascribed to a broad temporal component (Table 5.3)

Considering collection unit size and artifact count, an area-density index was developed (average collection unit area in hectares multiplied by the artifact density expressed in cubic meters). This number was then corrected for period duration by dividing it by the number of centuries represented by the target period (for example, there are 15 centuries represented in the Bronze Age [4500-3000 BP]). Within each survey quadrat, clusters of collection units dating to the same period were designated as “sites” or local communities. A list of each site and corresponding period corrected area-density index is contained in Appendix 1 and is also on file at the University of Pittsburgh’s Comparative Archaeology Database (http://www.cadb.pitt.edu). Section 6.1.1 outlines how this corrected period area-density index provides the basis for two relative proxy measures, landscape utilization and intensity of use.

Table 5.3 Chronological Divisions for Ikh Nart Study.

Period	Approximate Age	Characteristics
Neolithic (Oasis 2)	8000-5500 BP	**Lithics** typical of Oasis 2: Large formal tools; formal grinding stones; bone tools; bifacial core;, flake cores; microblade cores (wedge, conical. cylindrical); unifacial points; perforators, awls; end scrapers; perforators; shouldered projectile points; adz/axes; hoes. **Ceramics:** Early Neolithic wares characterized by grey clay with "heavy sand temper, thick walls, and low-fired paste". Organic temper is common, resulting in blackened pastes. Decoration characterized by "net-impressed, corded, textile impressed" motifs.
Early Bronze Age (Oasis 2-3)	5500-4500 BP	**Lithics:** continuation of previous period. **Ceramics:** thin friable redwares, with sandy inclusions, coarse paddle-decoration
Bronze Age (Oasis 3)	4500-3000 BP	**Lithics** typical of Oasis 3: Informal grinding tools; bone tools; bifacial cores; flake cores; microblade cores (wedge, conical, cylindrical, barrel); end scrapers; perforators; expanded base drills; bifacial points; projectile points (straight, stemmed, convex bases); adz/axes, grooved slabs. **Ceramics** include high-temperature fired (producing fine red wares) and a wide range of decoration and surface treatments including string-paddled, incised geometric designs, channel wear, stamped, roller stamped, molded rims, and raised bands. Late Bronze Age pottery is typically more coarse-grained, composed of black and brown clays with fine and coarse sand.
Iron Age (Early-Middle)	3000-2300 BP	**Ceramics**: Wide array of forms with plain burnished surfaces and a limited range of appliqué decorations than during earlier periods.
Xiongnu (Late iron Age)	2300-1600 BP	Ceramics are thick (7-12 mm), coarse with many inclusions, range from thick, fine grey wares to thinner utilitarian vessels made of friable red-brown clay. Decoration includes vertical "scrape polish" with wavey lines or having "flat-combed designs". Forms include simple wide mouth jars and flat rim bowls, to "fancy" large jars (for alcohol), strainer jars (for processing dairy) and beakers Some vessels appear to have been wheel thrown.
Turkic	6^{th}-8^{th} c. AD	Ceramic assemblages include grey and red-brown wares bearing distinctive stamped decorations reflecting a range of designs (arcs, diamonds, herringbone, chevrons. A unique wave patterns is also characteristic of Turkic wares.
Kitan	10^{th}-12^{th} c. AD	Ceramic wares are wheel-turned and fired at high temperatures, with a fine grey paste. Extensive angular punctate designs covering much of the vessel body) are the dominant decorative feature.

5.1.2.3 Environmental Parameters

While the survey data and population proxies allow us to compare how populations distributed themselves across environmental zones, understanding how trends relate to the development of pastoralism requires that we identify the factors that shaped settlement decisions (i.e., habitat selection). Specifically, it requires us to look to patterning of population proxies within the natural environment as they relate to pertinent environmental variables including proximity to water, winter vegetation, pasture, and big game habitat.

Understanding habitat selection of foragers and herders requires that I consider basic needs for each economic strategy. For foragers, the most suitable habitats are those in proximity to reliable water sources (wetland habitats, springs, large drainage systems), big game, and protection from cold northerly winds. Regional studies have identified forger and early mixed forager/herder populations in wetland contexts including former wetland margins, riparian corridor, shallow draws, bluff tops, or terraces overlooking wetland resources (Janz et al. 2017; Wright et al. 2019). Janz's work in the Gobi suggests that this riparian and "wetland-centric" land use strategy was accompanied by logistical exploitation of other zones, a trend that appears to have continued throughout the Bronze Age until about 3000 BP (Janz et al. 2017:64, 2021).

Early pastoralists would also have favored these locations, but would have prioritized areas with forage for herds, especially winter-season vegetation. That said, more established post-Bronze Age herding economies are often associated with a diversified land use strategy (i.e., an even distribution of habitation sites across different ecozones), with a strong focus on interfluvial areas or those with high visibility (Wright et al. 2019:12).

Within the bounds of Ikh Nart, modern herding groups strongly favor upland pasturelands year-round, with a few selecting areas on the lakebed, but close to the contact with upland zones.

Today, few herding groups occupy lowland zones to the south, clustered around seasonal wetland areas just south of the upland/lowland interface (Mongolian Ministry of Nature, Environment, and Tourism 2014: Maps 4 and 19). The upland areas of Ikh Nart are important to herders from bordering areas (parts of Dalanjargalan soum to the northeast, parts of Airag soum to the southeast), with groups traveling as far as 50-100 km to establish winter encampments in the elevated, protected, and most productive zones of the reserve.

The environmental analysis for my study includes two parts, that together provide the basis for identifying preferred habitats of hunters and herders and for assessing the nature of preference change through the lens of the IFD. The analysis involved 1) comparison of the proportion of period area-density index associated with each environmental factor; followed by 2) an assessment of the relationship between population and environment through the application of multidimensional scaling.

Chapter 6 (Section 6.3) details the environmental analysis of site locations, including an examination of population proxies by environmental variable (i.e., elevation, landform, pasture productivity, and winter vegetation productivity) (Table 6.4). Environmental variables for each archaeological site were recorded using GIS raster analysis that combined existing data on lakes, wetlands, plant productivity, and landform. Specifically, the analysis employed a digital elevation model (DEM) of the region (ASTGTM2_N45E108_dem.tif) and existing raster files of lakes, landform, pasture resources (Mongolian Ministry of Nature, Environment, and Tourism 2014) and a reclassified raster of local vegetation that depicts wetlands, seeps, and ephemeral lakes (GobiERA_GISshare\Gobi_vegesys.img). Location estimations of winter vegetation was accomplished through computation of the Normalized Difference Vegetation Index (NDVI) from LANDSAT multiband imagery (Landsat4-5 from USGS Earth Explorer) for February 2011. A composite raster image was made using Bands 1-4; the NDVI was created using band 4 (NIR) and band 3 (Visible Red). Section 6.3 (Figures 6.15-6.19) presents NDVI patterning, with the highest ranked areas (densest winter vegetation) having a value of seven, and the lowest a value of 4.

Section 6.3 also presents the results of the multidimensional scaling analysis (Figures 6.35-6.39). Multidimensional scaling provides a visual representation of distances (similarities or dissimilarities) between sets of objects or cases (i.e., sites), taking into consideration an array of variables; cases that are more similar (or have shorter distances between them) are closer together on the graph than objects that are less similar (or have longer distances). Considered to be one of the simplest forms of multivariate analyses, it offers an intuitive or "commonsense" approach to identifying patterns between complex datasets, providing a "picture of the relationships between cases that are incapsulated in the matrix of similarity coefficients" (Drennan 2010:285).

The current study seeks to compare archaeological sites based on a range of environmental variables through the application of Gowers Coefficient. The multivariate dataset used to calculate the Gowers Coefficient is contained in (Appendix 1). Gowers similarity scores were entered into SYSTAT (a statistics and statistical graphics program) to produce graphical representations of the relationship between sites, with the goal of producing the best rank order correspondence between similarity scores and distance between point pairs as possible, in as few dimensions as possible. The number of dimensions was determined by assessing the rate of declination in stress scores produced by the multidimensional scaling program in SYSTAT (final stress of 0.15 is typically associated with interpretable configurations). The iterative history for each dimension is on file at the University of Pittsburgh's Comparative Archaeology Database (http://www.cadb.pitt.edu).

For the current study, three dimensions were determined to provide an effective representation of patterning among the period datasets. For each variable, the cube of a three-dimensional configuration was represented by three plots (Dimension 1-2; Dimension 3-1: and Dimension 3-2); all three dimensions for each variable are on file at the University of Pittsburgh's Comparative Archaeology Database (http://www.cadb.pitt.edu). Chapter 6 (Figures 6.35-6.39) presents dimensions that depict the most important observations for each environmental factor by period.

5.2 Flaked Stone Tool Analysis

As presented in Chapter 4, technological studies conducted over the past four decades provide the foundation for developing a set of expectations linking technology and settlement organization. From these studies, I have identified flaked stone tool and assemblage characteristics believed most sensitive to changes in mobility; these traits provide the basis for comparing settlement strategies of foragers and herders (Farquhar 2003; Janz 2012). Attributes of other lithic artifact classes (i.e., ground and battered stone) were recorded as a part of this study, however, were not included in the assessment of technological organization and mobility. Analysis methods and findings are contained is on file at the University of Pittsburgh's Comparative Archaeology Database (http://www.cadb.pitt.edu).

5.2.1 Objectives

Flaked stone materials from study sites include a variety of formed tools and waste debris representing the remains of on-site tool manufacture and maintenance activities. Lithic artifact studies involve the identification of key debitage and artifact attributes to identify specific reduction strategies, but also the nature of discard patterning to understand potential constraints on procurement and manufacturing activities connected to settlement strategies (i.e., residential mobility).

Excepting debitage, basic attributes identified for each tool class include length, width, thickness, and weight. In conjunction with artifact class-specific criteria (i.e., condition, cortex present, use-wear, break type, reworking), these attributes provide baseline descriptions from which to derive morphological categories, identify production technologies, and interpret procurement strategies, tool use, and discard patterns. Analysis methods for each artifact class are on file at the University of Pittsburgh's Comparative Archaeology Database (http://www.cadb.pitt.edu).

Samples of flaked stone debitage from select datable contexts were also examined, segregated by material type and size class to characterize assemblage composition. Flakes were then assigned to key categories that reflect specific reduction technique (i.e., biface manufacture, microblade core reduction, core/flake reduction). Debitage analysis results are presented on file at the University of Pittsburgh's Comparative Archaeology Database (http://www.cadb.pitt.edu).

Understanding that flaked stone tools were generally transported from place to place through various stages of procurement, manufacture, use, and discard, the current analytical approach involves identification of manufacturing sequence segments present on site (cores, preforms, debitage), and the state of discarded objects (complete/still functional tools, exhausted forms, broken fragments). Together, these data permit characterization of site function, raw material acquisition, manufacture, use and discard behavior, and ultimately, an assessment of organizational strategies.

5.2.2 Analysis Parameters: Study Model and Expectations

The current analysis focuses on tool and assemblage attributes thought to be responsive to changes in settlement mobility, specifically, assemblage diversity, tool formality, and degree of material conservation (i.e., intensity of retouch and recycling behavior). I pursue several analytical avenues to characterize technological organization over time. As discussed in Chapter 2, preliminary analysis of stone tools from excavated contexts at Ikh Nart (Table 1.2) indicates some degree of temporal variability in assemblage and tool attributes, possibly related to intensity of occupation and settlement structure (e.g., density; flake to tool ratio; proportion of retouched tools; ratio of expedient to formal tools).

The following section outlines a set of four expectations linking settlement mobility and technological strategies. While this research focus is necessarily narrow, it is understood that prehistoric land use is but one aspect of human behavior that shapes technological organization. Research on the impact of raw material quality and quantity on flaked stone assemblages, for example, highlight problems in underestimating the role of local conditions on human behavior; in other words, over emphasizing the role of mobility (Andrefsky 1994, 1998; Bamforth 1990 1991; Brantingham and Kuhn 2001). For instance, it has been proposed that in areas rich in tool stone, there may have been little need for the creation of portable, multi-functional tools regardless of the settlement configuration (Andrefsky 1991:131). While this brings into question the relationship between settlement structure and technological choice (Brantingham 2003), the connection between the two remains an important avenue of research (Andrefsky 2009; Janz 2012; Odell 1996). The following approach is modeled after studies that have demonstrated a correlation between assemblage attributes and settlement organization in regions where lithic resources are considered both abundant and ubiquitous (Andrefsky 1991; Bamforth 1991; Odell 1996), conditions that characterize lithic resources in and around Ikh Nart.

5.2.2.1 Assemblage Diversity

As discussed previously, variation in assemblage composition provides information about on-site activities, and offers insight to the ways people ordered movements in response to local conditions including subsistence, resource seasonality, raw material availability, scheduling, mobility constraints, transport costs, and perceived risk (Bousman 1993; Nelson 1991; Parry and Kelly 1987; Torrence 1983). Assemblage diversity is widely regarded as one way to quantify differences in toolkit structure, and importantly, to make inferences about the degree of residential mobility (Oswalt 1976; Shott 1986). Diversity subsumes both assemblage richness (the number of tool classes represented in a component assemblage) and evenness (the relative proportion of each class represented); it is typically understood to be linked to the number of tasks carried out in a specific context. Highly diverse toolkits are associated with relatively longer periods of residence (i.e., comparatively low residential mobility), or manufacture of tools for specific tasks. As such, artifact assemblages of groups who move often should be less diverse than are those from logistically organized arrangements. While all residential sites (no matter the length of occupation) are places where a variety of tasks are performed, toolkits of highly mobile groups will contain a somewhat even combination of tools to attend to both on-site and off-site needs. This premise is based on the supposition that people who move frequently face limitations on toolkit size, and therefore will focus on tool classes that have a broader range of applications. For the current study, assemblage diversity for each identified temporal component is based on the number of artifact classes and their proportion, through application of Simpson's Index of Diversity (1-D, where $D=\sum n[n-1]/N[N-1]$).

5.2.2.2 Assemblage Formality

Recognizing that access to raw material is impacted by mobility, and further, that frequency of movement and predictability of resource access influences technological choice, several studies have examined the relationship between the amount of effort expended in tool production and settlement configuration (Andrefsky 1991; Parry and Kelly 1987). In contexts where access to high quality tool stone is variable or unpredictable, toolkits should contain more formally manufactured implements that provide reliability in uncertain contexts (Shott 1986). Consequently, tool assemblages from highly mobile populations are expected to contain a higher ratio of formal to expedient tools than those who move less often. In addition, limitations on the amount of tool stone that can be transported by highly mobile groups favor the production of formal tools that are generalized or multifunctional (i.e., flexible) as opposed to highly specialized (Bleed 1986; Elston and Brantingham 2002; Kelly 1988; Parry and Kelly 1987; Torrence 1989). Reliance on reliable, generalized, multifunctional, and flexible tools is viewed as a strategy for *provisioning individuals* (Kuhn 1995). In desert and desert-steppe environments of northeast Asia, generalized formal tools include extensively retouched flake tools, non-hafted bifacial tools, microblade technology (blades and cores), and prepared non-microblade cores (e.g., bifacial cores). Specialized tools include drills/awls, projectile points, highly modified grinding stones/slabs, pottery, and ground or chipped adzes or axes.

In contrast, lower levels of residential mobility are often associated with the production of more expedient toolkits (Parry and Kelly 1987). Reduced mobility is often (but not always) with increased predictability in access to raw materials, and consequentially, diminished concern for material conservation. Reduction strategies are necessarily focused on the functional needs at hand (or *provisioning places, sensu* Kuhn 1995) rather than production of reliable and highly portable tools. Examples of generalized expedient gear include flake tools with limited or no retouch and expedient or amorphous cores (Andrefsky 1991:135). Expedient task-specific tools include minimally modified versions of drills (flake-based perforators), grinding stones, and grinding slabs. Lithic Reduction Classification

5.2.2.3 Raw Material Conservation Strategies

In addition to assemblage diversity and individual tool formality, material conservation strategies relating to degree of reduction and intensity of retouch or recycling before discard illuminate possible constraints on transport and access to raw material sources (Bamforth 1986; Bleed 1986; Kuhn 1995). Conservation strategies are thought to extend tool use-life in situations where concerns for access to raw material are heightened, such as those involving high levels of residential mobility. Material conservation strategies are less common in contexts where high quality material is readily available (Dibble et al. 2005; Shott 1986).

For the current study, quantification of raw material conservation is achieved through an examination of four attributes: invasiveness of retouch on flake tools; evidence for recycling; remnant cortex on bifaces and cores; and intensity of core reduction. The degree or invasiveness of retouch on flake tools is measured using Kuhn’s (1990) reduction index (vertical thickness at termination of retouch scar divided by the maximum medial thickness of the flake). Recycling behaviors (efforts to extend the use life of worn or broken tools) are evidenced by attributes including presence/absence of flaking on fractured surfaces, distinct changes in a working edge; or evidence that tool has been chipped into new form or used as a different tool.

The third method of evaluating the degree of material conservation is an estimation of remaining cortical cover on cores and biface specimens. For expedient or non-formalized cores, high levels of cortex (> than 25% coverage) are expected in contexts where relatively large quantities of raw material are available (stockpiled or naturally occurring) and where the earliest stages of reduction occur. Here, reduction intensity is comparatively low, signaling only minimal concern for tool stone conservation.

For bifacial tools, remnant cortex on early and middle stage forms representing early and middle stages of reduction is also instructive. Understanding that biface production represents a continuum from material procurement (a thick, unshaped mass) to final product (relatively thin, regularly shaped tool), the amount of cortex present is inversely related to the stage of production. Generally, specimens representing the earliest stages of reduction (e.g., blank production, edging, initial thinning) are expected to have greater cortex coverage than those of later stages (production of preform, final shaping). Deviations from this trend (e.g., early-stage forms with little or no cortex) may signal that items we not locally manufactured, but were likely imported to the area in pre-reduced form, further indicating heightened levels of mobility.

Estimations of remaining cortex on cores and bifaces can be compared with the types of flakes used as tools (e.g., cortical versus interior flakes) to identify potential disjunctions in material acquisition, manufacture, use, and discard). Interruption of the procurement-to-discard trajectory suggests that activities took place in multiple locations, again, signaling heightened mobility.

The amount of remnant cortex on highly formalized or prepared cores (i.e., microblade cores, bifacial cores) is a less useful as they were likely subject to extensive decortication efforts prior to flake removal, with little cortex remaining once in use. That said, the very presence of highly prepared or formalized core speaks to some level of concern for tool conservation to mitigate constraints imposed by high levels of mobility (see discussion on formal versus informal tools in 5.2.2.2).

The final method of assessing material conservations is an assessment of reduction intensity, measured by the number of flake removals per core platform (including amorphous/expedient cores and prepared variants including microblade cores). Comparatively high numbers of flake removals indicate a high degree of manufacturing intensity, which in turn signals a concern for tool efficiency (need to maximize the production of flake edges) (Kuhn 1994) an/or tool stone conservation to mitigate constrains on access to quality raw material.

5.2.3 Analysis Methods

All flaked stone tools from dated contexts (e.g., collection units) were analyzed as part of the present study. Debitage analysis was restricted to chipped stone flakes recovered from systematic artifact collection units (1.78 m radius circles) within the collection units. An inventory of materials recovered from each collection unit (including chronometric assessment) is on file at the University of Pittsburgh's Comparative Archaeology Database (http://www.cadb.pitt.edu). Flaked stone artifact classes recovered from the study sites include projectile points, bifaces, flake tools (i.e., scrapers), drills/perforators, cores (microblade and flake varieties), and flaked cobble tools. Ground stone implements include pestles, hand stones, and milling slabs.

Basic attributes identified for each tool class include length, width, thickness, and weight. In conjunction with artifact class-specific criteria, these attributes provide baseline descriptions from which to derive morphological categories, identify production technologies, and interpret tool use and discard patterns. These data permit assessment of site function, raw material acquisition, chronology, and ultimately the four criteria listed in the previous sections. Flaked stone tool classes are described below, accompanied by a brief discussion of analytical attributes examined for each.

5.2.3.1 Projectile Points

Projectile points are bifacial forms that exhibit a hafting element. Analytical criteria for the current study were chosen to advance understanding of not only morphological variability, but also organizational issues involving tool use and discard patterning. Overall size measurements (length, axial length, width, thickness, and weight), and proximal shape measurements (basal width, neck width, stem length, distal shoulder angle, proximal shoulder angle, and notch opening) were recorded to identify point types, while other traits such as break type, use-wear, and reworking, were documented to understand production trajectories, use, and discard behavior. Analysis codes and data sheets for each artifact class are on file at the University of Pittsburgh's Comparative Archaeology Database (http://www.cadb.pitt.edu).

5.2.3.2 Bifaces

This tool class includes bifacially worked implements that show modification along the margins of opposing faces. Planar and cross-section views of these tools are relatively symmetrical, the product of a highly organized mode of tool production (not incidental or expedient). Bifaces can be used in several ways; as formal tools (blades, knives, projectile points); preforms for formal tools (see Elston and Brantingham 2002, Figure 8); or as cores for the production of usable flakes. General tool shape and size attributes such as length, width, and thickness are commonly used to establish biface function (Andrefsky 1998:174). While this artifact class subsumes functionally specific forms such as projectile points and drills, these classes are better characterized by specific diagnostic attributes, and are treated separately (following Farquhar 2003). The study of bifacial tools has been a key component of hunter-gatherer research providing insight to a range of issues relating to human tool use including approaches to raw material procurement, technological processes, site function, and settlement mobility strategies

(Bouey and Basgall 1991). Bifaces are often conceived as being highly adaptable (used in a variety of ways), maintainable, and portable, characteristics that are well suited to groups who move often, either by way of residential movements, or through logistical targeting of resources, particularly in unpredictable contexts (Kelly 1988).

To better understand tool use behavior, the current study focuses on criteria relating to manufacturing stage, original form, size, percent cortex coverage, use-wear type, break type, and reworking. Procurement strategies can be assessed through consideration of a tool's original form, material type, manufacturing stage, cortex coverage, and ratio of weight/thickness. The original form of a bifacial tool (cortical cobble, tool preform) provides information on conditions of material acquisition (i.e., direct access vs. exchange), while manufacture stage assessments (Callahan 1979) help to understand what phases of production are represented. Manufacturing stage data in conjunction with cortex coverage data provide insight to how people managed/coordinated procurement and production activities (Andrefsky 1998:184) and changes in those strategies over time. Discard patterning was evaluated by way of observations on condition, break types, and recycling.

5.2.3.3 Flake Tools

These are flakes that have been modified either through use or intentional modification. They are commonly classified according to presumed function (e.g., end scraper, side scraper, thumbnail scraper), however, the current study focuses on form or morphology as a basis for classification; two basic categories are recognized. *Simple* or unpatterned flake tools exhibit little modification of the original shape, while *formed* or patterned flake tools have been modified during manufacture (extensive retouch) so that little of the original flake shape remains. An important aspect of flake tool analysis is distinguishing use-related wear from incidental edge-damage; this is accomplished through identification of edges with continuous edge damage and well developed micro-chipping, or step fracturing.

Issues pertaining to procurement, use, and discard patterning were assessed by way of the following attributes: tool condition, material type, flake type, number of used or modified edges, and amount of cortex coverage. Tool function was determined by examination of use-wear (low power magnification, under 100X), the number of modified edges, edge shape, angle, and length. Identification of tool type (simple vs. formed) was useful for assessing tool formality. Where possible, morphological "types" were distinguished using regional nomenclature (i.e., side scraper, end scraper, thumbnail scraper, among others; see Wright 2006:151). For each used edge, a retouch index was calculated by dividing the vertical thickness of retouch (at flake termination) by the medial thickness of flake; the degree of invasiveness increases on a scale of 0-1) (Kuhn 1990). In addition to evidence for reworking, invasiveness of retouch on flake tools is used to assess efforts to conserve raw materials (see Section 5.2.2.3).

5.2.3.4 Cores, Core Tools, and Flaked Cobble Tools

A core is a piece of stone from which flakes have been removed. Like bifaces, cores can function in different ways including a parent piece for productin flake tools; or it can be used as a tool for cutting or chopping activities. Flaked cobble tools are cortex covered stones that exhibit only few flake removals (very expedient tools).

Inferences about procurement strategies from core assemblages were based on core size, original form, and amount of remaining cortex. The identification of production strategies was facilitated by classification of cores into morphological categories: unidirectional informal (bladelet); unidirectional formal (microblade, including boat, wedge, conical, and cylindrical [see

Elston and Brantingham 2002:107-108; Janz 2012:175-178, and 195]); bifacial; unpatterned or multidirectional; and bipolar.

For most core types (all except microblade) estimated size (volume) was determined by multiplying the length, width, and thickness; for microblade cores volume was calculated by multiplying overall core length by two perpendicular platform measurements (shortest and longest measurements of the platform).

Tool function was inferred by way of platform characteristics and the size of flake removals. Level of tool curation (e.g., effort put into tool production) was assessed by platform configuration and level of preparation, the number of flake removals per platform, and percentage of cortex remaining.

5.2.3.5 Drills/Perforators

Analytical categories of drills include basic metric data as well as morphological descriptions of drill bits including end-length, width, thickness, edge angle, end type, and use-wear. Drill bit morphology is assumed to be related to the task for which the tool was used (i.e., drill or perforator).

5.2.3.6 Debitage

Unmodified flakes and shatter produced by the manufacture, use, and rejuvenation of flaked stone tools were classified as debitage. During the cataloguing process, all debitage was sorted by material, then counted, and weighed by provenience (collection unit and systematic collection unit). Selected flakes were then sorted into one of five general size classes according to maximum flake diameter: <1.0 cm,1.0-2.0 cm, 2.0-3.0 cm, 3.0-5.0 cm, >5.0 cm. Each size-sorted flake was weighed individually and categorized by its diagnostic traits into one of *17 different* *technological classes* that represent a reduction trajectory from early percussion shaping to pressure finishing (Table 5.4).

For certain technological comparisons the above flake types can be merged into *six inclusive reduction groups*. The first five are technologically “diagnostic”, representing the stages of unifacial (core/flake), bifacial (bifacing), and microblade reduction strategies (Table 5.5).

Table 5.4 Debitage Classification.

Flake Type	Description
Primary Decortication	Flakes with more than 70% dorsal cortex.
Secondary Decortication-	Flakes with less than 70% dorsal cortex or only a cortical platform.
Simple Interior Percussion	Noncortical (interior) flakes which are relatively straight in cross-section, generally with broad platforms and one principal dorsal arris.
Complex Interior Percussion	Interior flakes with two or more principal dorsal arrises, usually displaying more refined platforms and somewhat more uniform dorsal topography than the simple variety.
Linear Interior Percussion	Flakes have straight cross-sections, are at least twice as longas they are wide, and have a single major longitudinal arris.
Platform Removal	Microblade core preparation flake that is flat and cylindrical; the dorsal surface shows previous platform preparation and flake removal scars (see Wright 2006:150).
Ridge Removal Flake	Long, blade-like microblade core preparation flakes that are triangular in cross-section (Wright 2006:150).
Early Biface Thinning	Flakes which have curved cross-sections, narrow and/or lipped and faceted platforms, and one or two major dorsal arrises.
Late Biface Thinning	Flakes with curved cross-sections, narrow/lipped and faceted platforms, three or more dorsal arrises, and often more intensively prepared platforms than the earlier thinning flakes.
Pressure Flakes	Flakes with a simple or complex dorsal surface, a platform that may be oblique or perpendicular to the longitudinal axis, and includes edge preparation/pressure flakes (i.e., small flakes that retain remnants of tool or core margins and show complex dorsal surfaces).
Cortical Flake Fragment	Broken piece of a cortical flake.
Simple Interior Fragment	Broken piece of a simple interior flake.
Complex Interior Fragment	Broken piece of a complex interior flake.
Cortical Shatter	Small, chunky pieces of debitage that exhibit any cortex.
Angular Percussion	Cuboidal or chunky pieces of debitage without cortex.
Indeterminate Percussion	Whole interior flakes that cannot be categorized because of weathering or some other hindrance; indeterminate pressure, whole pressure flakes which could not be assigned to another pressure flake type.
Pressure Fragment	Broken pressure flakes that cannot be further classified.

Table 5.5 Lithic Reduction Classification.

Reduction Group	Description
Decortication	Combines all cortical flakes (primary, secondary, and shatter) and represents material from the initial or "primary" reduction of raw tool stone masses and/or the production of large, cortical flake blanks.
Interior Percussion	Includes the two interior flake types (simple, complex), typifying debris from the "secondary" core reduction stage that involves the shaping and thinning of non-bifacial and bifacial cores.
Biface Thinning	Accounts for both early and late biface thinning flakes, representing the percussion-thinning of already shaped bifacial cores and bifacial tool preforms .
Pressure	These flakes constitute the final, or "tertiary" stage of tool production, shaping, and maintenance (retouch); in bifacial reduction modes, late-stage biface thinning flakes may also be considered part of tertiary reduction.
Microblade	Includes three flake types associated with the production and maintenance of microblade cores (ridge removal, platform removal, and interior linear flakes).
Indeterminate	Includes three flake types (angular shatter, cortical shatter, indeterminate percussion). This group is normally omitted from technological analyses, as it contains only undiagnostic flakes and fragments.

6.0 Study Results: Archaeological Survey

This chapter is divided into four parts. The first section (Section 6.1) presents findings from field survey that took place between 2018 and 2019. It begins with a brief presentation of survey results across broadly defined environmental zones (i.e., lakebed, upland, and lowland), followed by an assessment of patterns over time (Section 6.2). Section 6.3 incorporates more fine-grained environmental data relating to landform, water, vegetation, and elevation to assess the relationship between settlement and the natural environment. A discussion of the environmental characteristics selected for this study is presented in Chapter 5.

The examination of settlement trends in these first sections describe how populations distributed themselves across three broad environmental zones over time, providing a basis from which to compare land use strategies between hunters and herders. As discussed in Chapter 5, the study employs the area-density index as a relative population estimate based on the distribution of archaeological materials that facilitates an estimation of the intensity of human utilization of the landscape across space and time, as well as an approximation of relative group size (Drennan et al. 2015:34). This index is a continuous-scale population proxy based on the idea that more people in one location for a longer period of time will result in debris scatters that are either larger in extent or in density (Drennan et al. 2015:37). The chapter concludes with a summary of the survey findings (Section 6.4).

6.1 Survey Description and Settlement Distribution

A stratified systematic survey was carried out at the Ikh Nart Nature Reserve over a period of eight weeks in 2018 and 2019. A total of 592 square quadrats (2.07 ha each) was systematically selected across each environmental zone, for a total of 1,225.44 ha surveyed (Table 6.1 and Figure 6.1). Collections were made in a total of 4305 collection units discovered in this way. The sampling fraction varied from one zone to another, but the sample size in each was determined to achieve estimates of artifact proportions in each environmental zone with error ranges of approximately ±5% at the 90% confidence level, appropriate for comparing population proportions across space and time (Drennan 2010:142).

Table 6.1 Summary of Survey Results.

Environ. Zone	Zone Area (HA)	No. of Quadrates Possible (2.07 ha)	No. Quadrats Surveyed (2.07ha)	Total Survey Area (ha)	% of Total Survey	% of Zone Surveyed	No. Quadrats w/ Collection Units (No. Collection Units)	Proportion of Quadrats w/ Collection Units*
Lakebed	6825	3,297.1	199	411.93	33.68	6.01	41 (84)	20.60 ±4.7
Upland	27,281	13,179.23	223	461.61	37.67	1.69	79 (270)	35.43 ±5.3
Lowland	10,585	5,113.53	170	351.9	28.65	3.31	24 (51)	14.12 ±4.4
All	**44,691**	**21,589.86**	**592**	**1,225.44**	**100.00**	**-**	**144 (405)**	**22.63 ±2.8**

Using the criteria outlined in Chapter 5, artifact collection units within each survey quadrat were assigned temporal component designations; collection unit size and artifact count for each component were used to develop an area-density index (average collection unit area in hectares multiplied by the artifact density expressed in artifacts/cubic meter). This number was then corrected for period duration by dividing it by the number of centuries represented in the target period (Table 5.3). The resulting corrected period area-density index provides the basis for two relative proxy measures including *landscape utilization* and *intensity of use (i.e., local group size or duration of occupation)*

Landscape utilization for each period was assessed using an estimated total area-density index for each period within each zone. This was calculated by dividing the total of all observed period area-density indices of collection units in a zone (Table 6.2 column e) by the percentage of survey coverage in that zone (Table 6.2, column a).

Evaluation of temporal and spatial land use patterns was facilitated by calculating the estimated *proportion* of all estimated period area-density indices observed in each zone (Table 6.2, column g). A comparison of proportions over time (including confidence levels of 80%, 95%, and 99%) is depicted in Figure 6.2. Data are presented for Neolithic, Bronze Age, Iron Age, Xiongnu, and Kitan periods; Early Bronze Age and Turkic Period datasets were too small for meaningful comparison (only 9 and 3 positive quadrats, respectively).

Within each quadrat, clusters of collection units dating to the same period were delineated as "sites" or local groups, entities whose members likely engaged in interaction on a near daily basis (Drennan et al. 2015:53). The corrected period area-density index calculated for each site was used to track changes in intensity of use (i.e., group size or duration of occupation). Specifically, the *median value* for each period was calculated for each zone to examine spatial and temporal population trends (Table 6.2, column i).

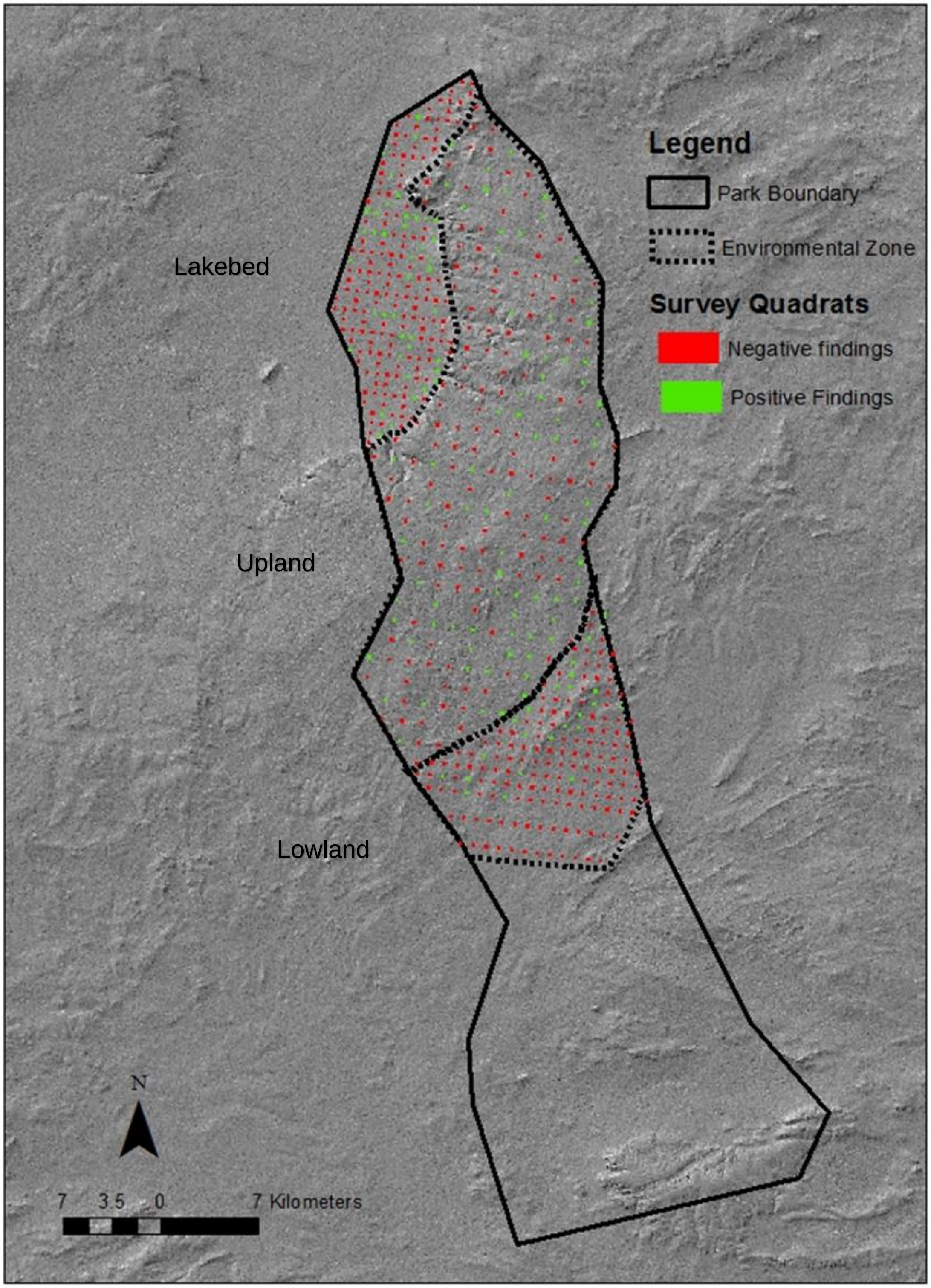


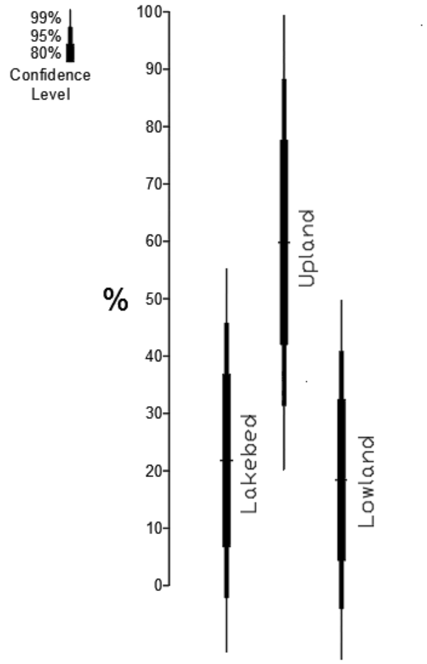
Figure 6.1 Survey areas and quadrats, Ikh Nart Nature Reserve, Mongolia.

Table 6.2 Time Component Summary by Survey Area.

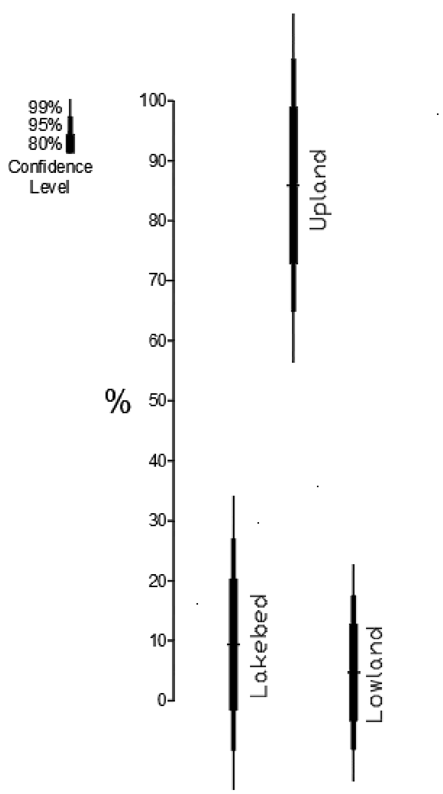
(a) Zone	(b) # Quadrats surveyed/ # Quadrats (Zone)	(c) #/ % Positive Quadrats Observed (Zone)	(d) Est. No. Positive Quadrats (Zone)	(e) Total Observed Period ADI (Zone)	(f) Est. Total ADI (Zone)	(g) Est. % Period ADI (All Zones)	(h) No. Sites	(i) Median ADI Period Sites
Lakebed (6.04% Survey)								
Neolithic/ Oasis 2 (8000-5500 BP)	199/ 3297.1	31/15.58	513.6	0.18305	3.02	21.84	31	0.00038
E. Bronze/Oasis 2/3 (5500-4500 BP)	199/ 3297.1	0	0	0	0	0	0	0
Bronze/ Oasis 3 (4500-3000 BP)	199/ 3297.1	11/5.53	182.30	0.074139	1.22836	9.38	11	0.002
Iron (3000-2300 BP)	199/ 3297.1	8/4.02	132.547	0.018623	0.30855	6.16	8	0.00129
Xiongnu (2300-1600 BP)	199/ 3297.1	3/1.51	49.705	0.00134	0.022202	0.32	3	0.00038
Turkic (6-8th c. AD)	199/ 3297.1	1/0.50	16.568	0.001303	0.021573	3.77	1	0.00130
Kitan (10-12th c. AD)	199/ 3297.1	2/1.01	33.136	0.002469	0.040907	0.85	2	0.001235
Upland (1.69% Survey)								
Neolithic/Oasis 2 (8000-5500 BP)	223/13179.23	55/24.66	3250.483	0.14053	8.30528	59.80	55	0.0006
E. Bronze/Oasis 2/3 (5500-4500 BP)	223/13179.23	8/3.59	472.797	0.081883	4.844970	99.79	8	0.0016
Bronze/ Oasis 3 (4500-3000 BP)	223/13179.23	38/17.04	2245.788	0.190311	11.24732	85.90	38	0.00189
Iron (3000-2300 BP)	223/13179.23	37/16.592	2186.688	0.277084	13.421	91.72	37	0.00188
Xiongnu (2300-1600 BP)	223/13179.23	33/14.798	1950.290	0.1162	6.87	98.82	34	0.00198
Turkic (6-8th c. AD)	223/13179.23	2/0.896	118.199	0.009509	0.562663	96.23	2	0.00475
Kitan (10-12th c. AD)	223/13179.23	22/9.865	1300.193	0.268962	15.9	92.93	23	0.0094760
Lowland (3.3% Survey)								
Neolithic/Oasis 2 (8000-5500 BP)	170/5113.53	14/8.235	421.1142	0.08476	2.549546	18.36	14	0.00078
E. Bronze/Oasis 2/3 (5500-4500 BP)	170/5113.53	1/0.588	30.080	0.00034	0.010210	0.21	1	0.00034
Bronze/Oasis 3(4500-3000 BP)	170/5113.53	9/5.294	270.716	0.020562	0.618647	4.72	9	0.000806
Iron (3000-2300 BP)	170/5113.5	5/2.941	150.398	0.006357	0.191216	2.11	5	0.001587
Xiongnu (2300-1600 BP)	170/5113.5	4/2.353	120.318	0.00202	0.06076	.863	4	0.00053
Turkic 6-8th c. AD)	170/5113.5	0	0	0	0	0	0	0
Kitan (10-12th c. AD)	170/5113.5	2/1.176	60.159	0.018005	0.541538	6.22	2	0.00902

***some quadrats have multiple components; not all control units could be assigned a time component.**

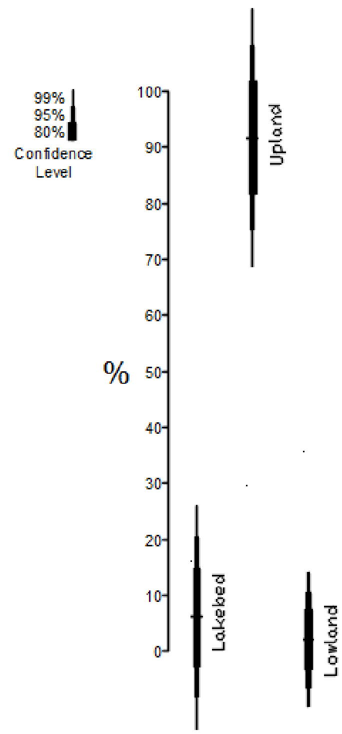
a) Neolithic



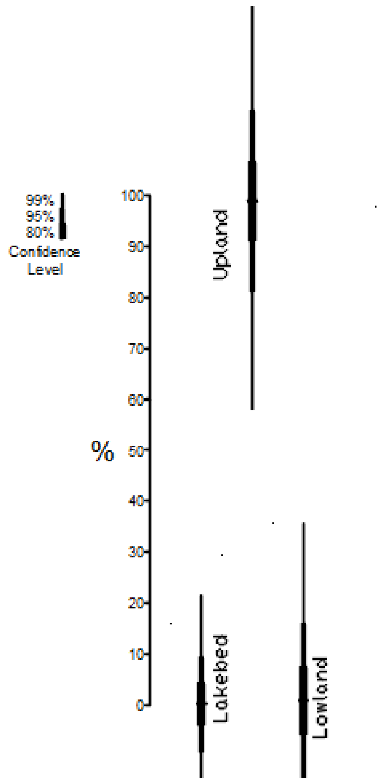
b) Bronze Age

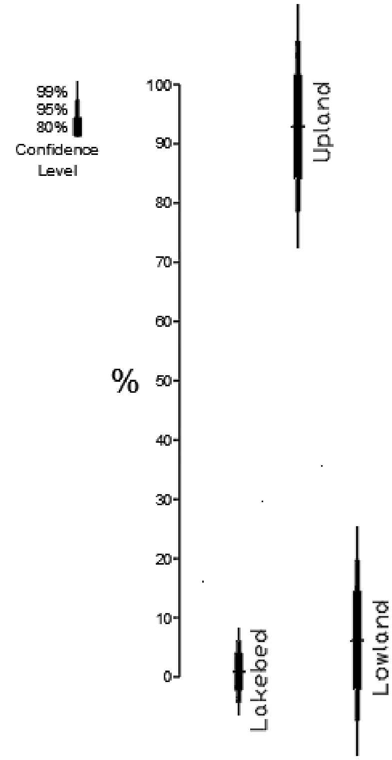


c) Iron Age



d) Xiongnu





e) Kitan Period

Figure 6.2 Proportion of area-density index by period and environmental zone .

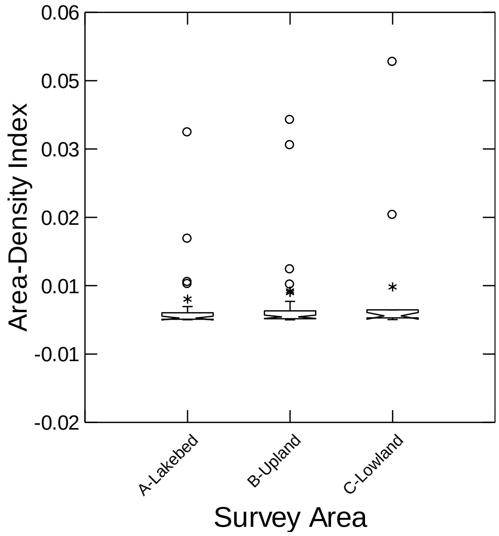
6.2 Settlement Trends by Period

6.2.1 Neolithic/Oasis 2 (8000-5500 BP)

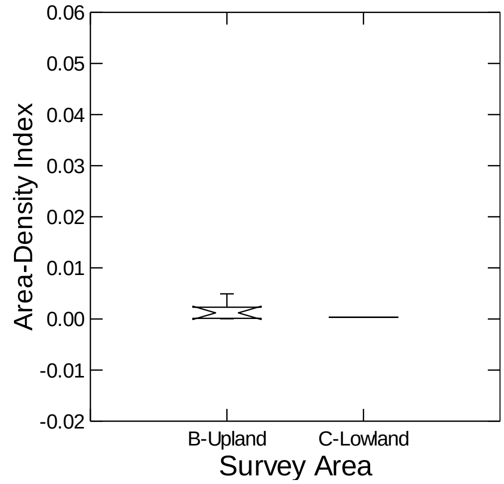
Neolithic age sites were recorded in 100 survey quadrats across the three environmental zones, comprising between 8% and 25% of survey quadrats in each zone (Table 6.2c). Upland environs were favored during this period, holding nearly 60% of the total estimated Neolithic land use (Table 6.2g and Figure 6.2a). The proportion of Neolithic area-density index observed in the upland zone falls outside the 99% confidence error range for the lakebed and lowland samples, demonstrating a high level of assurance that these areas were targeted to different extents, with upland areas strongly favored. Lakebed and lowland contexts were targeted to a lesser degree, with little difference in utilization (estimated mean for each are well within the 80% confidence level error range for the other).

Area-density indices corrected for period duration are variable but overall, very low for all Neolithic sites, indicating low yet comparable local population (i.e., small group size or short period of occupation) across all environmental zones (Table 6.2i). Overlapping median values depicted in the notched box plot illustrated in Figure 6.3a indicate that samples likely derived from similar populations. All areas exhibited a range of population measures (Figure 6.4a); comparison of transformed indices (level and spread removed) shows that all areas had a number of sites that exceeded or far exceeded the median area-density index, possibly indicating areas of special importance (Figure 6.4a). The location of Neolithic sites and corresponding period corrected area-density indices are depicted in Figure 6.5.

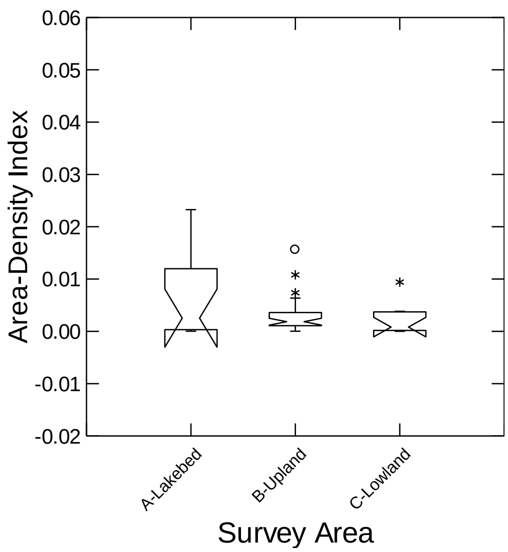
a) Neolithic



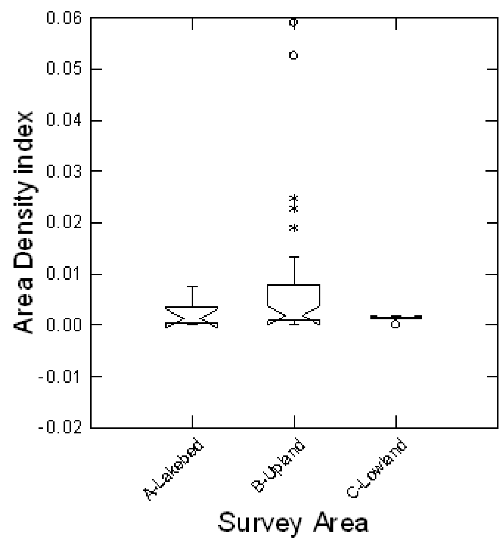
b) Early Bronze Age



c) Bronze Age



d) Iron Age



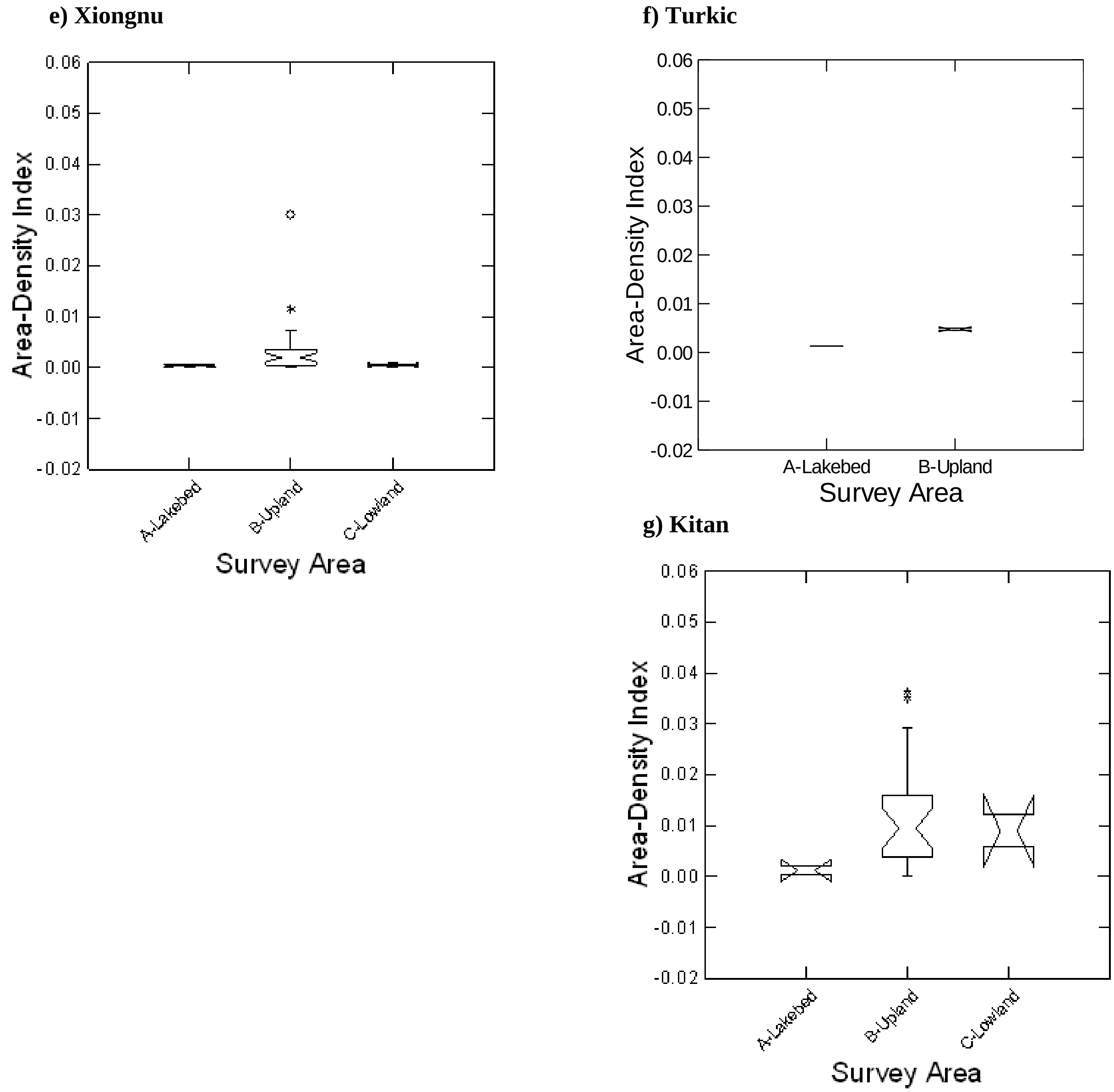
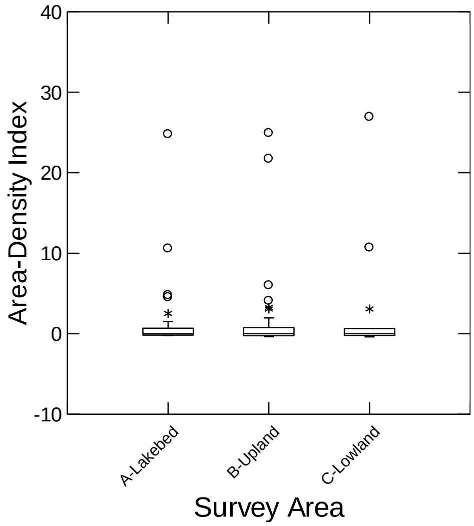
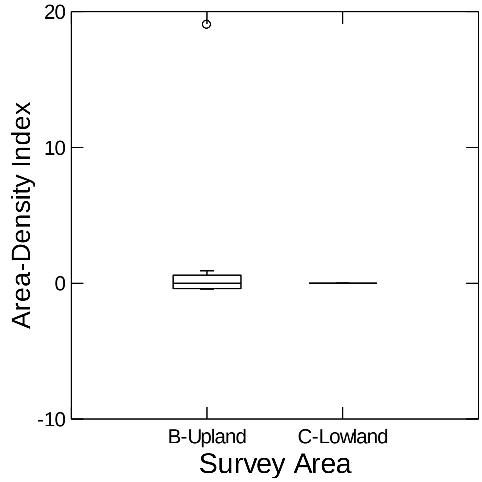


Figure 6.3 Median area-density index by period and environmental zone (box plot showing with 95% confidence interval).

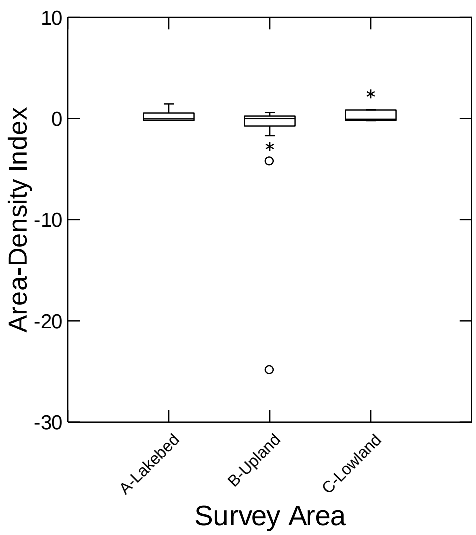
a) Neolithic



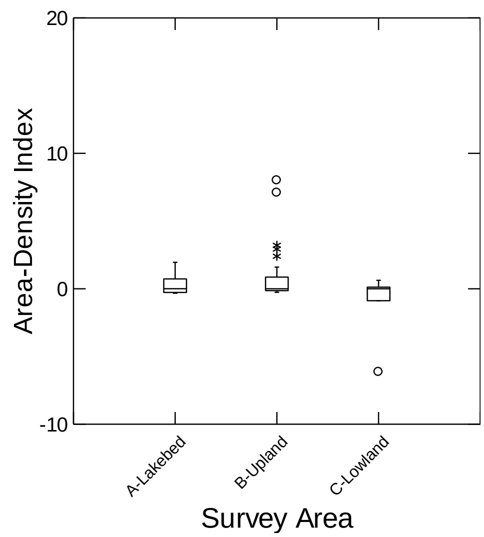
b) Early Bronze Age



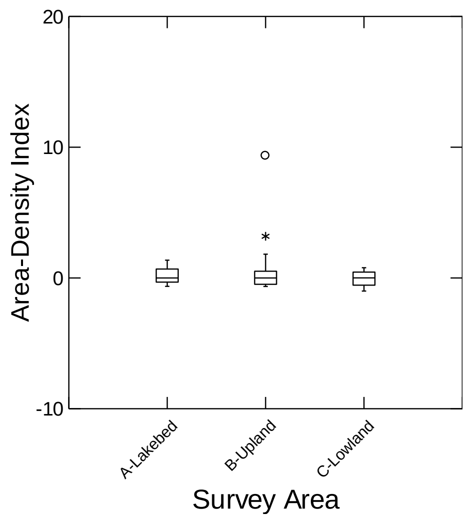
c) Bronze Age



d) Iron Age



e) Xiongnu



f) Kitan

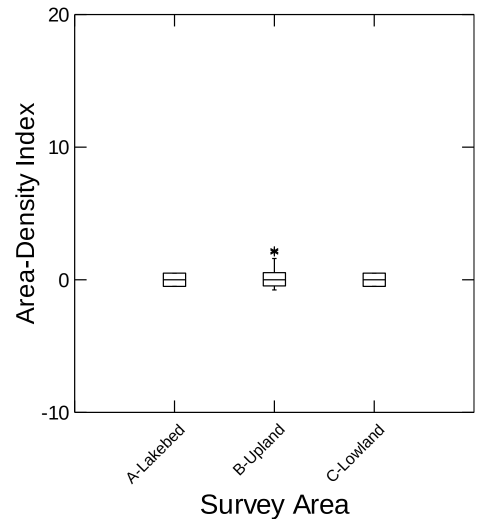


Figure 6.4 Median area-density index by period and environmental zone (level and spread removed).

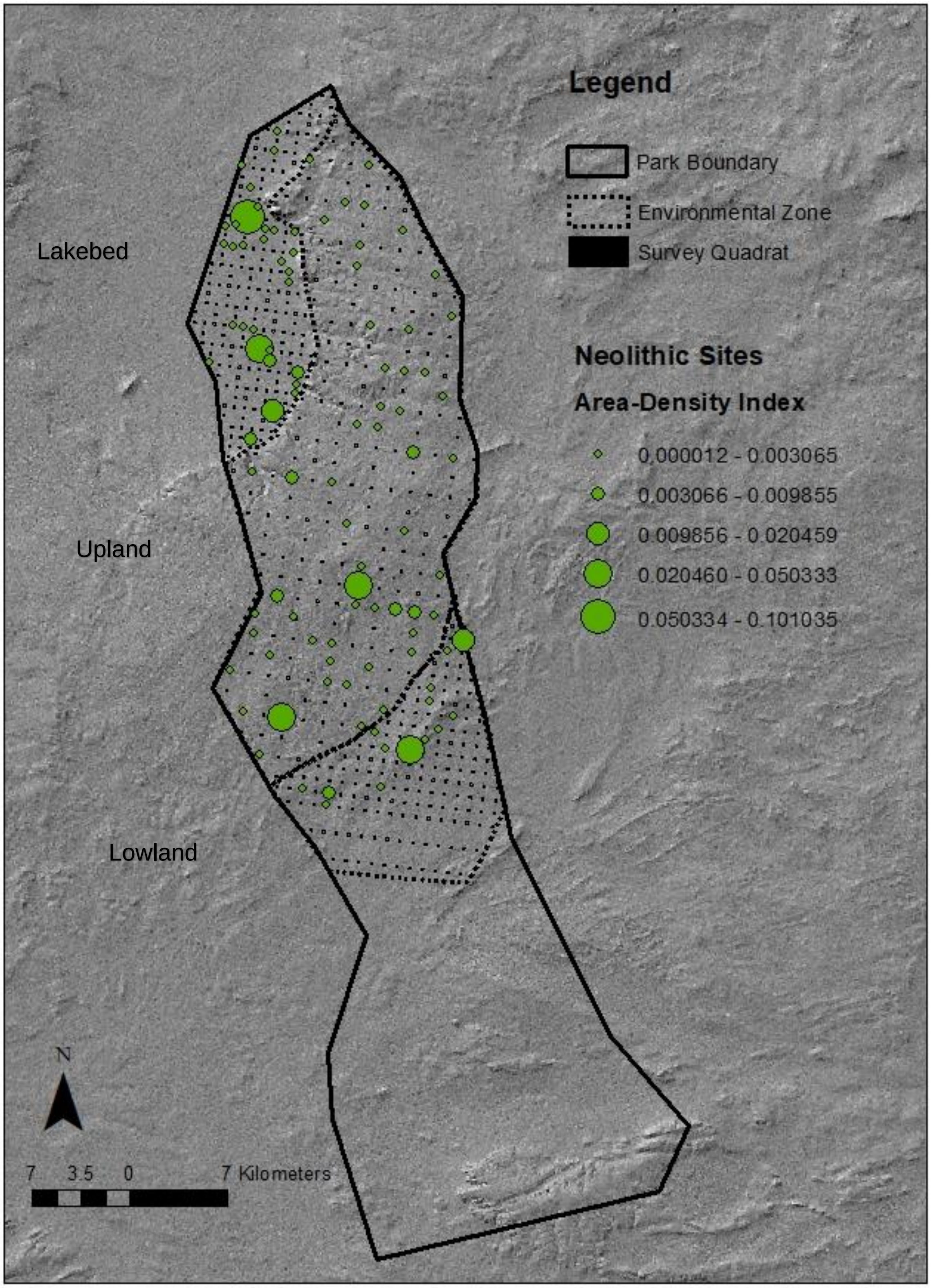


Figure 6.5 Corrected area-density indices for Neolithic sites.

6.2.2 Early Bronze Age/Oasis 2-3 Transition (5500-4500 BP)

A small number of Early Bronze Age sites were recorded (*n*=9), all but one found in the upland zone (Table 6.2h). Sites dating to this era were relatively rare, occurring in only 0.6% to 4% of survey quadrats in each zone (Table 6.2c). Corrected area-density indices for Early Bronze Age sites in upland areas are low (Table 6.2i); the median index for period sites is notably larger than the Neolithic sites (approximately at 95% confidence level), possibly indicating an increase in intensity of use at the start of the Bronze Age (e.g., group size or length of occupation) (Figure 6.6). The single site observed in the lowlands has a very small area-density index suggesting smaller local group size (or length of stay) than contemporary upland sites, and smaller than Neolithic age lowland sites. The small sample of Early Bronze Age sites, however, make it impossible to draw conclusions with even a moderate level of confidence (Figure 6.3b). Figure 6.7 depicts the location of Early Bronze Age sites and corresponding period area-density indices.

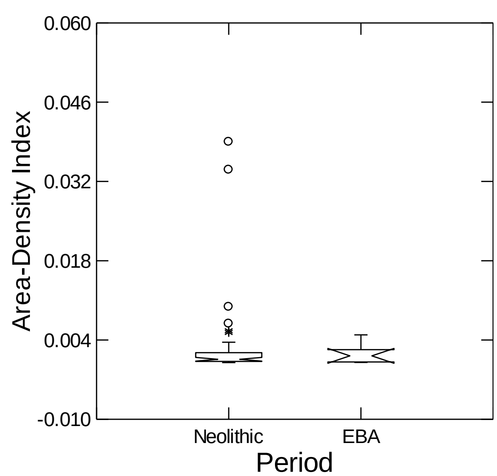


Figure 6.6 Comparison of Upland Neolithic and Early Bronze Age median area-density indices (95% confidence interval).

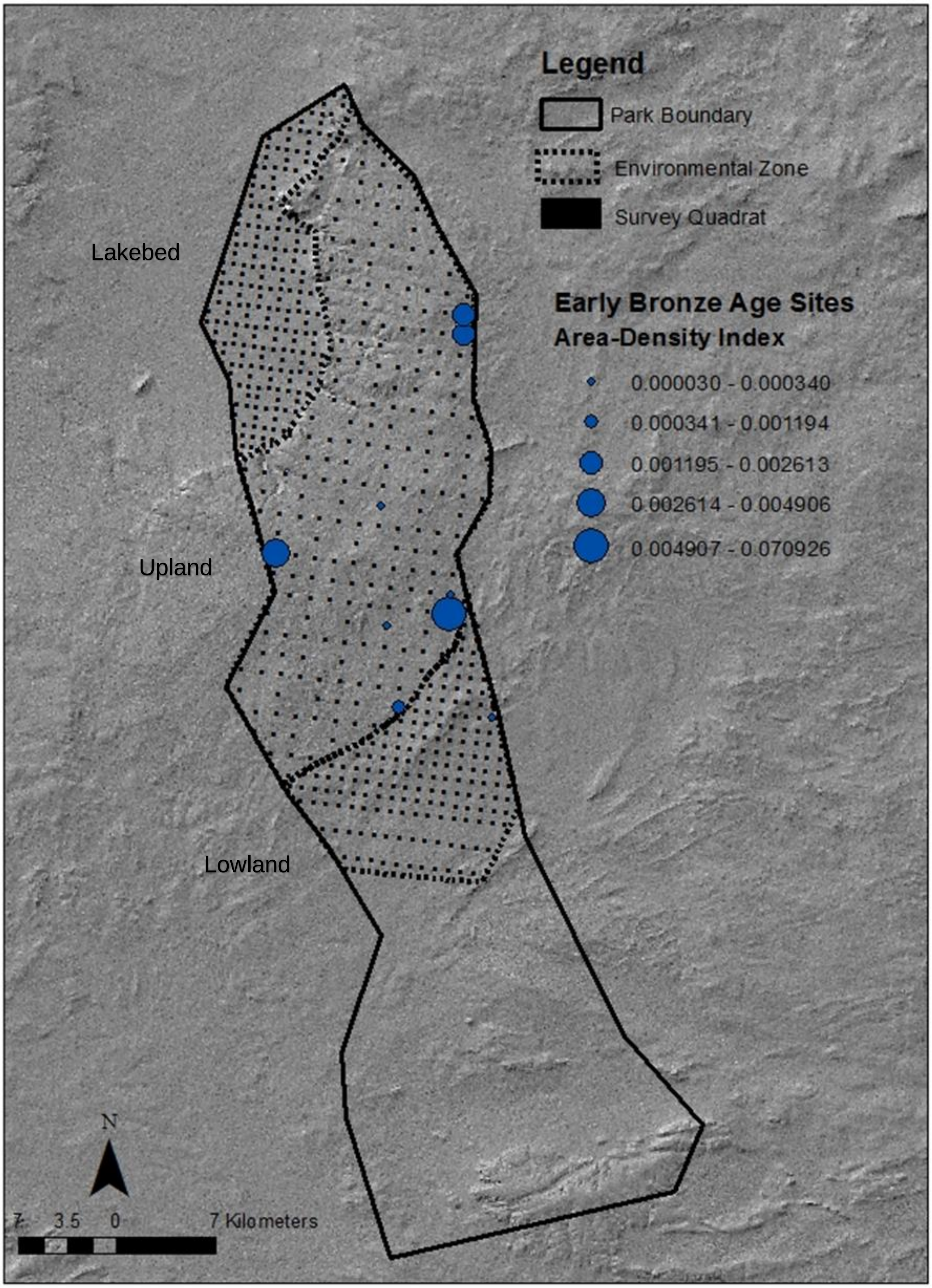


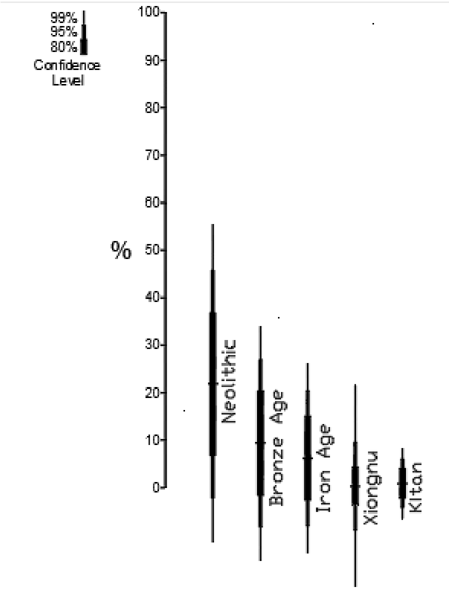
Figure 6.7 Corrected area-density indices for Early Bronze Age sites.

6.2.3 Bronze Age/Oasis 3 (4500-3000 BP)

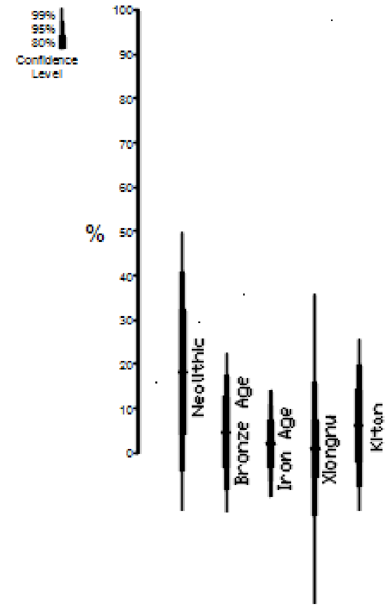
Bronze Age components (*n*=58) are less abundant than Neolithic age, comprising between 5% and 17% of survey quadrats in each area (Table 6.2c). Upland areas saw increased use from Neolithic times, with nearly 90% of the total estimated areas-density index for this interval occurring in this zone (Table 6.2g and Figure 6.2b). Use of lakebed and lowland areas decreased from Neolithic times, together, making up around 10% of the total period index (Table 6.2g).

The increased use of upland regions at the expense of lakebed and lowland zones during the Neolithic-Bronze Age transition may signal a narrowing of habitat preference, possibly related to the introduction of herding practices proposed for this interval. While indeed intriguing, trends in land use change are not robust. For example, differences in use of the upland zone over time hold a high level of statistical significance (between 95% and 99% confidence level as depicted in Figure 6.8c), while differences in use of lowland and lakebed zones are less strong (just within the 80% confidence level depicted in Figure 6.8a,b).

a) Lakebed



c) Lowland



b) Upland

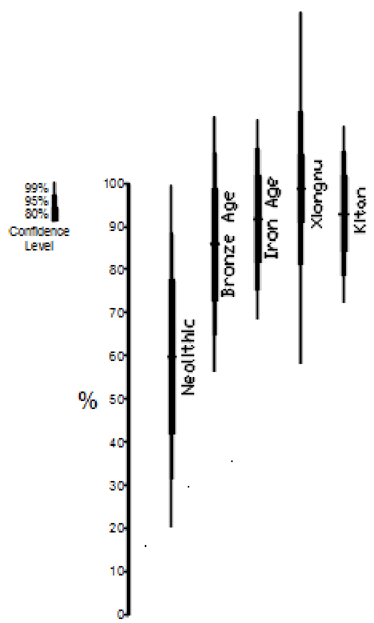


Figure 6.8 Proportion of area-density index by area and period.

Area-density indices corrected for period duration are variable but overall very low for all Bronze Age sites, indicating comparable populations (small group size or short duration of occupation) across all environmental zones (Table 6.2i). Overlapping median values depicted in the notched box plot illustrated in Figure 6.3 (c) indicate that samples derived from similar populations. Comparison of transformed indices in Figure 6.4c does show that upland and lowland areas had sites that deviated from the median, however the occurrence is lower than in the Neolithic sample (Figure 6.4a), signaling decreased variability (increased uniformity) in population size during this time.

Compared to the Neolithic occupations, intensity of use during the Bronze Age appears to have increased in both upland and lakebed settings, but declined in lowland contexts. Of interest here, is the increase intensity of lakebed occupations as the overall utilization of this zone decreased. Though fewer in number, local groups were somewhat larger (or staying for longer periods) than during the Neolithic, with occupations situated primarily on elevated terraces near large draws that drain the adjacent upland zones (Figure 6.9). By the Bronze Age, smaller encampments are relatively rare in lakebed settings.

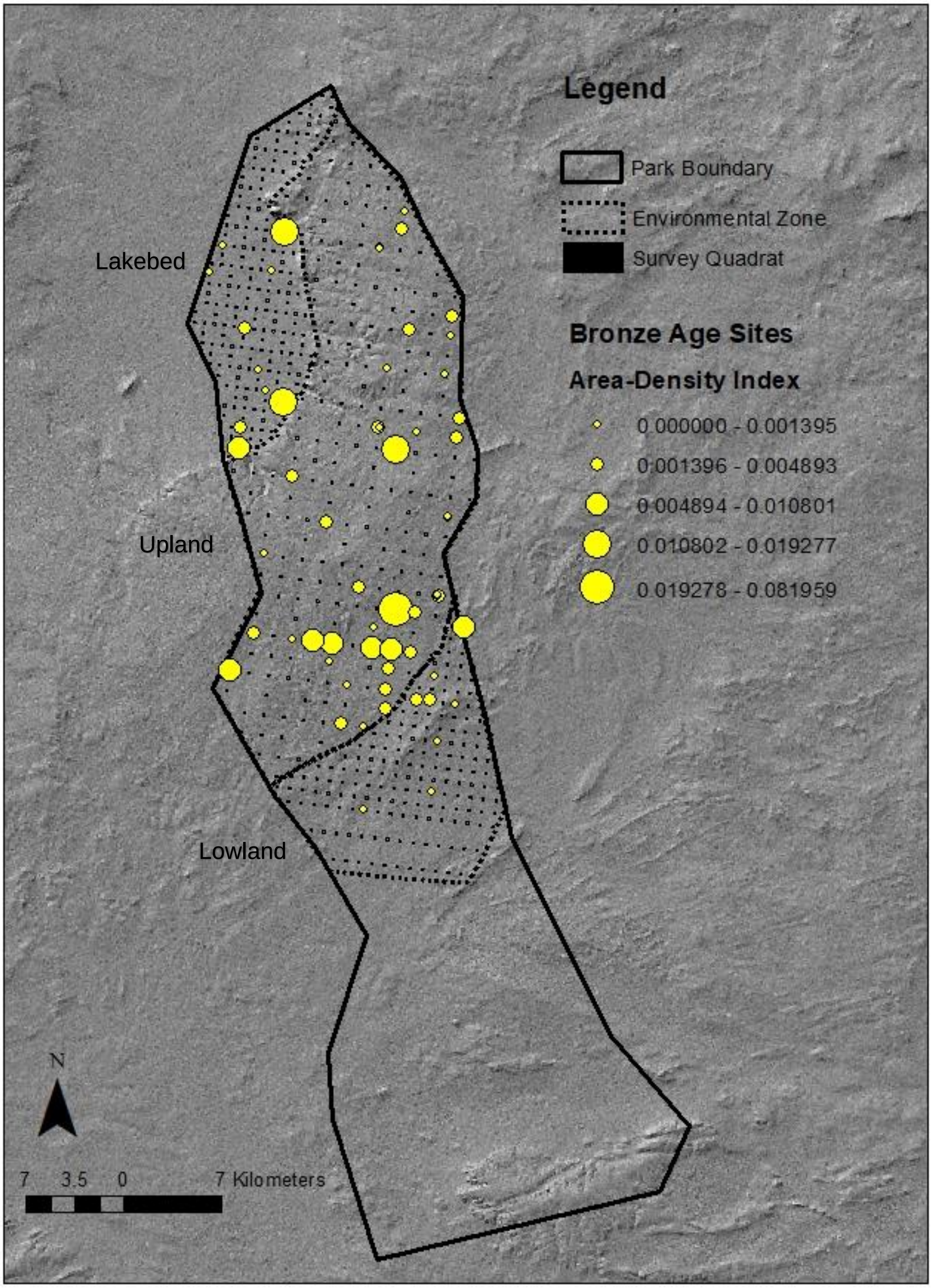


Figure 6.9 Corrected area-density indices for Bronze Age sites.

6.2.4 Iron Age (3000-2300 BP)

Land use patterns observed in the Iron Age dataset are similar to those of the Bronze Age, though they do demonstrate a slight narrowing of habitat preference. Period components were observed in 50 of the survey quadrats, making up 3-17% of quadrats in each area (50 sites recorded) (Table 6.2). Uplands are highly favored, making up over 97% of the period area-density index (Figure 6.2c), though the increased focus on of upland settings compared to the Bronze Age has low statistical significance (below 80% confidence level) (Figure 6.8c). Comparison with Neolithic trends, however, does signal a meaningful increase in use of these environments over time (95-99% confidence level). In other words, as herding practices became more entrenched, people focused more on upland resources, with decreasing use of surrounding lakebed and lowland contexts.

Area-density indices for Iron Age sites are low to very low (Table 6.2i and Figure 6.3d), demonstrating a continuation of low population density across all zones. Overlapping median values indicate that all samples represent similar populations (Figure 6.3d). Local communities in lakebed and upland areas were slightly smaller (or had shorter-term occupations) than those of the Bronze Age, while those in the lowland were larger/had longer-term occupations during this interval (Table 6.2i). Comparison of transformed indices shows that lakebed and upland areas had several communities that exceed the median population measure, while most communities in the lowland were smaller (Table 6.2d). In lowland and lakebed contexts, there is a notable reduction in the number of sites that exceed (or far exceed) the median compared to presumed Neolithic forager communities. This possibly demonstrates a continued decrease in the variability in the size of local groups with the adoption of a herding economy. The location of Iron Age components and corresponding period corrected area-density indices are depicted in Figure 6.10.

6.2.5 Xiongnu (2300-1600 BP)

Period components were observed in 40 of the survey quadrats with positive findings, making up 7%-42% of area quadrats (41 sites recorded). Patterning among Xiongnu components is similar to that observed in the Iron Age dataset, further demonstrating continued contraction of habitat preference. Nearly 99% of occupations of this interval occur in the upland zone (Table 6.2 and Figure 6.2d). Lakebed sites, while fewer in number, are located further away from elevated terraces and prominent drainages that were preferred during the Neolithic and Bronze Age, are more often situated on open dune field and associated grasslands, indicating a shift in habitat preference for established herding communities.

Across all zones, area-density indices for Xiongnu sites area very low, indicating an overall decrease in local group size or length of stay compared to previous intervals (Table 6.2 and Figure 6.3e). Despite the increased use of upland zones, populations appear to have become uniformly smaller, with an overall decline in the proportion of sites that exceed the median value for each zone (Figure 6.4e) (Figure 6.11).

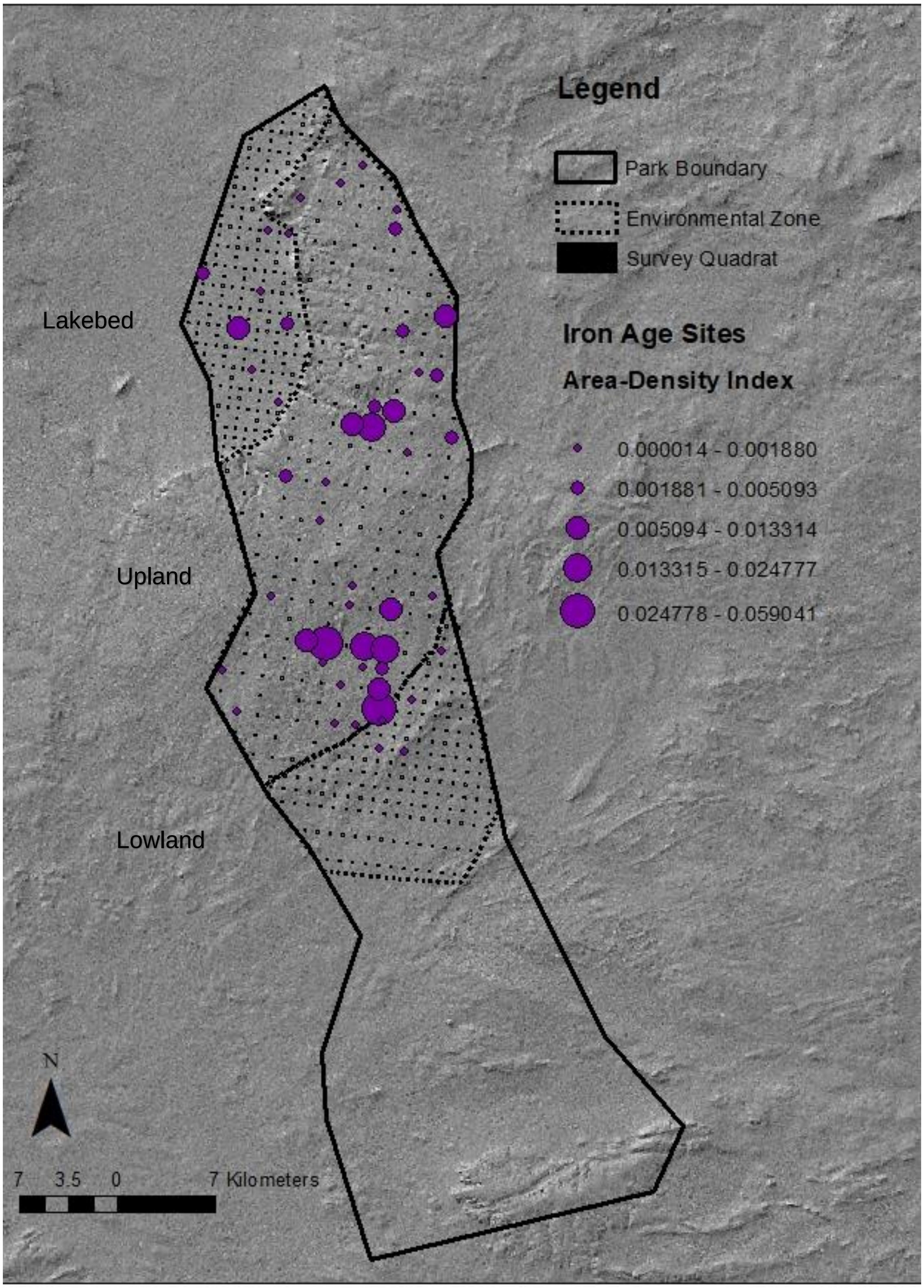


Figure 6.10 Corrected area-density indices for Iron Age sites.

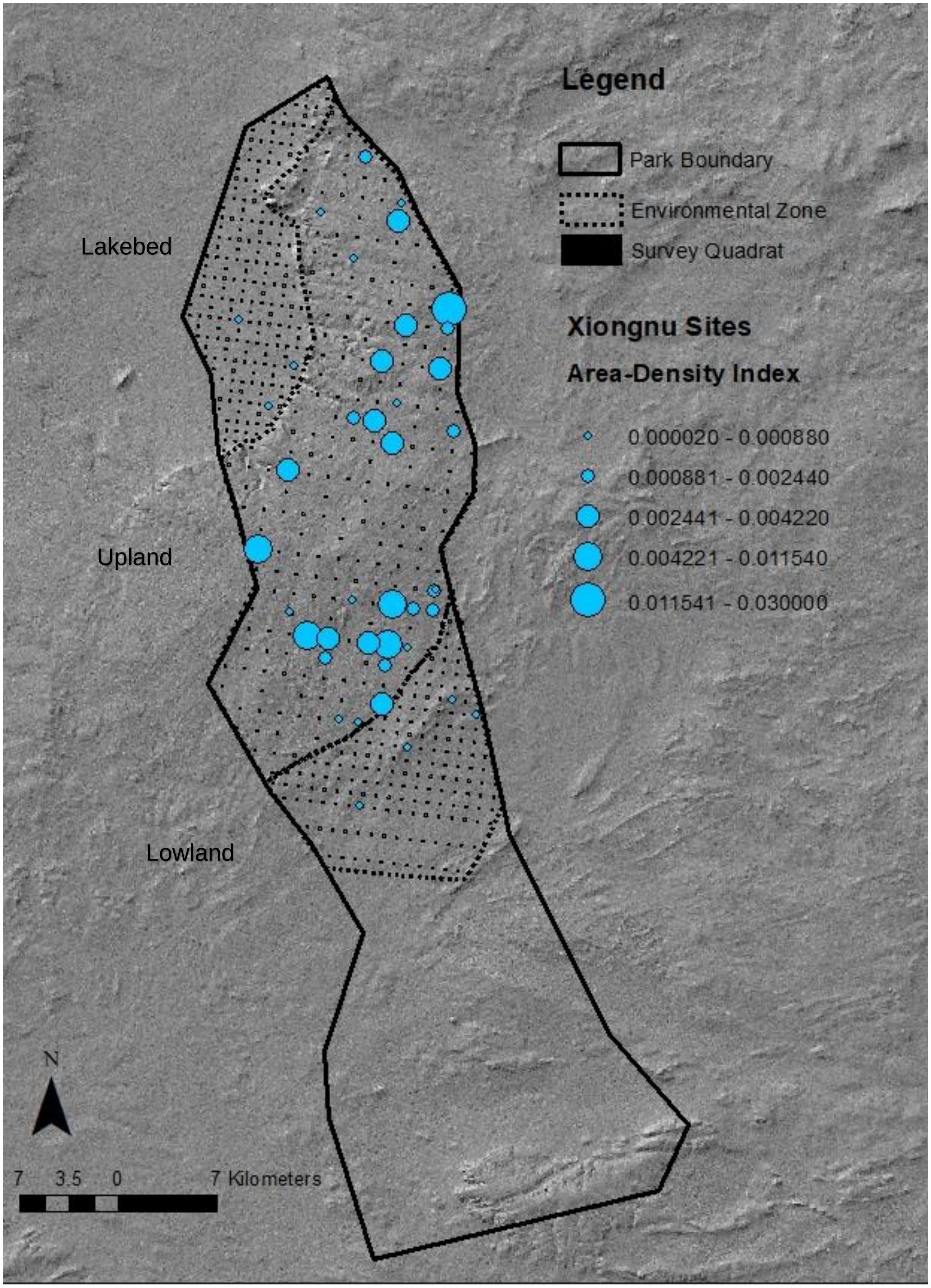


Figure 6.11 Corrected area-density indices for Xiongnu sites.

6.2.6 Turkic (6-8th c. AD)

Only a small number of the survey quadrats contained Turkic Period components (*n*=3), including one in the lakebed area, and two in the uplands (Table 6.2). Sites dating to this era were relatively rare, making up less than 1% of all survey quadrats. Corrected area-density indices for Turkic Period components are low, though, they are higher than Xiongnu assemblages, and close to values observed in Iron and Bronze Age sites (Table 6.2), suggesting an increase in local group size during this period. As demonstrated in Figure 6.3f, median area-density indices are very different between the two occupied zones (greater than 95% confidence interval), signaling larger or longer term occupations in upland areas. That said, the sample of sites dating to this period are too low to make meaningful comparisons. Figure 6.12 shows the location of Turkic era sites and corresponding period area-density indices.

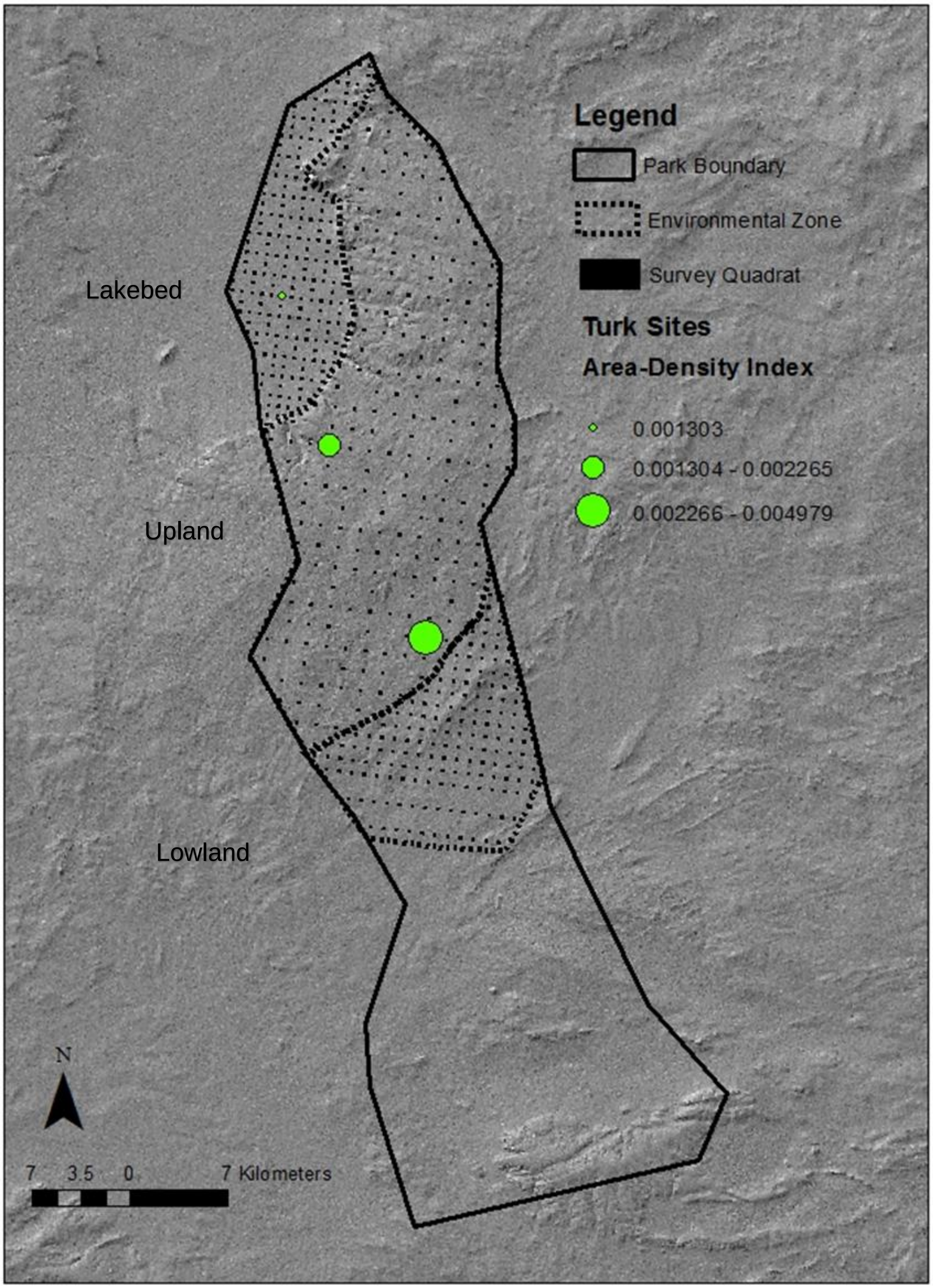


Figure 6.12 Corrected area-density indices for Turkic Period sites.

6.2.7 Kitan (10-12th c. AD)

Period components were observed in 26 of the survey quadrats, making up 1-10% of area quadrats (27 sites recorded). Patterns noted in the Kitan dataset are nearly identical to the Xiongnu, further demonstrating continuity in post-Bronze Age trends. As with all other periods, components were most common in upland areas, indicating restricted use of surrounding lakebed and lowland contexts (Figure 6.13), though proportions are not statistically different from Bronze Age-Xiongnu occupations (Figure 6.8c).

Corrected area-density indices for Kitan sites are low, comparable to the Turkic Period, and notably higher than Xiongnu in lowland and upland zones (Table 6.2i and Figure 6.3g). Median values for the lakebed fall outside the 95% confidence level of upland and lowland samples, indicating this region was not an important draw during this time. Variability in group size/length of occupation across all zones is low, with few sites deviating from the median value (Figure 6.4f).

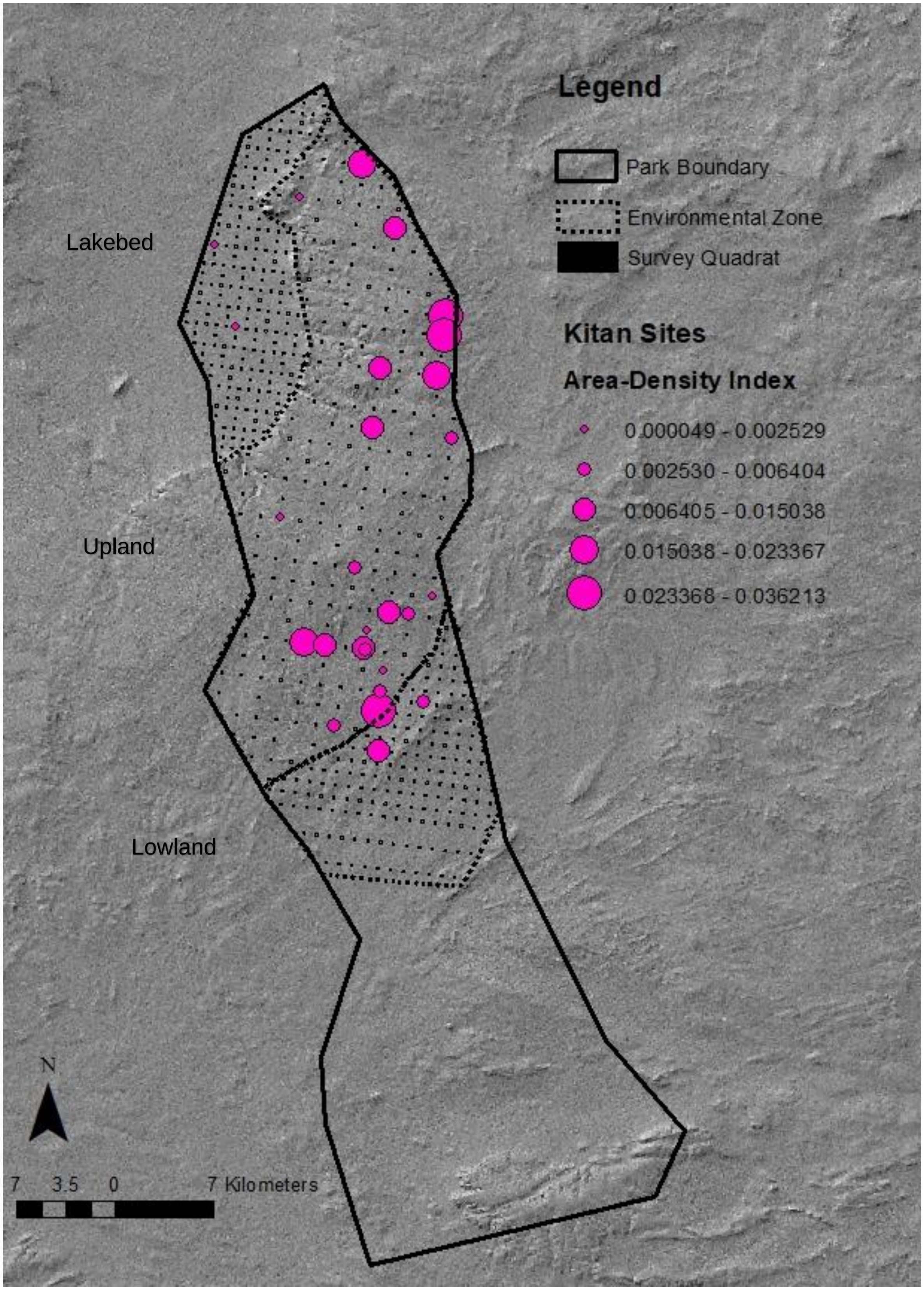


Figure 6.13 Corrected area-density indices for Kitan Period sites.

6.2.8 Discussion of Settlement Distribution

Considering temporal trends across broadly defined environmental zones, some important patterns emerge. Most notable is the predominance of occupations in upland regions across all periods, demonstrating its importance to both hunting and herding economies. This finding is not surprising given the range of life-supporting resources in this zone that that no doubt attracted animals and human populations, both past and present. For example, the extensive granite formations that characterize this area provide much needed shade in the summer and afford protection from extreme cold north winds in winter months. The area is also marked by numerous springs, seasonal watercourses, and a mosaic of grassland and riparian vegetation, providing food water and shelter for both human and animal populations. Today, the upland area is also an important migration corridor for Argali sheep and supports a range of other large mammals that may have been an important resource for hunters in the past (e.g., ibex, gazelle).. Local population measures (i.e., median period area-density index) are variable but with two notable increases; the first between the Neolithic and Bronze Age, the second during the Kitan era, which also saw the largest area-density index of all phases (Figure 6.14). The initial post-Neolithic increase in median area-density index noted in the upland zone corelates positively with a moderate increase in utilization (Figure 6.8c) illustrating a perceptible shift away from lakebed and lowland resources as herding practices were introduced. No noticeable shift in use of upland areas accompanied the increased local population size during the Kitan era, indicating continued infilling of preferred herder settings.

Broadly speaking, lake basin contexts were used less frequently than upland zones across most periods; however, during the Neolithic the area appears to have played an important role in settlement strategies of hunter-gatherer populations. Many of the largest Neolithic components in this area are found along the border between upland and lakebed zones, situated near the mouths of prominent draws that drain adjacent upland regions. Water resources including ephemeral lakes, ponds and drainages are relatively abundant today, and support an array of wetland and riparian plant communities (will add photos here Area-density indices of lakebed occupations are low across all periods, thought the small sample size from all post-Neolithic periods (*n*=1-10), make statistically meaningful comparison impossible.

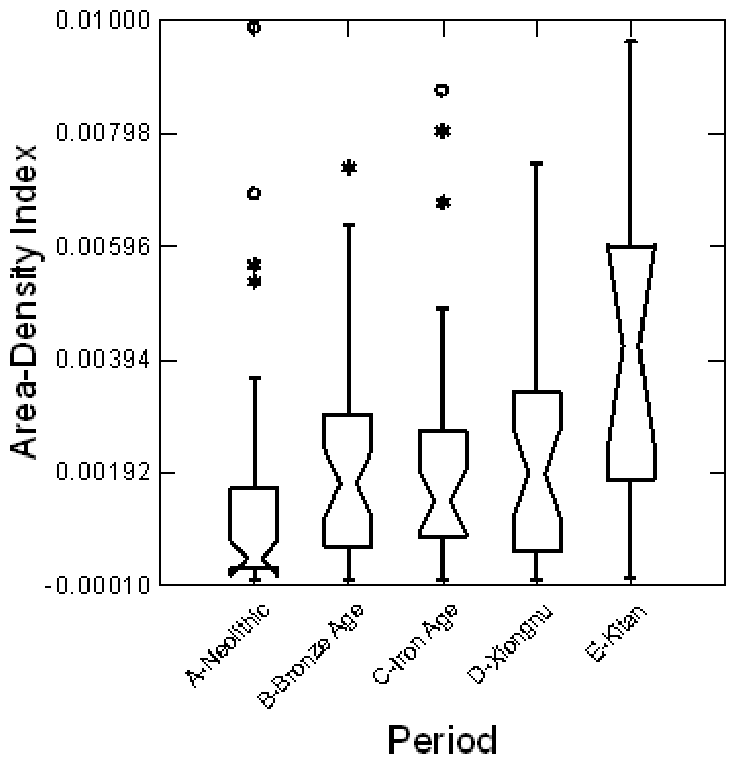


Figure 6.14 Box plots showing median area-density index of the upland zone over time (95% confidence interval).

Patterns in the lowlands mirror those of the lakebed, with most frequent use during the Neolithic, and decreasing over time. Most of the sites observed were in the northernmost reach of the survey unit, situated along the gently sloping contact between the granite formation to the north and flat plains to the south. Despite an abundance of wetland areas and extensive grasslands across the southern portion of this zone, the area was not a primary focus for either foragers or herders for most eras, though growth in local group size/or length of occupation is indicated by an increase in period area-density index during the Kitan era (Table 6.2i). This increase corresponds with an upturn of local group size/length of occupation in the upland zone, possibly signaling an increase in use of secondary habitats as more preferred upland zones faced continued in-filling by herder communities. Alternatively, increased local population could signal an expansion of preferred habitats, possibly related to changes in herd composition, however, we would expect to see an increase in overall utilization of this zone if this were the case. As with the lakebed contexts, occupation intensity of lowland areas was low across all periods, though the small sample of period collection units (each less than 18) does not lend itself to statistical analyses.

Taken together, land use and population data from broadly defined environmental zones seem to indicate a shift in settlement trends sometime after the Neolithic, one that included a decided narrowing of broadly defined settlement contexts. By the Bronze Age, an era presumably marked by increased aridification and experimentation with animal domestication, people seem to have had developed a strong preference for upland locations, with decreasing use of surrounding lakebed and lowland areas. Use of lakebed and lowland habitats persisted to some degree through the Bronze Age, but declined in succeeding periods. In other words, land use strategies established in the Bronze Age are generally persistent throughout all subsequent periods, indicating continuity in habitat selection over time.

6.3 Analysis of Environmental Factors

While the data presented here clearly demonstrate broad differences in how populations were distributed across the three environmental zones over time, understanding how these differences are connected to the development of pastoralism requires that we consider the factors that shaped settlement decisions (Table 6.3). For foragers, we may hypothesize that the most important locations (i.e., highest ranked) are those close to reliable water sources (wetlands, large drainage systems), and those that provide protection from cold northerly winds (e.g., south facing slopes). Early pastoralists would also have favored some of these locations, but would have prioritized areas with forage for herds, especially winter-season vegetation. In other words, upland pastures would be the highest ranked zones for herders. Proximity to large mammal habitats might have been a stronger organizing factor for hunter-gatherers than herding communities; though, early herding communities may have continued to target these resources to a similar degree.

Table 6.3 Environmental Factors Related to Hunting and Herding Economies.

Environmental Factor	Proxy Measure	Importance for Hunter/Gatherers	Importance for Herders
Protection from Elements	Landform location (south facing slopes)	High	High
Water	Proximity to water (drainages, wetlands)	High	High
Pasture	Modern distribution of pasture lands	Low	High
Winter Vegetation	Modern winter NDVI	Low/Medium	High
Large Mammal Habitat	Modern distribution of habitats (above 1600 m asl)	High	Low/Medium

To better understand the factors that shaped settlement decisions over time, it is imperative that we look for patterned relationships within the natural environment, specifically, how population proxies (i.e., area-density index for sites) correlate with pertinent environmental variables including proximity to water, winter vegetation, pasture, and large game habitat. Appendix 1 presents environmental data for each site to evaluate the relationship to land use including winter NDVI (normalized difference vegetation index), potential pasture resource productivity, landform (including protected areas, water features), and elevation. An in-depth discussion on the selection of these factors is presented in Chapter 5.

To understand land use trends we begin by comparing the proportion of area-density index (sum of total observed period area-density index) associated with each environmental factor for each period (Table 6.4, Figures 6.15-34). The connection between environment and population size is then examined using multidimensional scaling, a powerful tool for exploring and discerning patterns among multivariate datasets assembled for each period (Appendix 1). Multidimensional analysis includes an assessment of similarity between sites (by variable) through application of the Gower's Coefficient (Drennan 2010:280) and the development of multidimensional graphical representations of the relationships between sites, with the goal of producing the best rank order correspondence between similarity scores and distance between point pairs as possible, in as few dimensions as possible (Drennan 2010: 285-297). For the current study, three dimensions were determined to provide an effective representation of patterning among the period datasets. Figures 6.35-6.39 present dimensions that depict the clearest trends for each environmental factor by period. In these figures, each symbol represents one archaeological site; the symbol size corresponds to a value for a given environmental factor assigned to that site (e.g., area-density index, winter NDVI rank, pasture/fodder productivity rank, elevation class). Any directional patterning within each dimensional plot is noted with an arrow.

Table 6.4 Proportion of Period Area-Density Index by Environmental Factor.

	Neolithic	Bronze Age	Iron Age	Xiongnu	Kitan
NDVI Rank (increasing)					
5	7.06	7.02	3.74	0.89	6.22
6	56.04	14.36	1.98	8.16	12.19
7	36.90	78.62	94.28	90.95	81.59
Pasture Productivity Rank (Increasing)					
1	23.31	18.29	31.90	17.24	21.72
2	9.63	1.32	4.70	0.64	0.85
3	66.59	80.39	62.80	80.51	70.62
4	0.47	0.00	0.60	1.61	6.80
Landform Classification*					
Upland/interfluvial	52.18	24.27	34.50	28.30	49.30
Low/flat/	2.05	10.80	9.30	14.80	4.70
Upland/low contact	15.15	36.65	26.80	16.30	10.00
Minor Drainage	4.63	18.78	21.10	30.50	33.00
Major Drainage	0.52	3.10	7.40	8.70	3.00
S. Facing Hill	19.32	3.30	0	1.40	0
N. Facing Hill	6.15	3.10	0.90	0	0
Elevation (m asl)					
1040-1100	26.01	1.33	5.00	0.60	0.90
1100-1160	20.29	25.70	1.80	5.70	16.80
1160-1220	37.28	58.37	77.10	47.60	34.30
1220-1280	16.42	14.60	16.10	46.10	48.00

Some site locations have multiple landform features (e.g. upland, lowland contact with minor drainage).

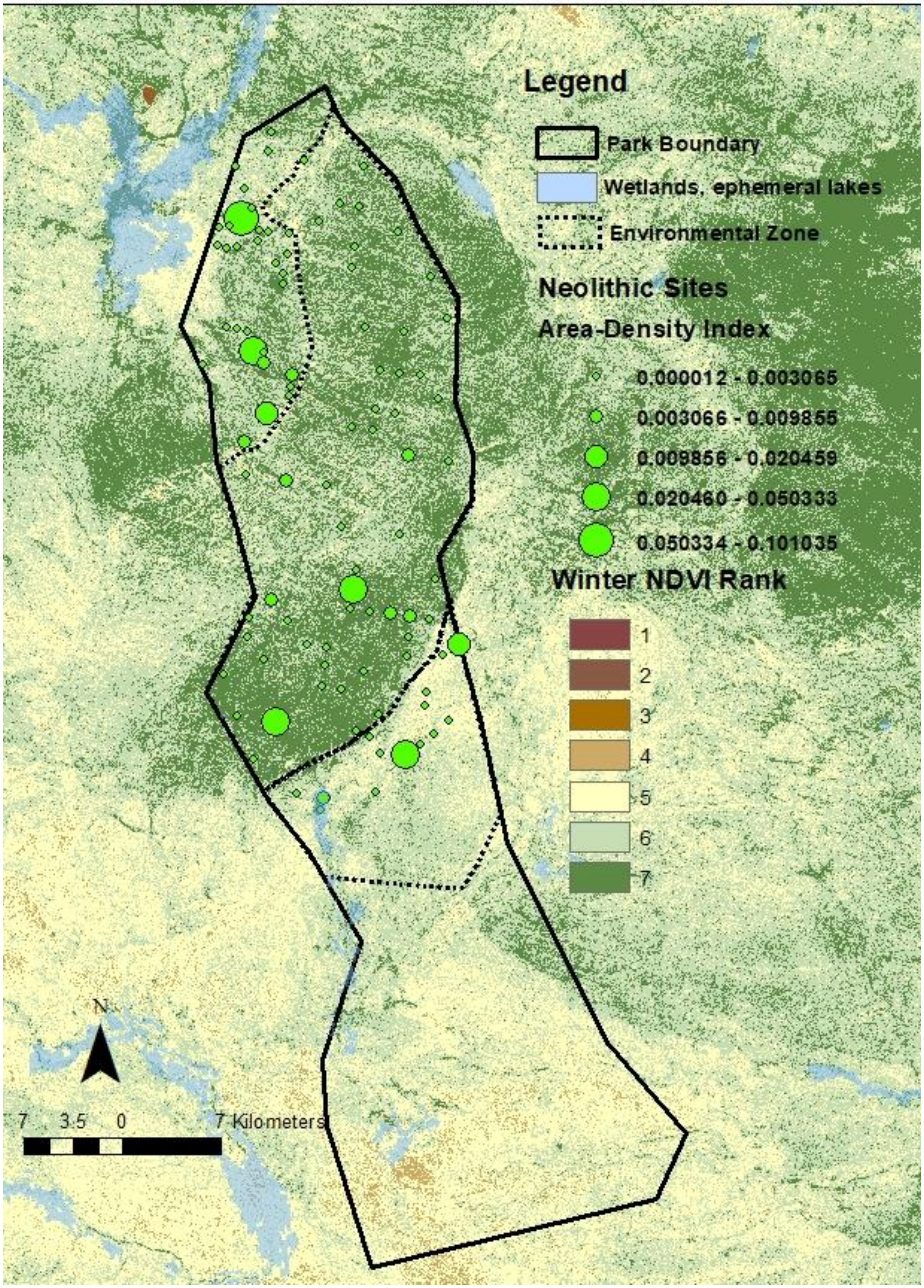


Figure 6.15 NDVI and corrected area-density indices for Neolithic sites.

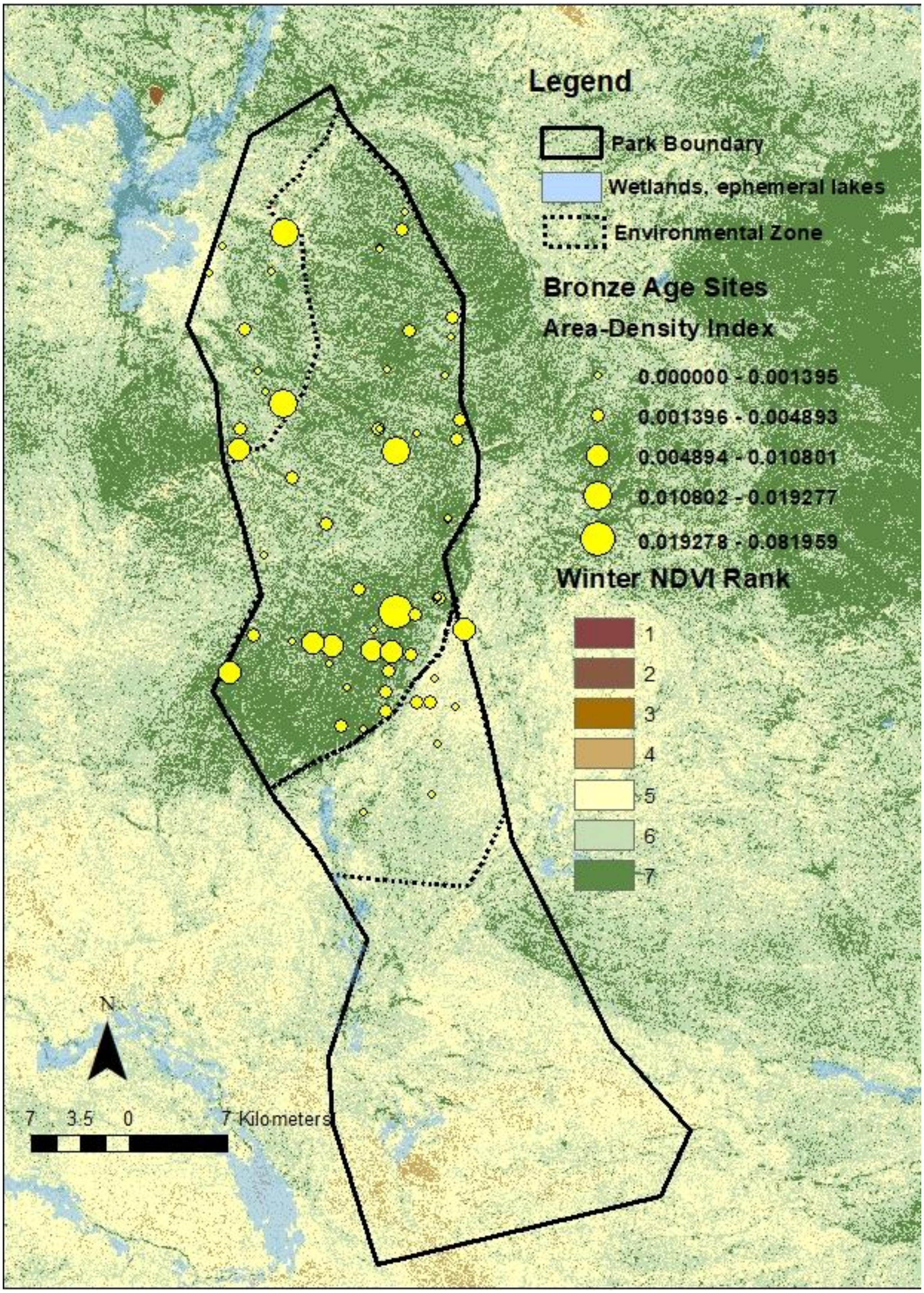


Figure 6.16 NDVI and corrected area-density indices for Bronze Age sites.

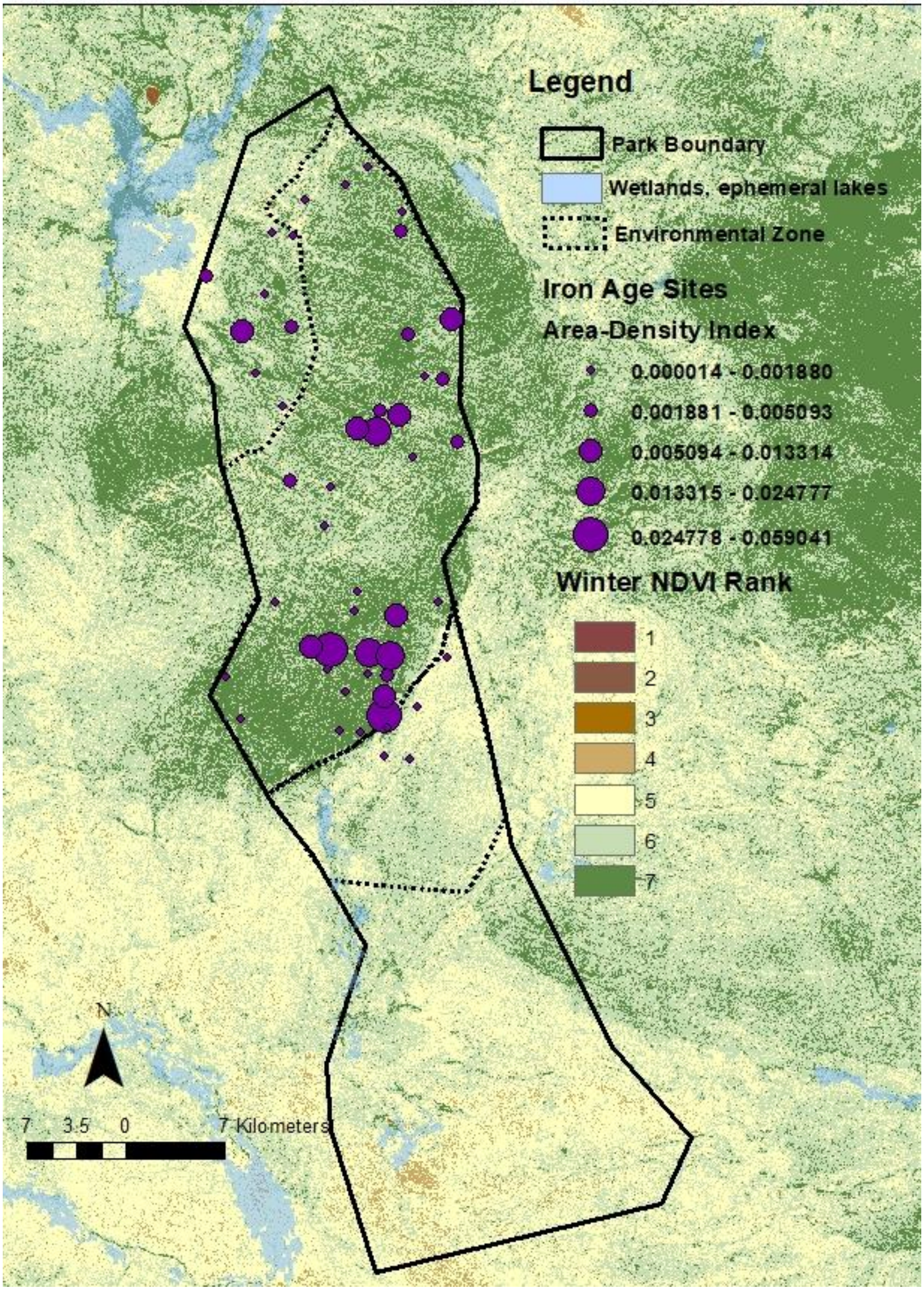


Figure 6.17 NDVI and corrected area-density indices for Iron Age sites.

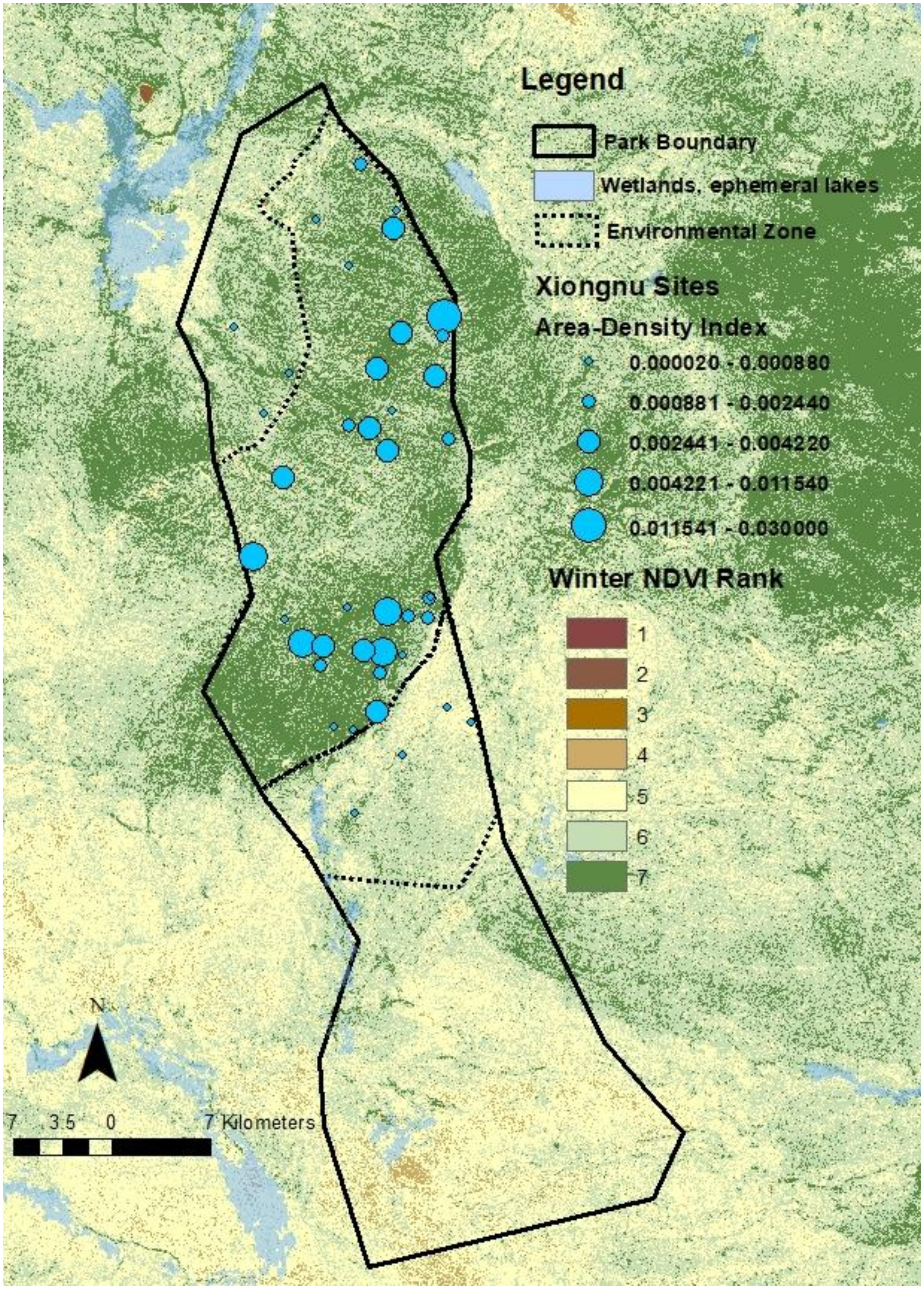


Figure 6.18 NDVI and corrected area-density indices for Xiongnu sites.

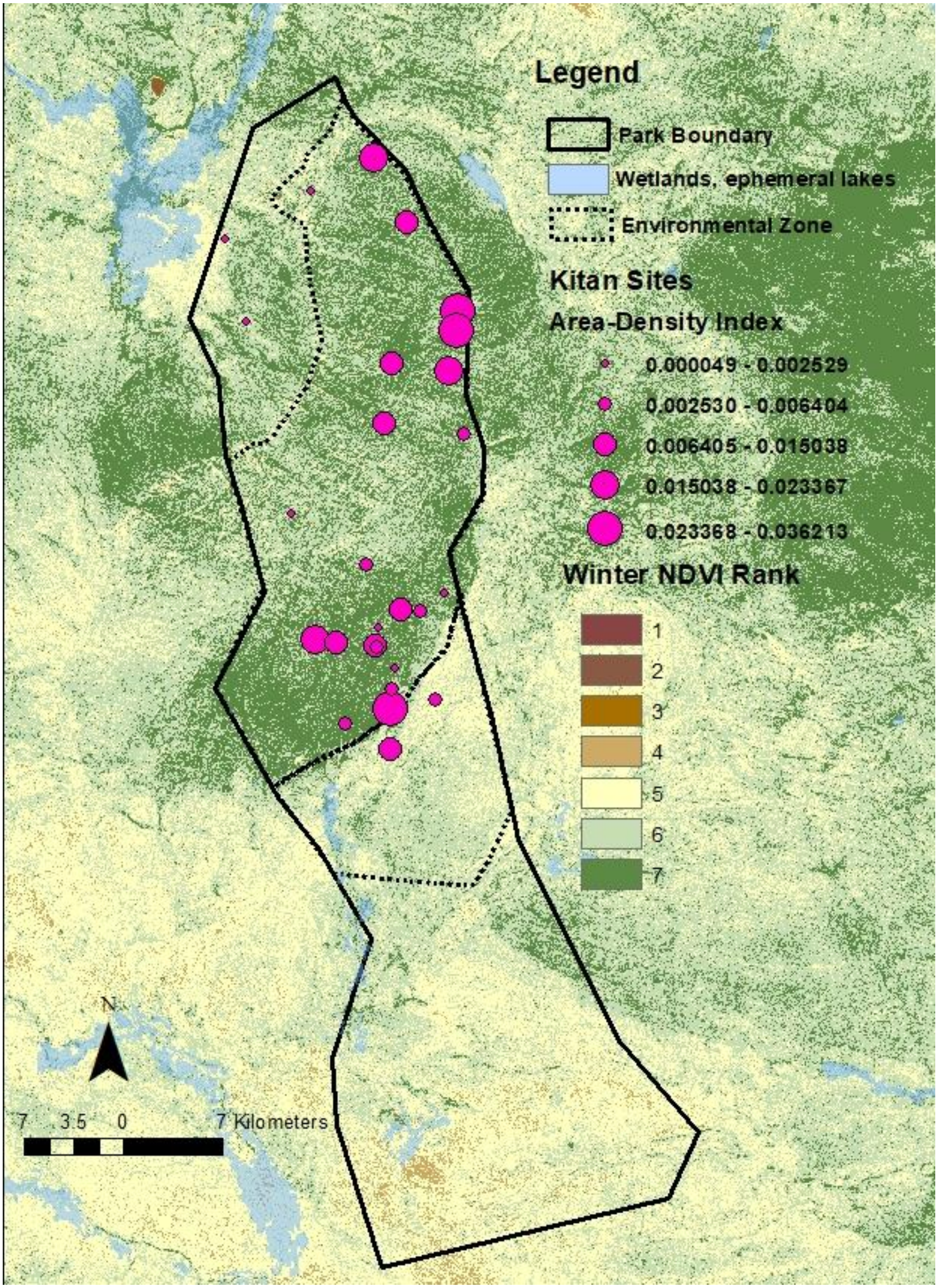


Figure 6.19 NDVI and corrected area-density indices for Kitan sites.

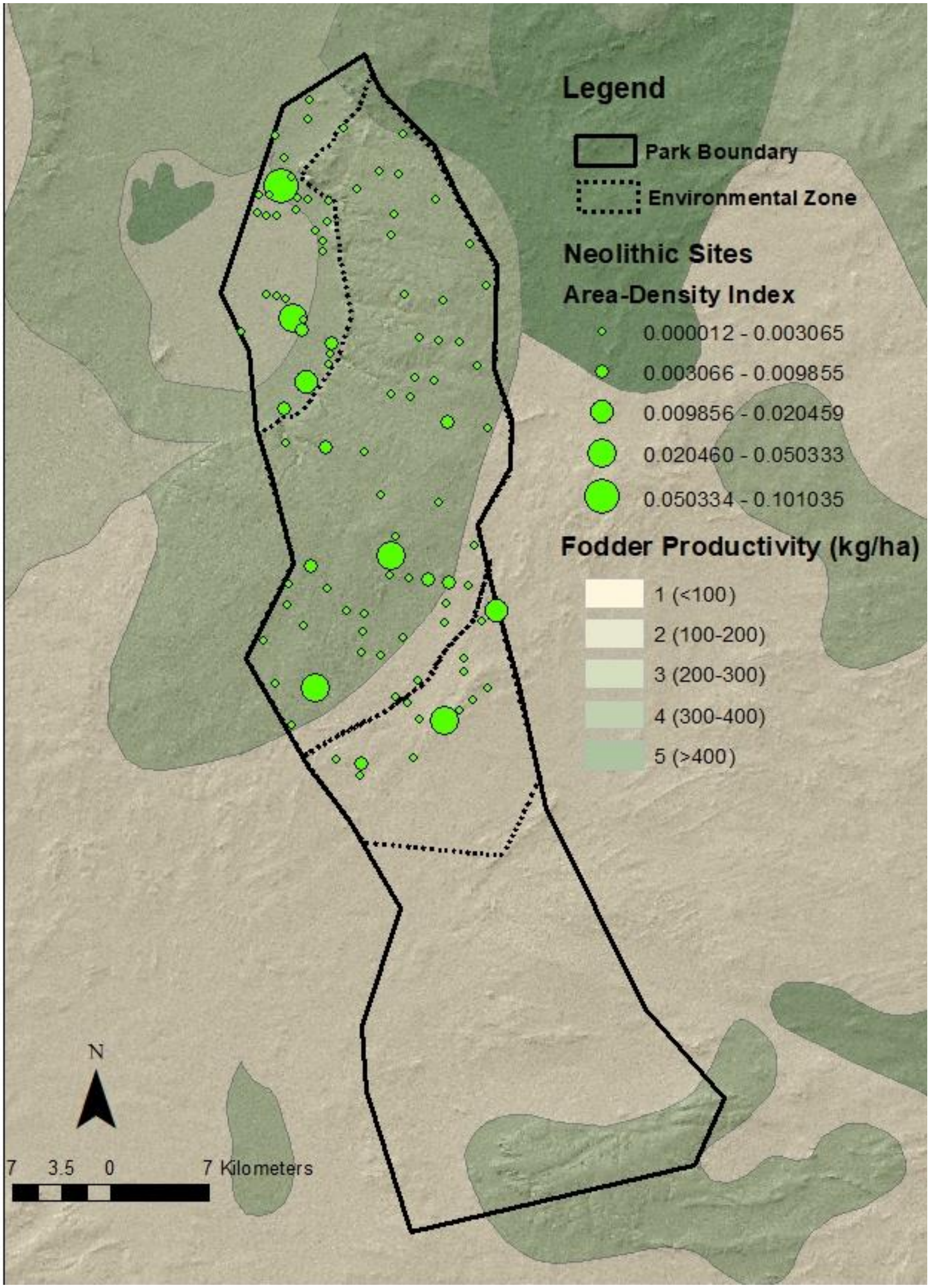


Figure 6.20 Pasture productivity and corrected area-density indices forNeolithic sites.

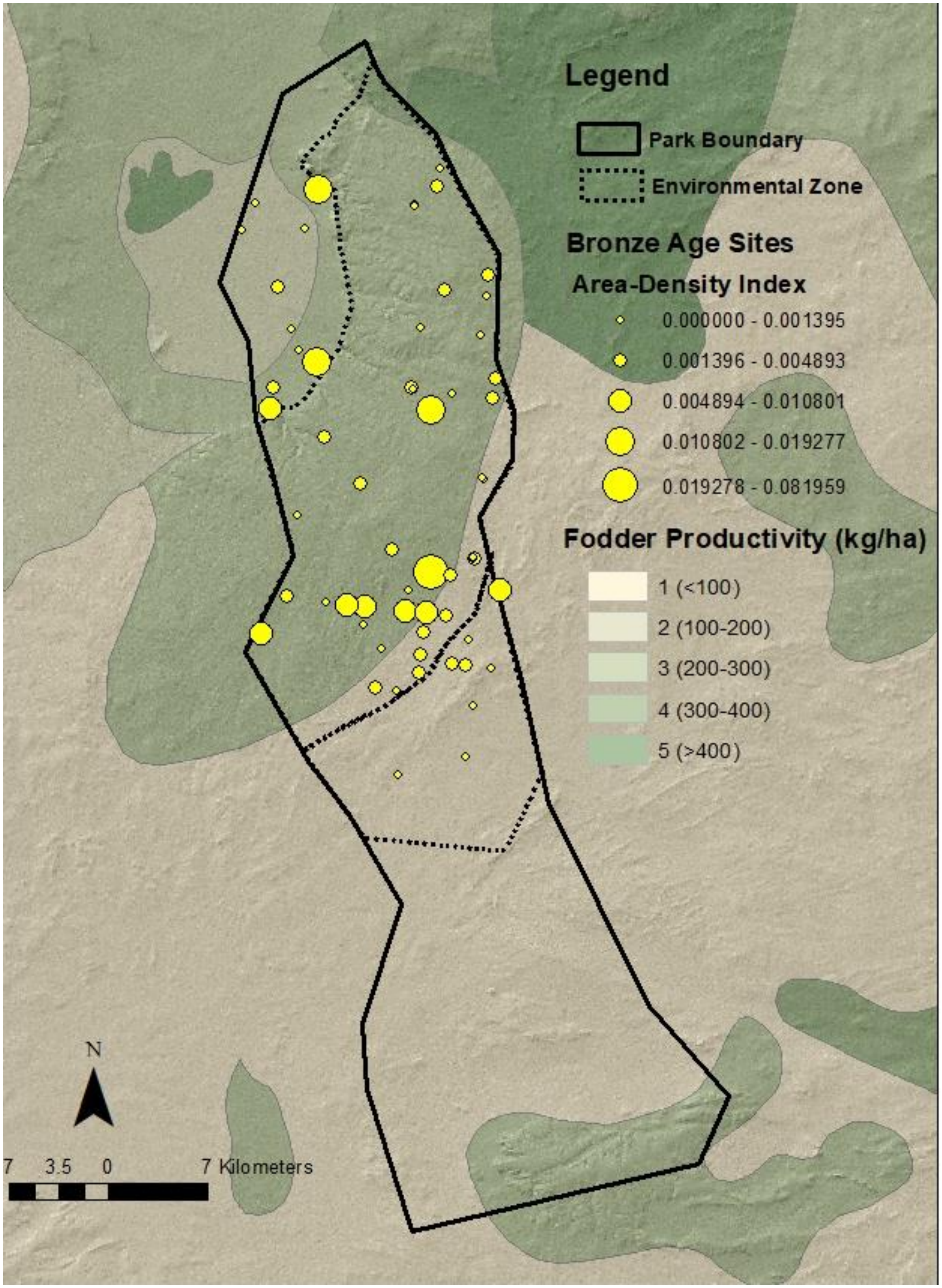


Figure 6.21 Pasture productivity and corrected area-density indices for Bronze Age sites.

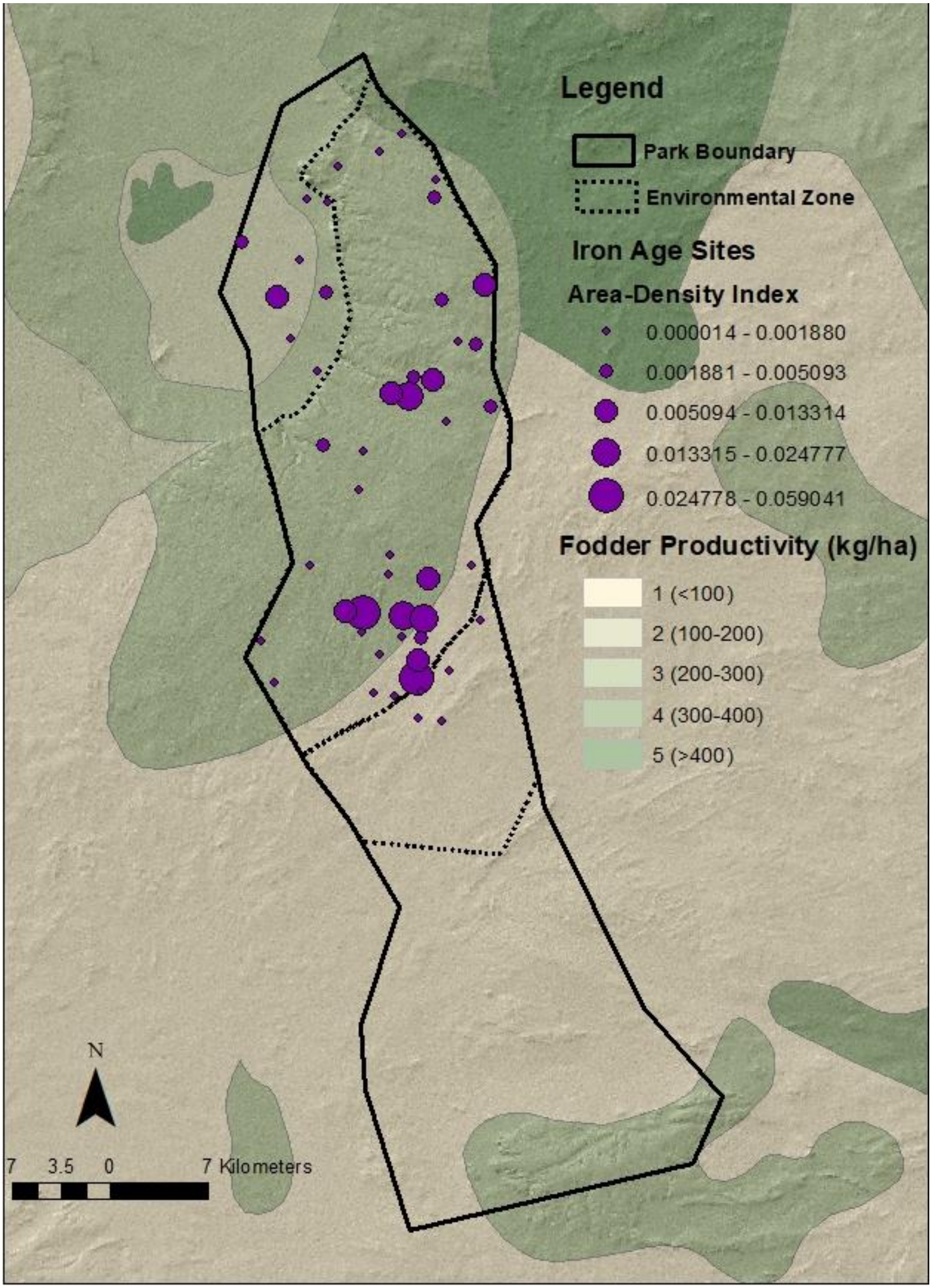


Figure 6.22 Pasture productivity and corrected area-density indices for Iron Age sites.

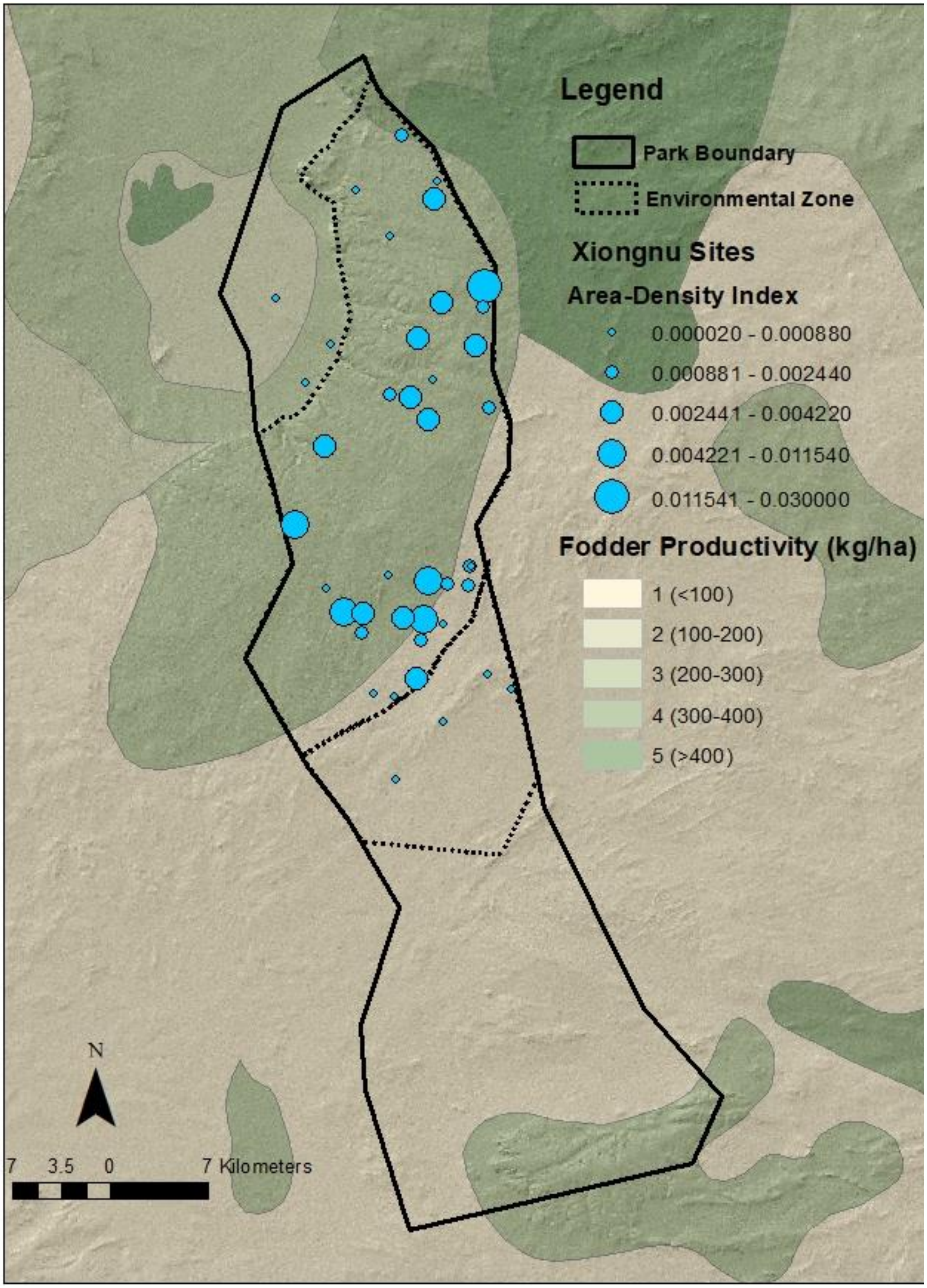


Figure 6.23 Pasture productivity and corrected area-density indices for Xiongnu sites.

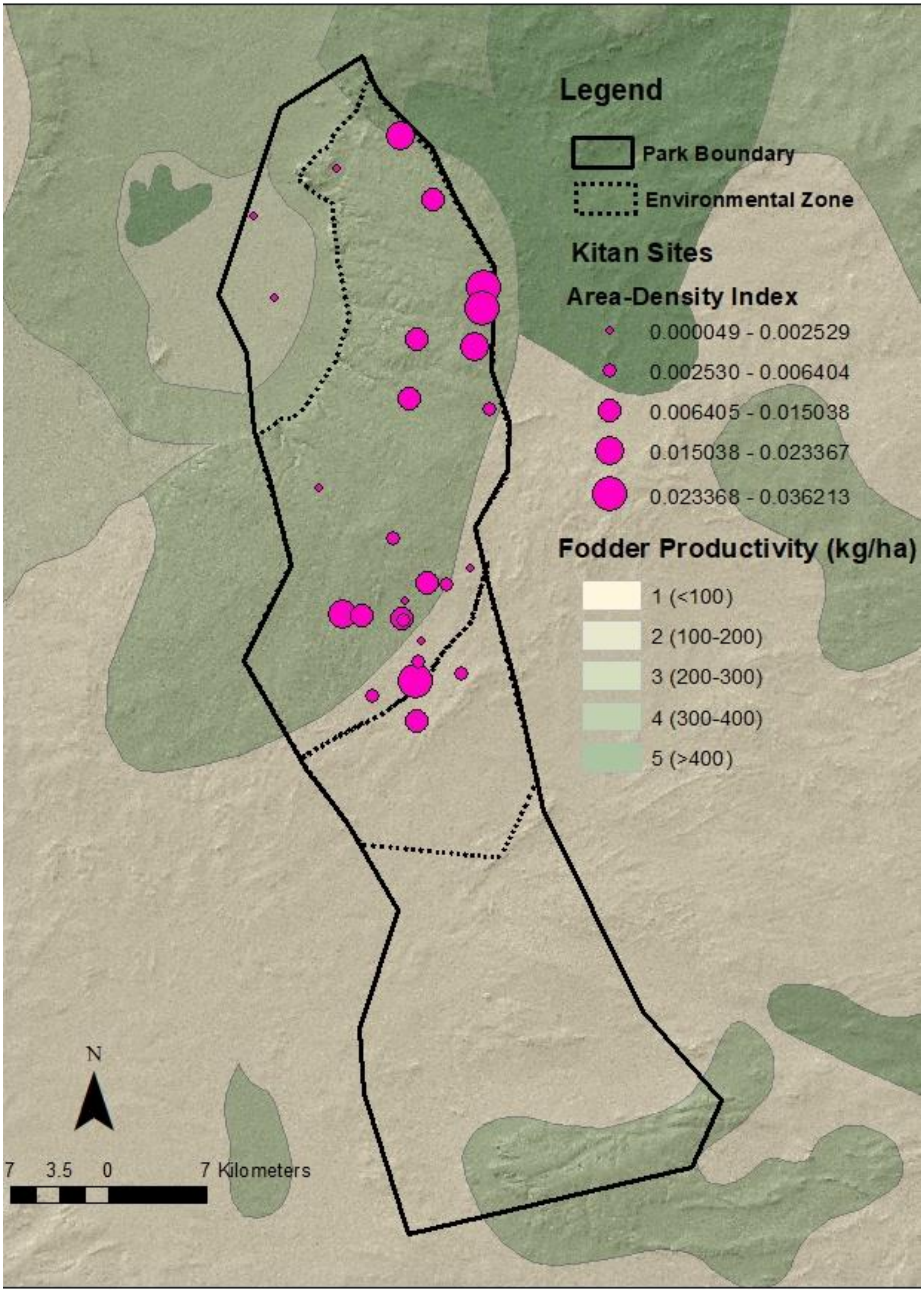


Figure 6.24 Pasture productivity and corrected area-density indices for Kitan sites.

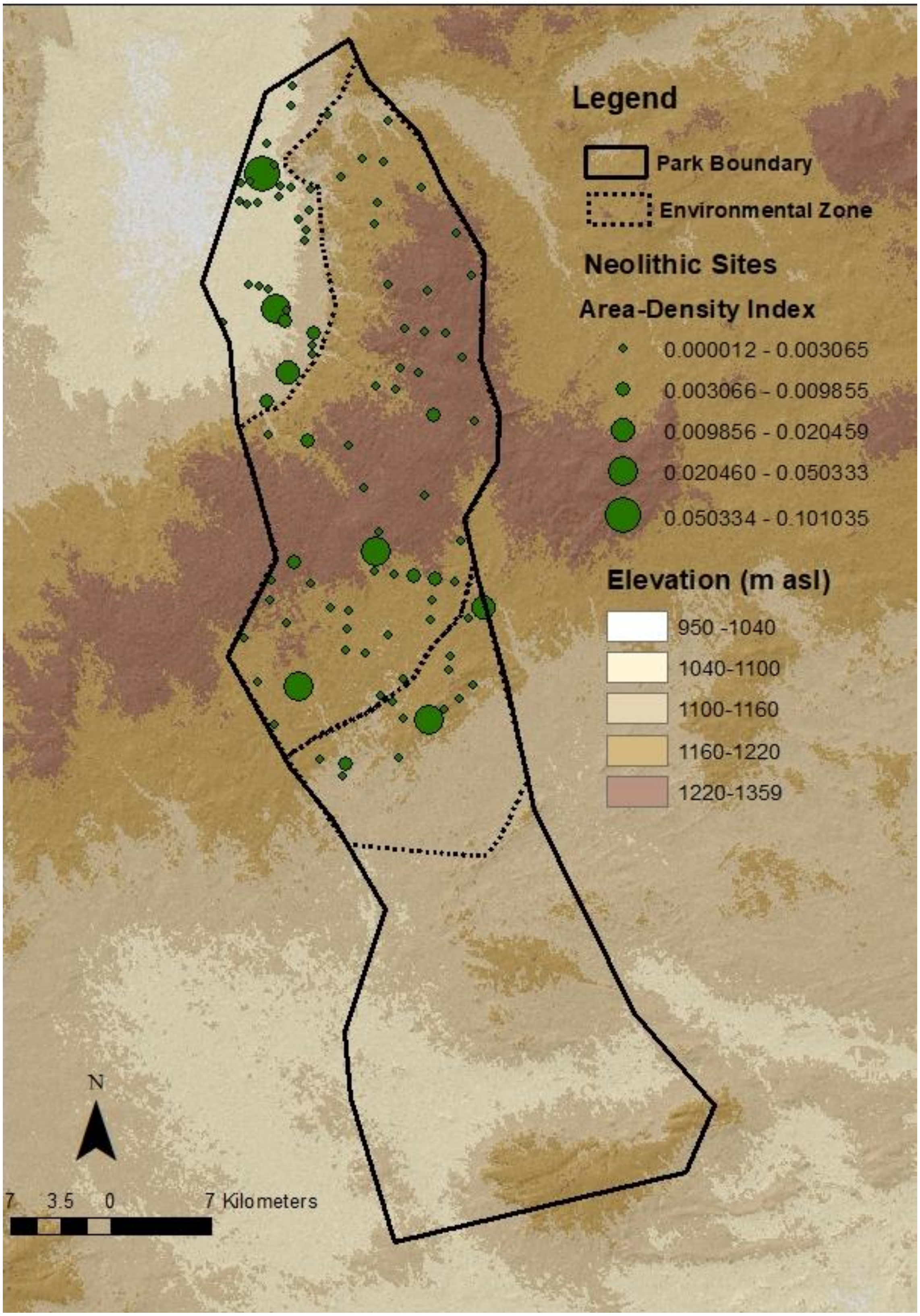


Figure 6.25 Elevation and corrected area-density indices for Neolithic sites

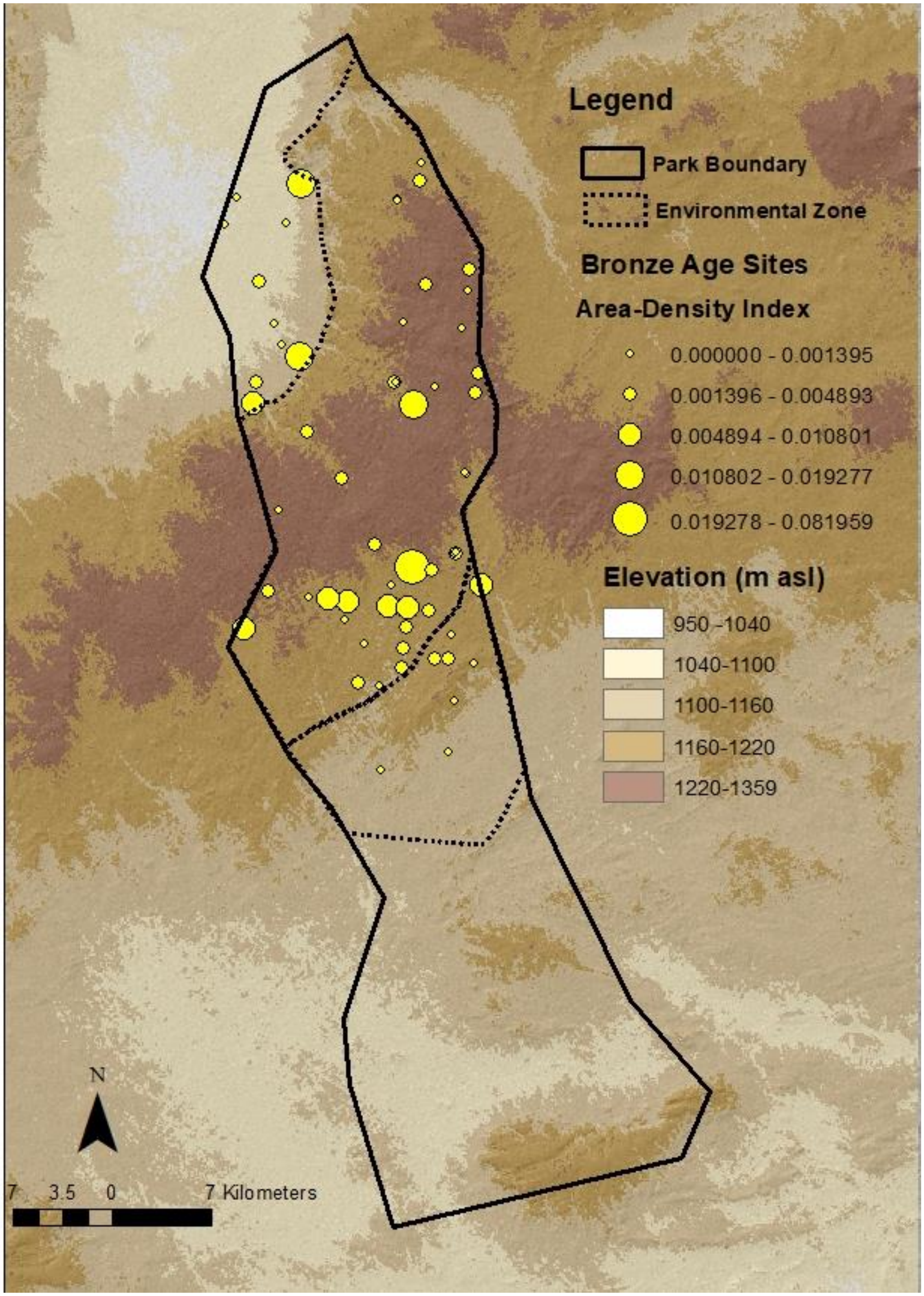


Figure 6.26 Elevation and corrected area-density indices for Bronze Age sites.

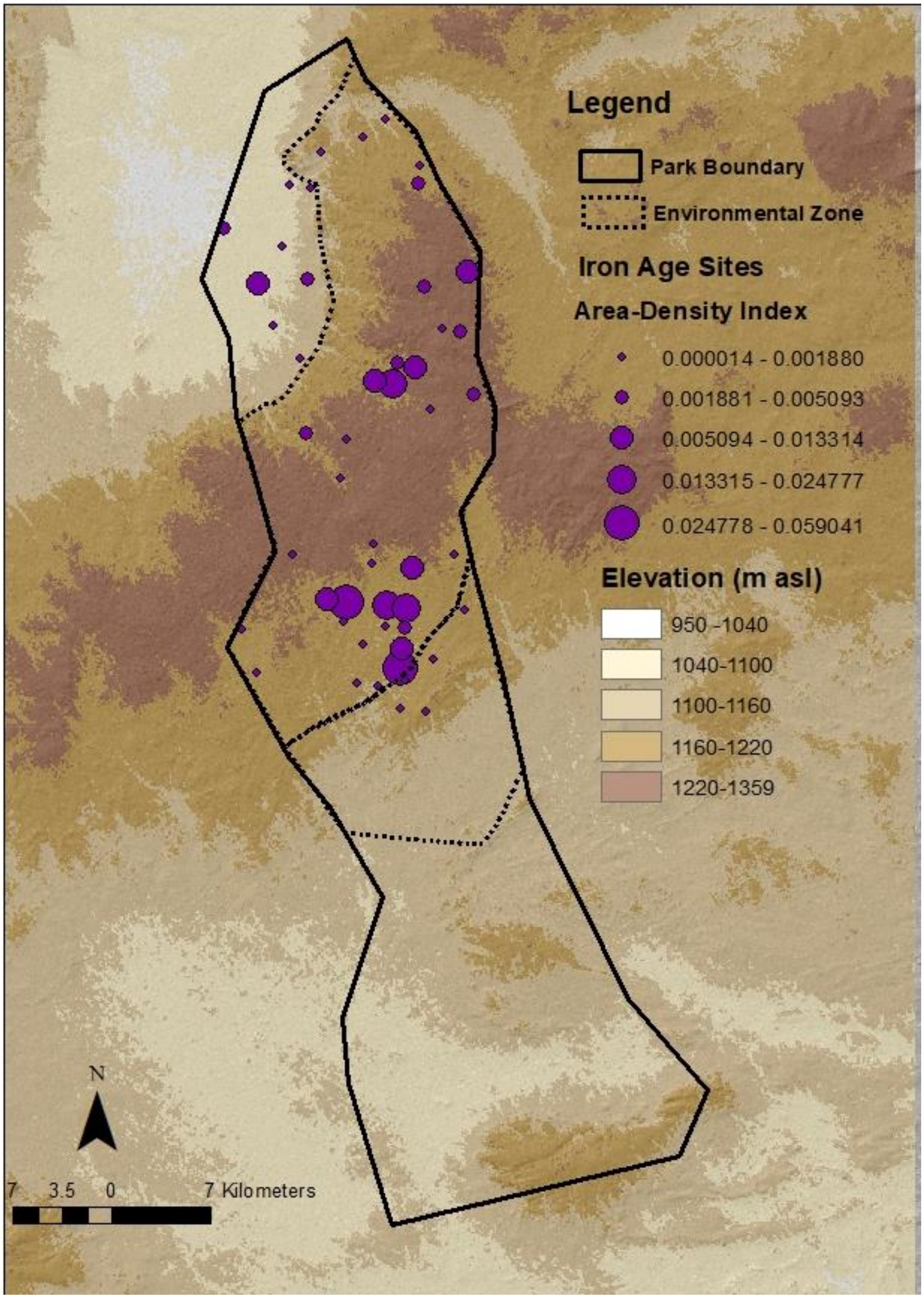


Figure 6.27 Elevation and corrected area-density indices for Iron Age sites.

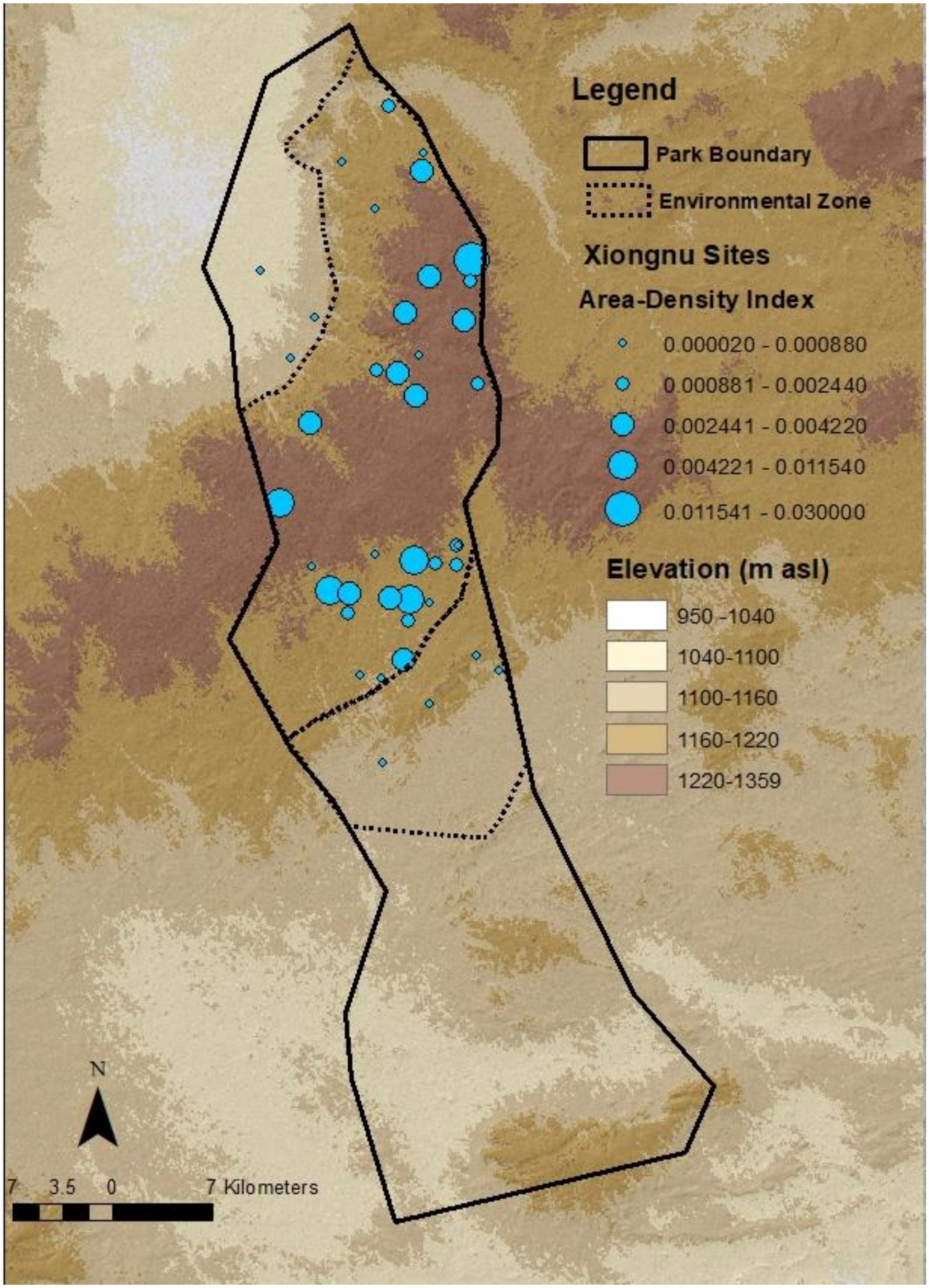


Figure 6.28 Elevation and corrected area-density indices for Xiongnu sites.

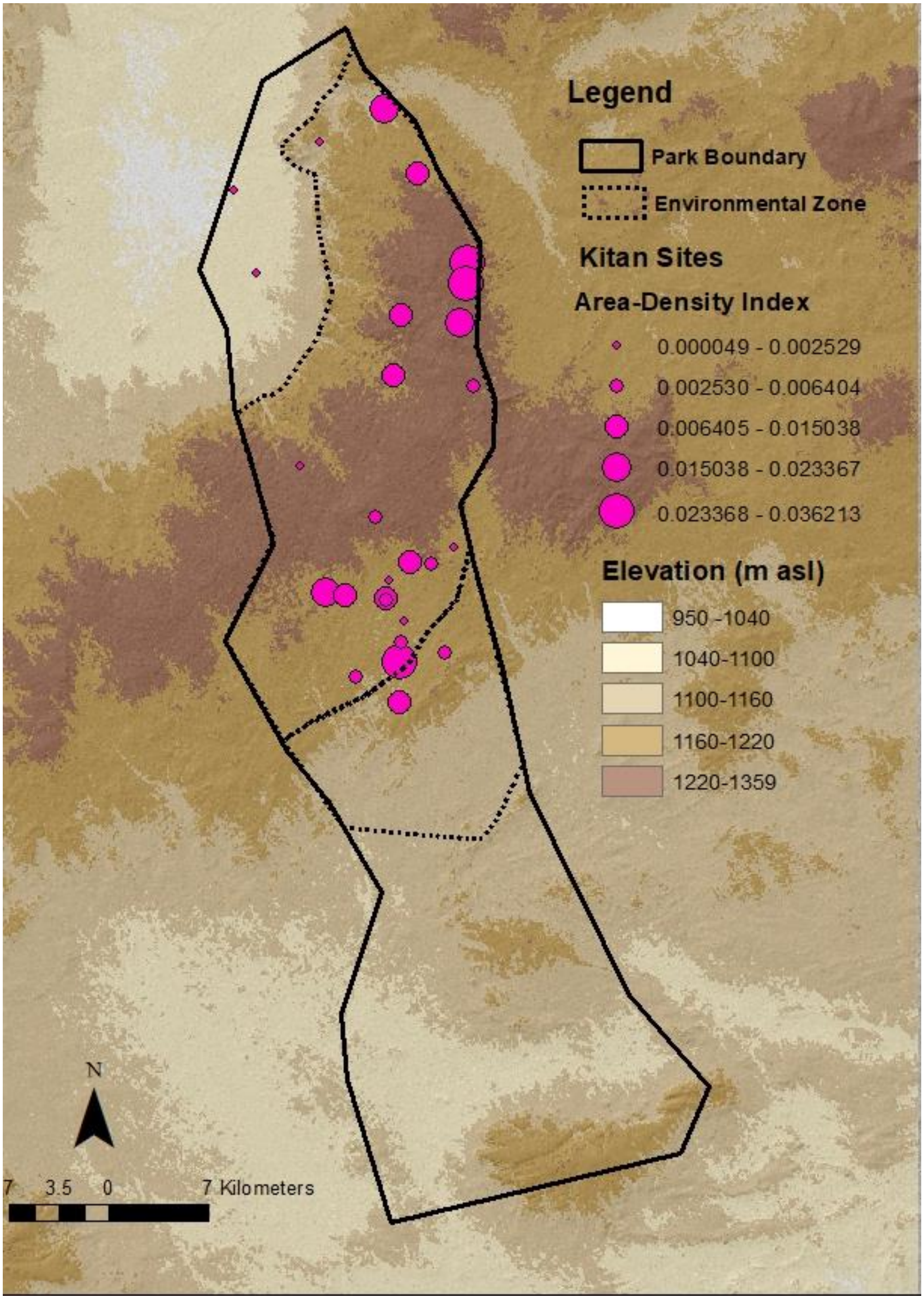


Figure 6.29 Elevation and corrected area-density indices for Kitan sites.

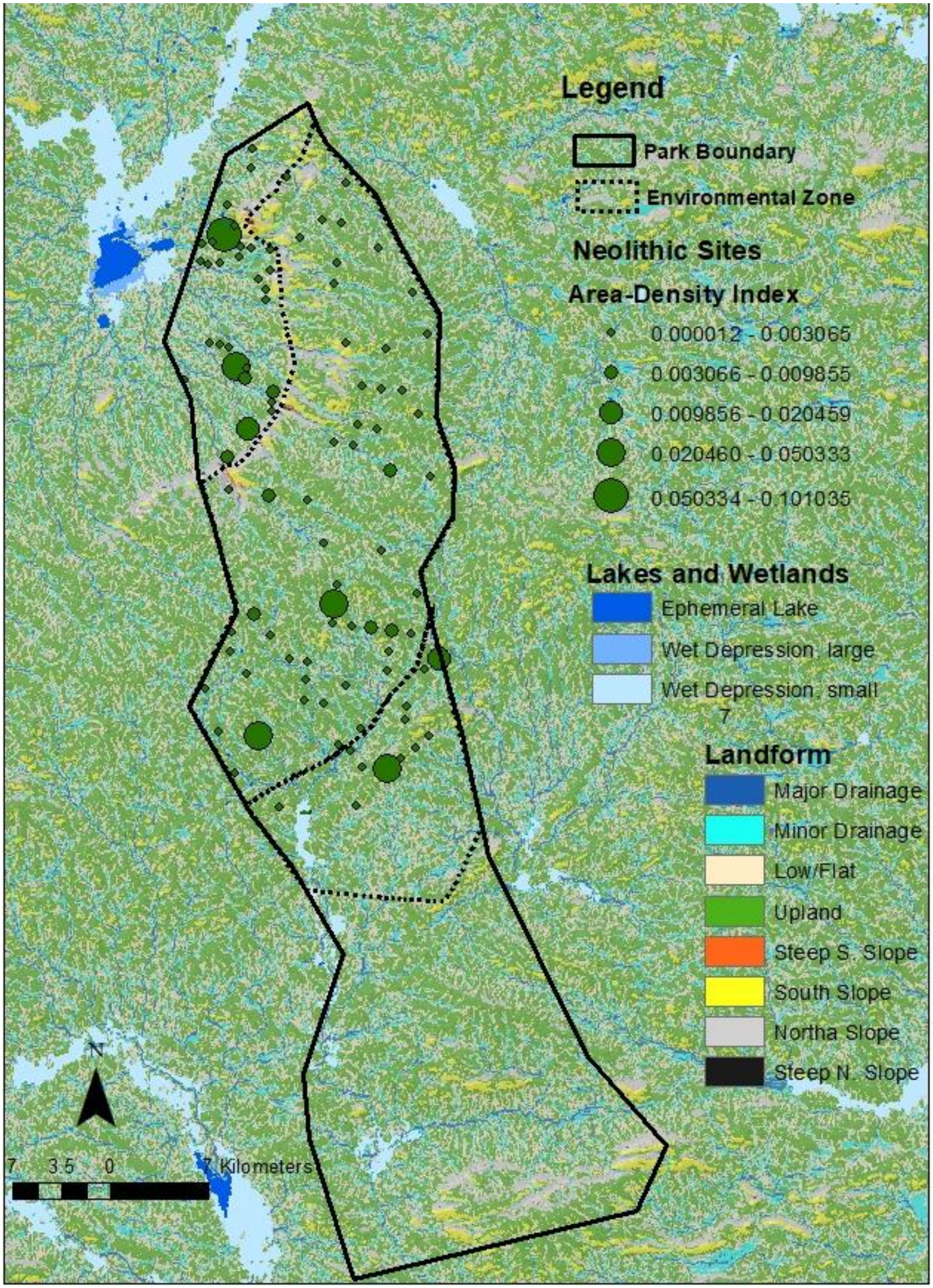


Figure 6.30 Landform and corrected area-density indices for Neolithic sites.

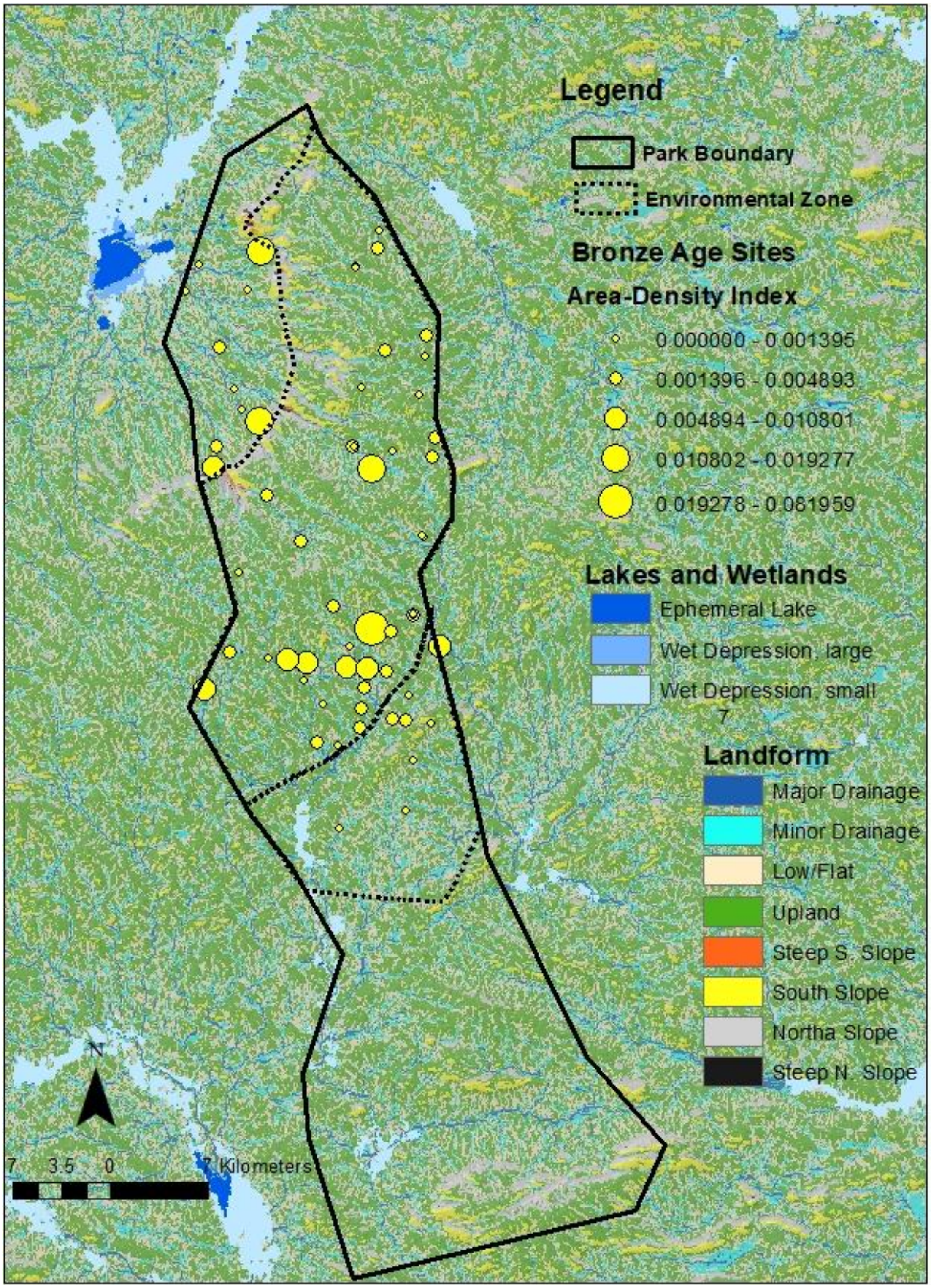


Figure 6.31 Landform and corrected area-density indices for Bronze Age sites.

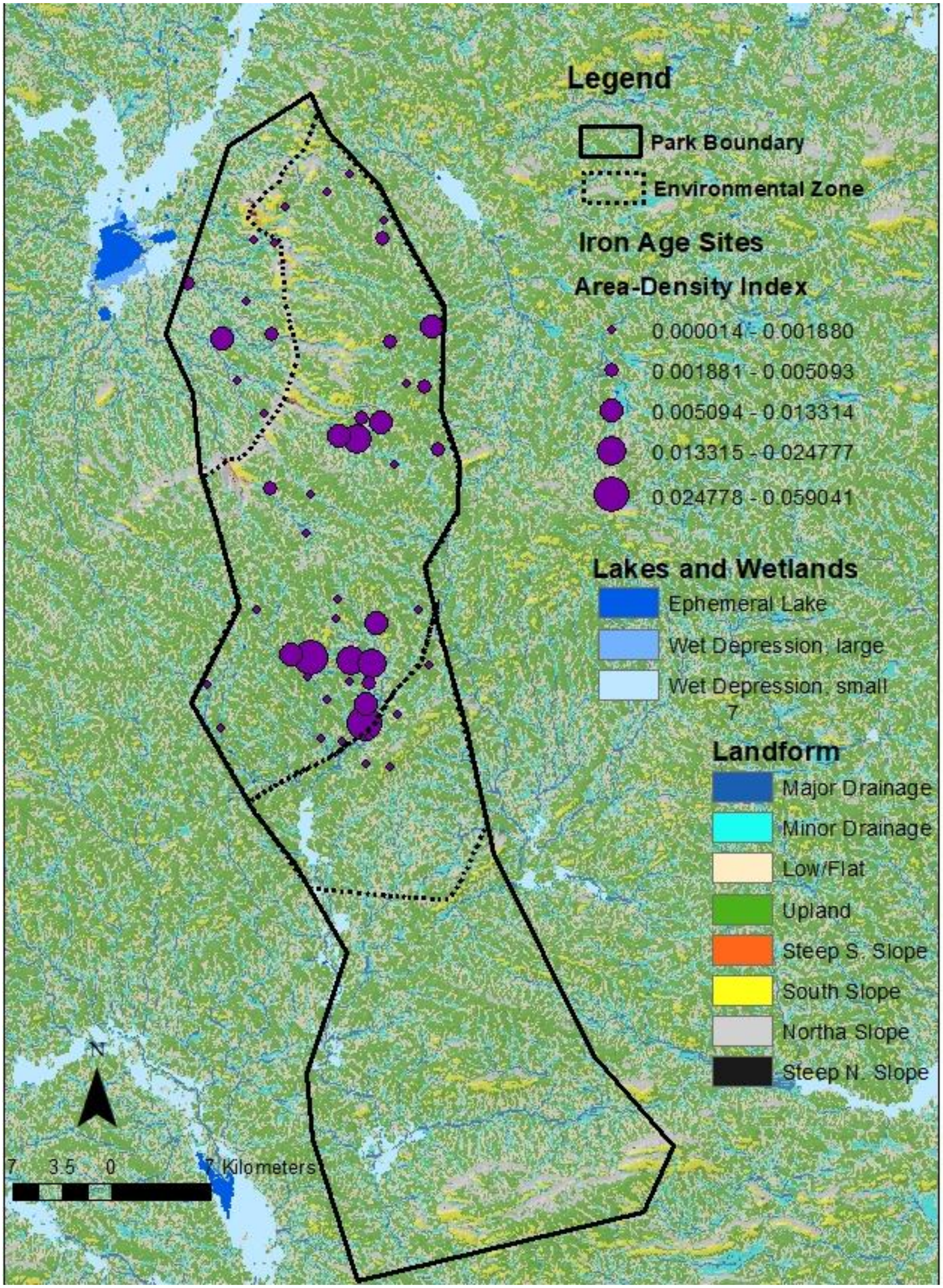


Figure 6.32 Landform and corrected area-density indices for Iron Age sites.

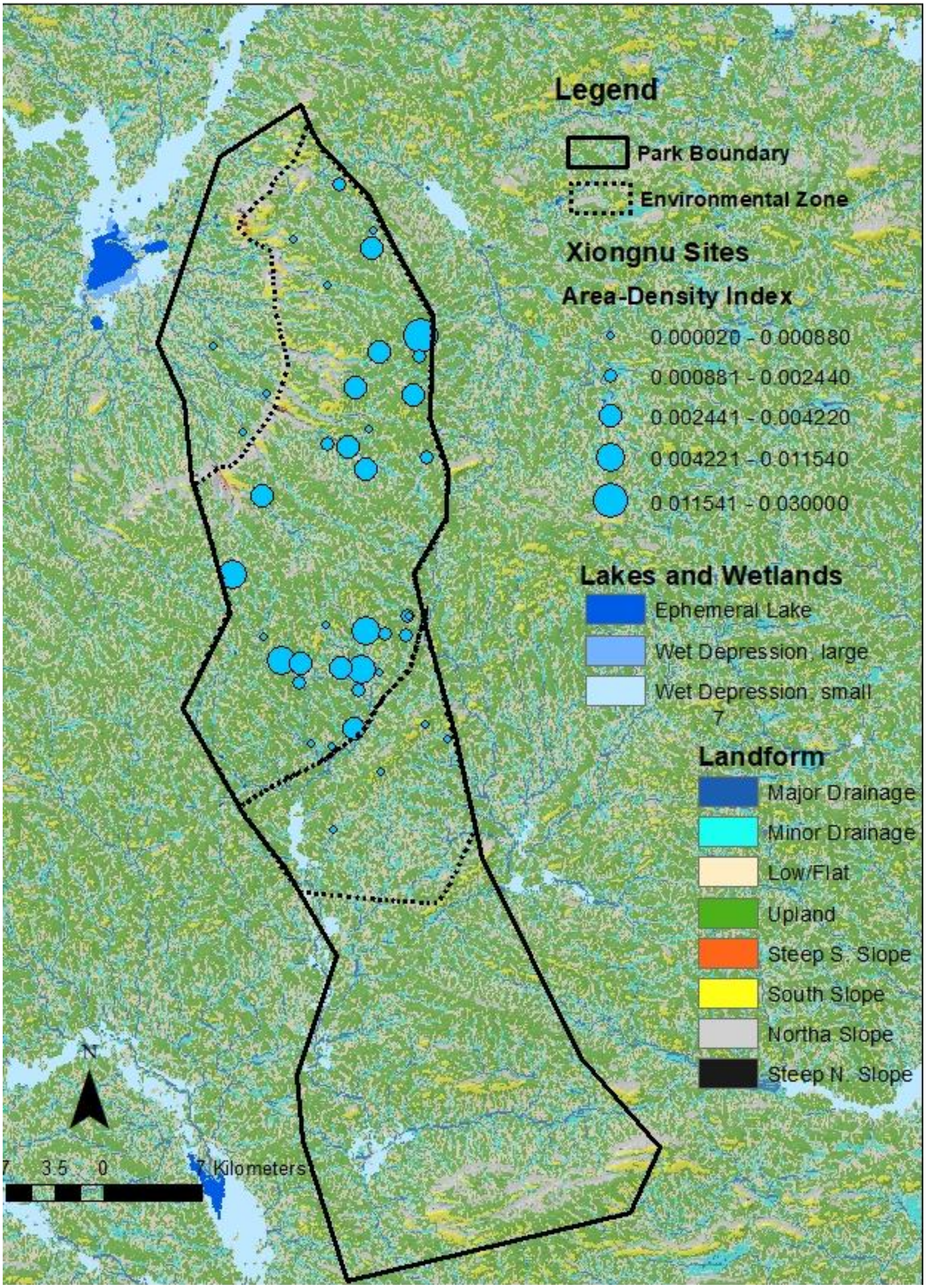


Figure 6.33 Landform and corrected area-density indices for Xiongnu sites.

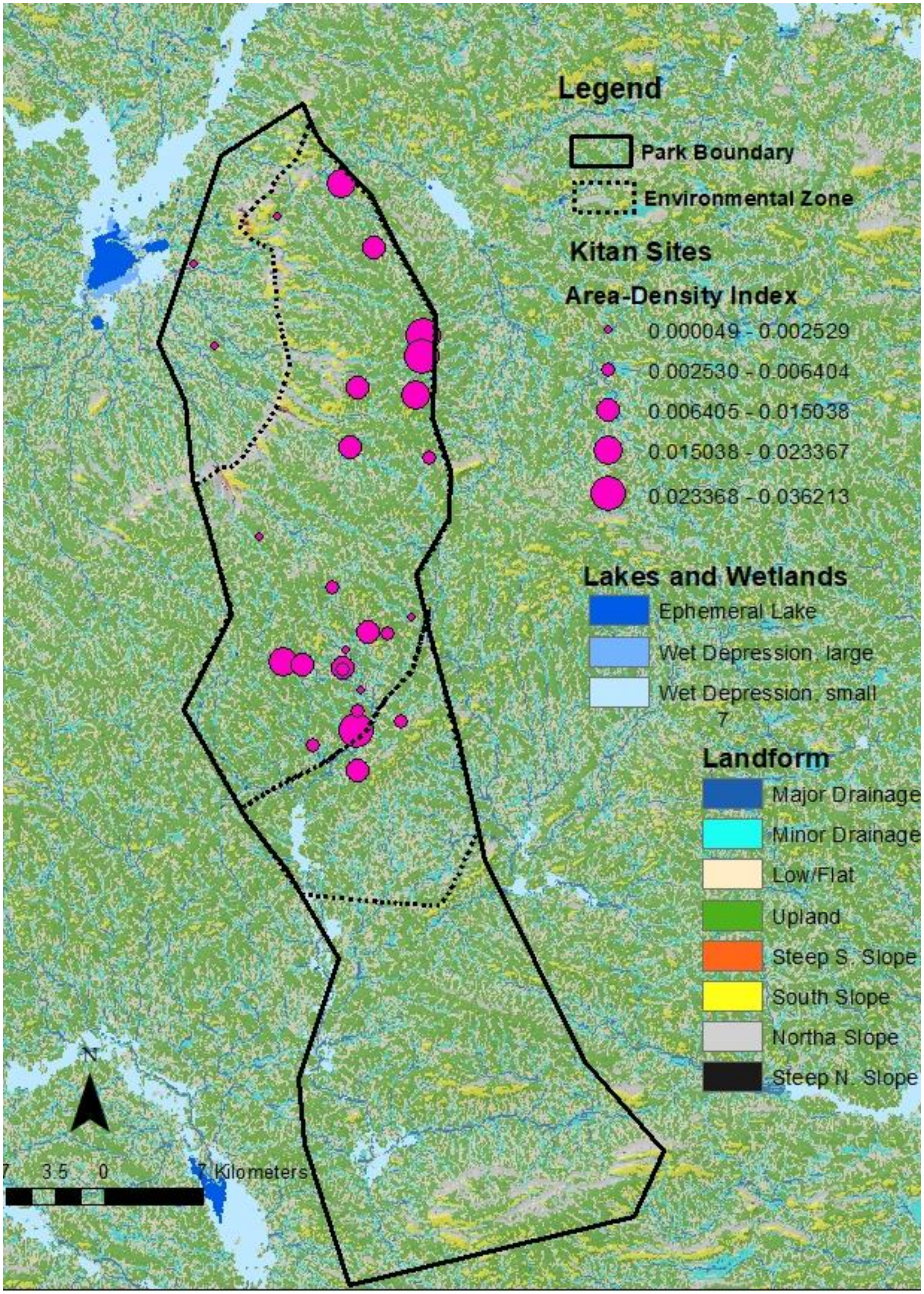


Figure 6.34 Landform and corrected area-density indices for Kitan sites.

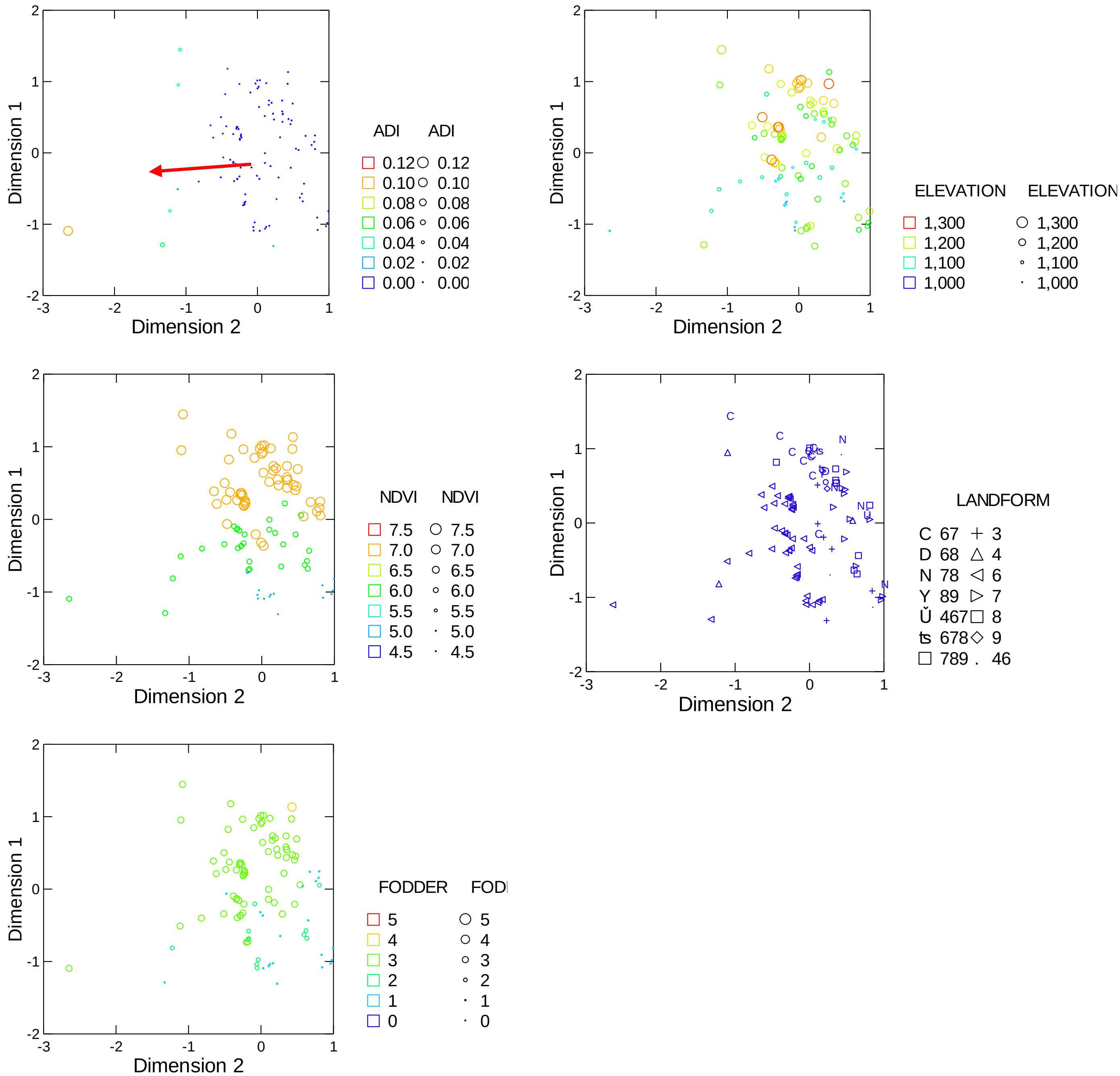


Figure 6.35 Multidimensional scaling by variable for Neolithic sites (Larger symbols indciate larger values, and red arrows indicate directional patterning).

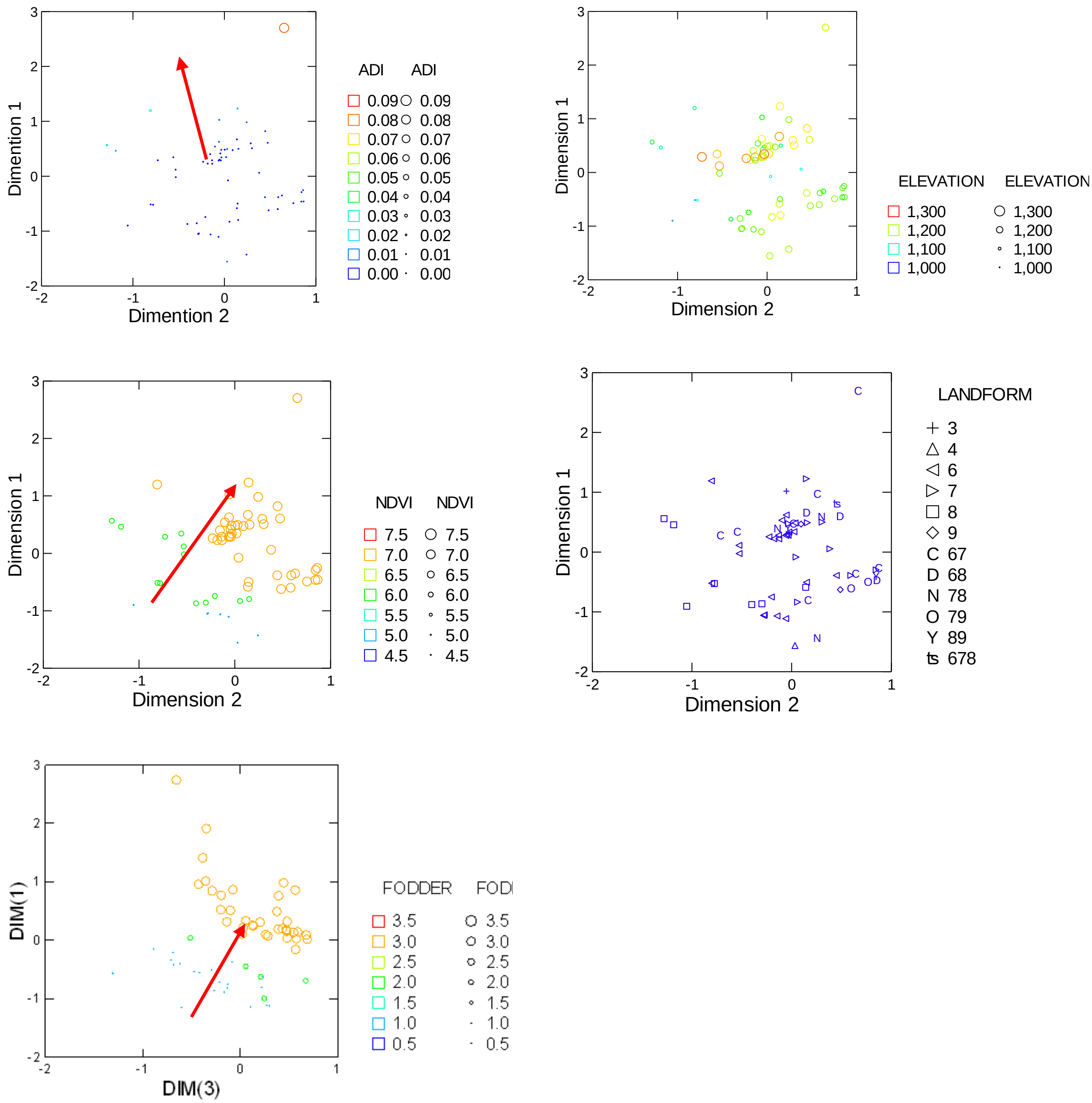


Figure 6.36 Multidimensional scaling by variable for Bronze Age sites. (Larger symbols indciate larger values, and red arrows indicate directional patterning).

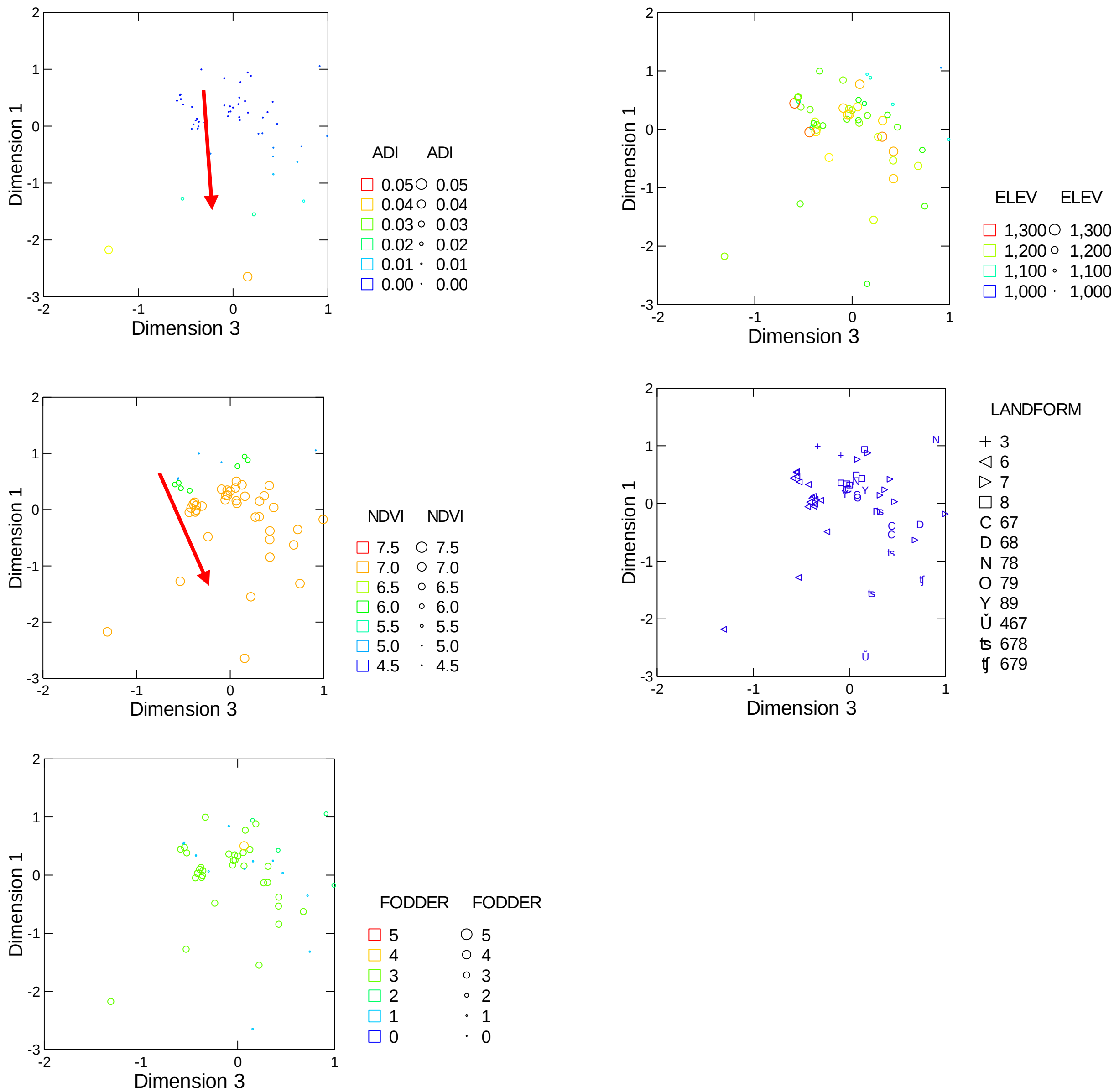


Figure 6.37 Multidimensional scaling by variable for Iron Age Stes. (Larger symbols indciate larger values, and red arrows indicate directional patterning).

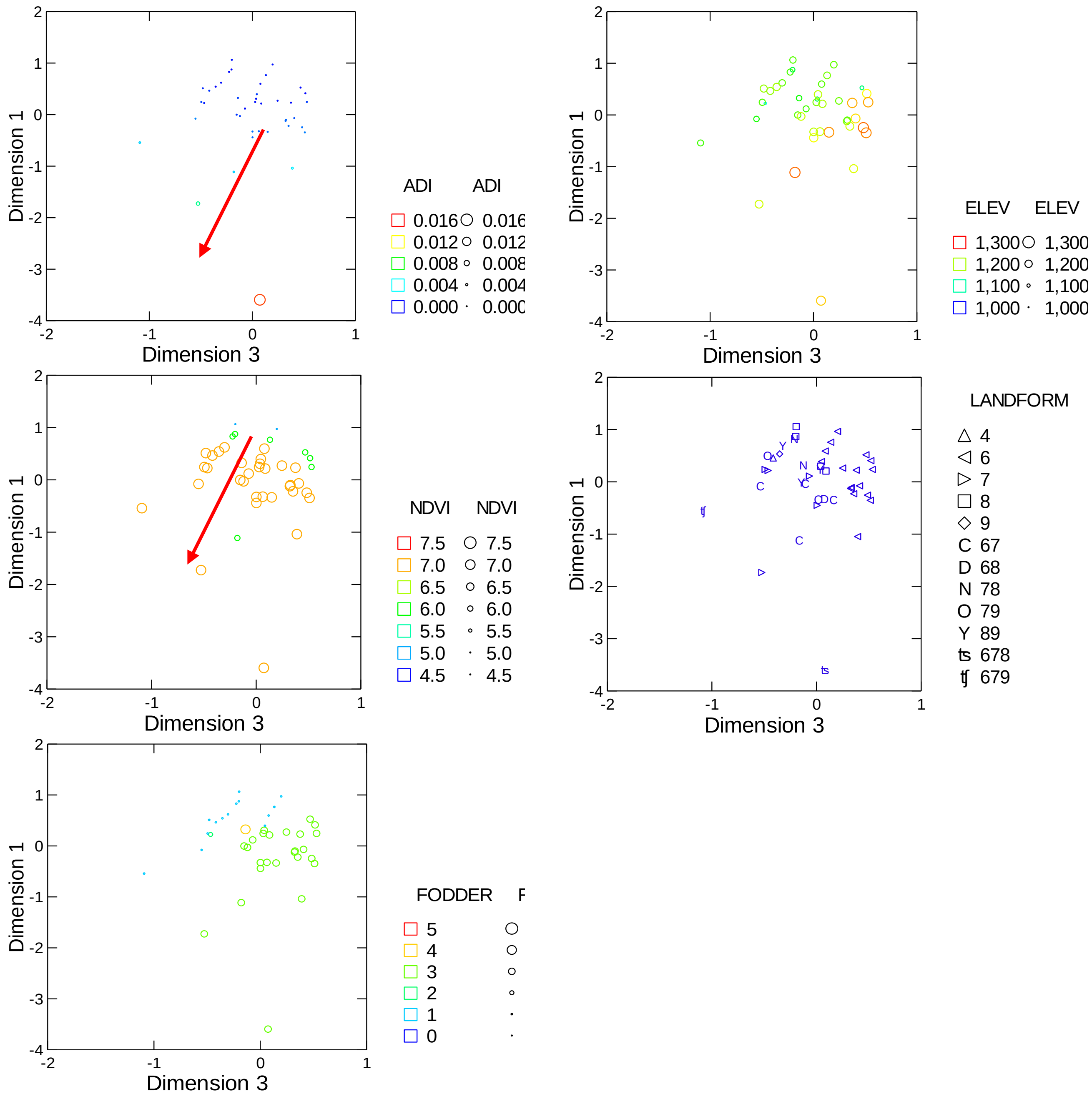


Figure 6.38 Multidimensional scaling by variable for Xiongnu sites. (Larger symbols indciate larger values, and red arrows indicate directional patterning).

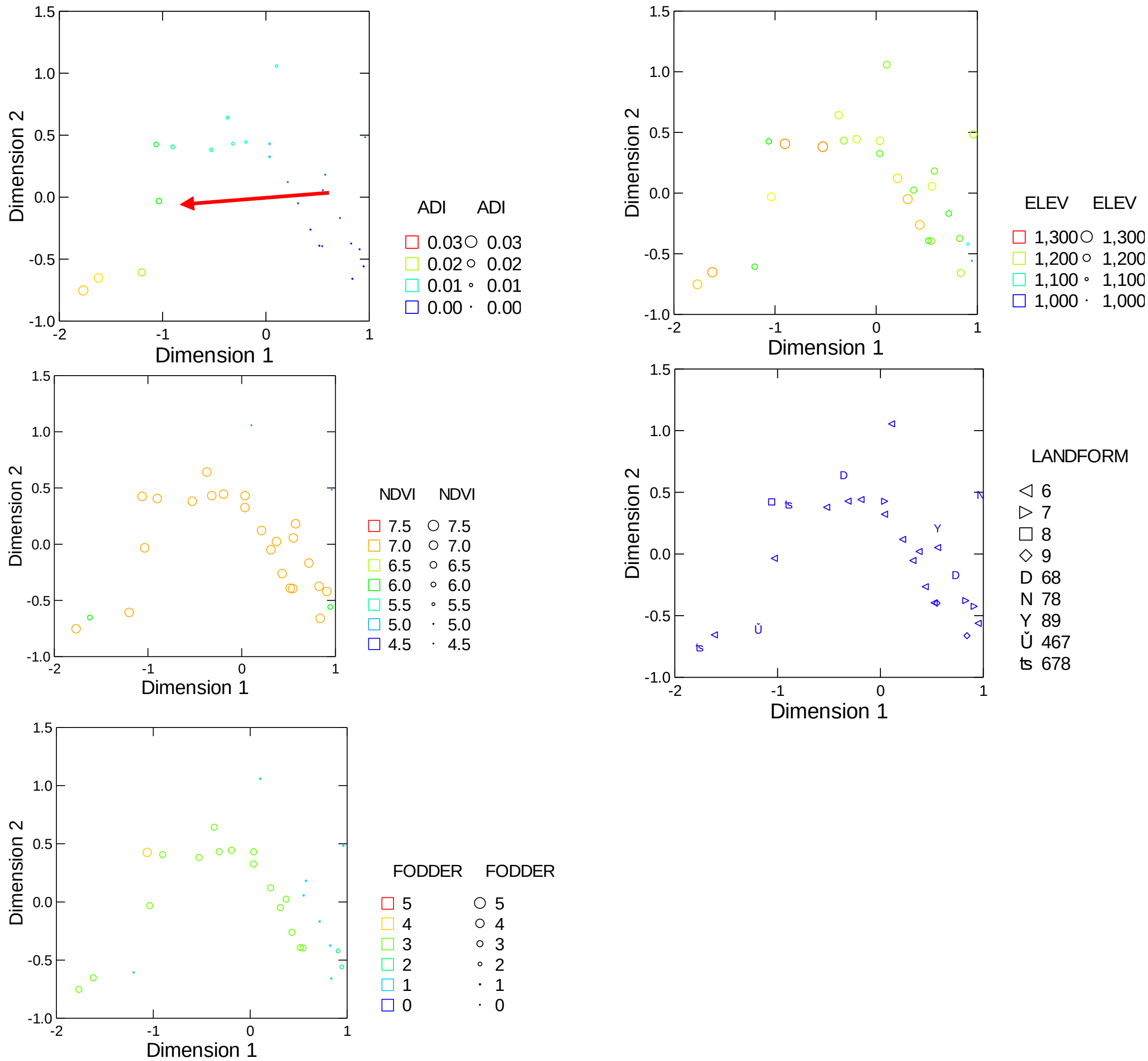


Figure 6.39 Multidimensional scaling by variable for Kitan sites. (Larger symbols indciate larger values, and red arrow indicate directional patterning).

6.3.1 Access to Winter Vegetation (NDVI).

As shown in Table 6.4 and Figure 6.40, occupation of areas with relatively high winter vegetation productivity (Rank 7) is variable. The proportion increases over time; however, there is a sizable increase in utilization after the Neolithic, and a smaller rise between the Bronze and Iron Age, possibly linked to a growing emphasis on herding activities.

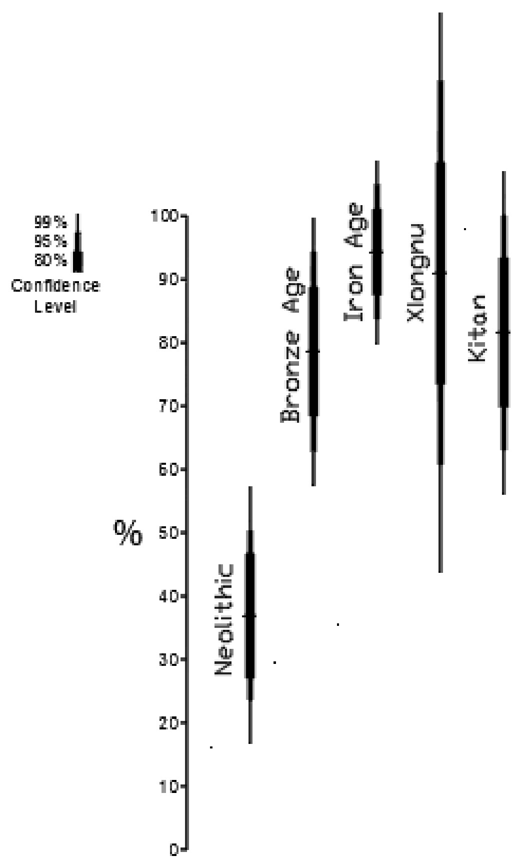


Figure 6.40 Proportion of period area-density index with highest winter NDVI rank.

We have very high statistical confidence (well above 99%) in the difference between Neolithic (presumed foraging economy) and Bronze Age (presumed mixed hunter/herder economy). The subsequent Iron Age increase is less substantial, but we can be quite confident (between 95% and 99%) of this change. Overall utilization of areas with high winter NDVI decreases somewhat in the remaining periods, but our statistical confidence in these changes is quite low (well below 80%). By the Kitan Period, there appears to be an expansion in use of areas with low winter NDVI (Figure 6.41). This trend coincides with an overall increase in lowland population discussed previously (Table 6.2i), possibly signaling an increase in use of secondary habitats as more preferred upland zones (and areas of high NDVI) faced continued in-filling by herder communities.

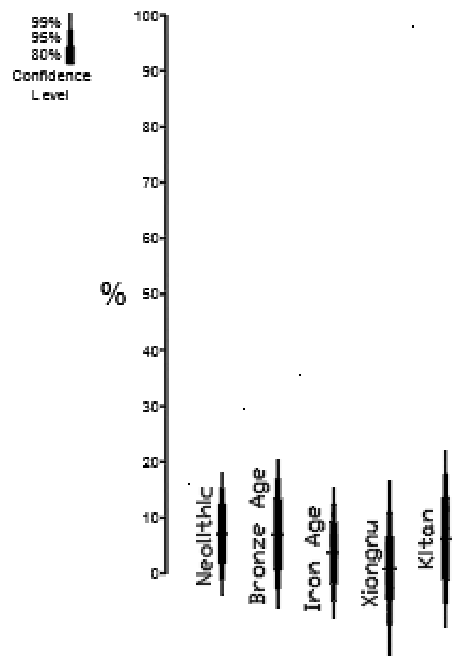


Figure 6.41 Proportion of period area-density index with lowest winter NDVI rank.

Patterns seem to suggest that both early adopters and more established herders prioritized areas of high winter productivity to a greater degree than did foragers, and likely constituted an important organizational factor. To verify this, we use multidimensional scaling to explore the relationship between winter NDVI and population size. For the Neolithic (Figure 6.35), there appears to be no relationship between population size (area density index) and winter NDVI rank, suggesting that during this interval, population trends were not influenced to any large degree by the availability of winter vegetation. Contrary to the proportional distribution of high NDVI among the Bronze Age occupations, the multidimensional scaling shows only a weak association between NDVI and population. By the Iron Age and continuing into the Xiongnu era (Figure 6.37 and 6.38), the association between area-density index and NDVI strengthens, suggesting that access to winter vegetation was an important factor in structuring of land use strategies as herding practices expanded. By the Kitan era, the correspondence between NDVI and area-density index is weakened (Figure 6.39), suggesting other factors shaped land use decisions during this time.

6.3.2 Pasture Productivity

As discussed in Chapter 4, modern distribution of productive pastureland (in addition to NDVI) can be used as a proxy to understand the dynamic between vegetation productivity and settlement across the transition from foraging to herding. We proposed that access to productive pastureland would be a strong organizing factor among pastoralists, significantly more so than among foraging economies. Data presented in Figure 6.42 do not support this proposition, demonstrating that occupation of areas with high pasture productivity was low for all periods. While this is largely due to the overall rarity of this zone in the study area (Figures 6.20-24), targeting of these areas did increase after the Bronze Age (Figure 6.42).

The Kitan period saw the highest utilization of productive pasture (Figure 6.42), however, multidimensional scaling of area-density indices and fodder productivity show only weak correspondence (Figure 6.39). Generally, areas with low fodder potential supported only small groups, however, some small groups also targeted areas with higher productivity, and the largest sites are found in areas with middling fodder productivity. No relationship between population size and fodder productivity was noted in earlier eras.

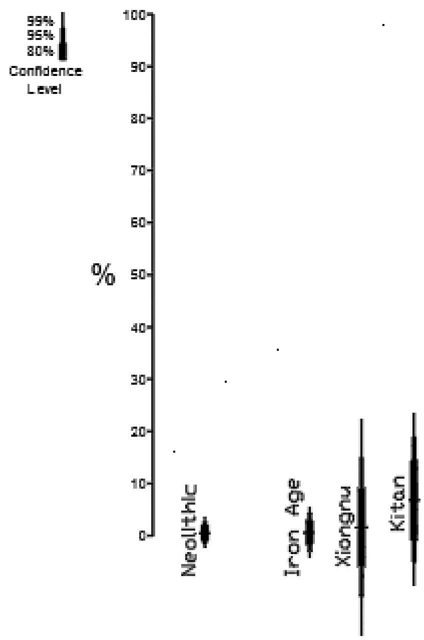


Figure 6.42 Proportion of period area-density index with highest pasture productivity.

6.3.3 Elevation

Elevation trends among occupations are similar to winter NDVI, showing a strong preference (>70%) for higher elevations (above 1160 m) across all periods, with increasing emphasis over time (Table 6.4 and Figure 6.43). As with NDVI, there is evidence for a slight decline in use during the Kitan period, although we cannot have much statistical confidence in this change (far less than 80%). Unlike NDVI trends, there is no correspondence between elevation and area-density index (local group size) for any period (Figures 6.35-39), rendering the relationship ambiguous at best. Elevation trends seem to reflect a general preference for upland areas identified for all periods, no matter local group size. As discussed, this preference is not surprising given the range of resources concentrated in upland regions that provide food, water, and shelter for human and animal populations. Today, upland zones (above 1160 m) are an important habitat for large mammals and were likely targeted by Neolithic and Bronze Age foraging communities. The high proportion of Neolithic area-density index in this zone may suggest that access to large game was an import factor in settlement decisions, though increased use of upland zones as herding lifeways developed signals that high elevations may have been valued for other reasons (e.g., winter vegetation).

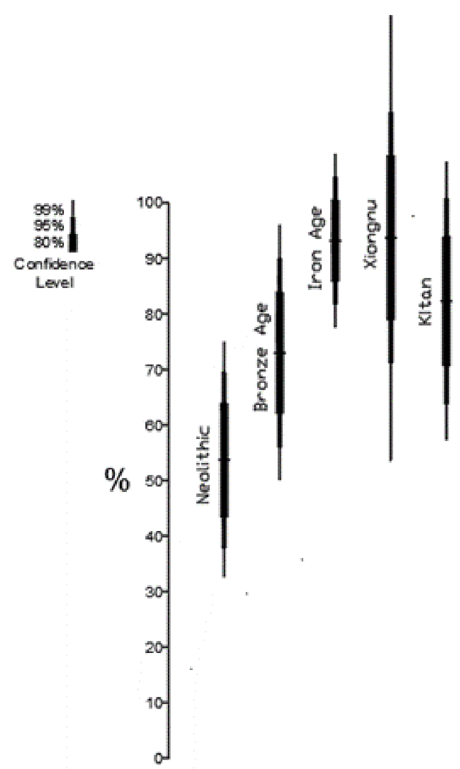


Figure 6.43 Proportion of period area-density index in high elevations (> 1160m).

6.3.4 Landform

Landform preferences were highly variable over time, though interfluvial uplands and areas of contact between upland and lowland contexts were the preferred landform across all periods (Table 6.4). Multidimensional scaling analysis reveals no connection between landform and population (Figures 6.35-39); however, a few broad patterns are evident. For example, occupation of south facing slopes was most pronounced during the Neolithic (Table 6.4); these protected areas were rarely selected in subsequent periods, indicating they were more important to hunter-gatherers than to herding communities. Minor drainages appear to have been more important to populations compared to larger drainages across all periods (Figures 6.44-45), though both increased in importance after the close of the Neolithic.

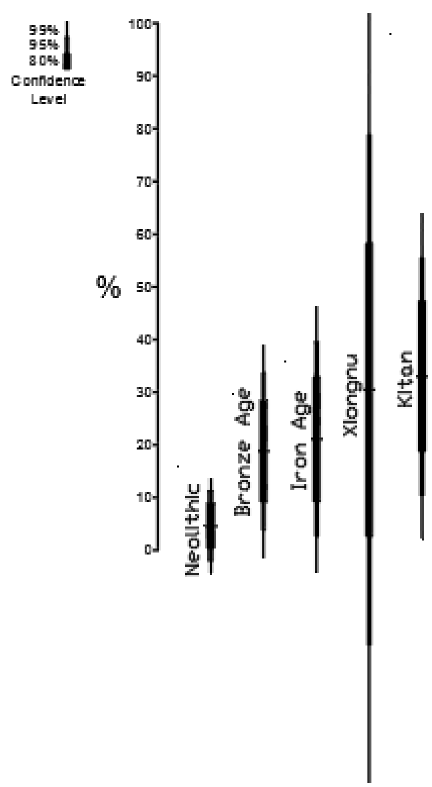


Figure 6.44 Proportion of period area-density index associated with minor drainages.

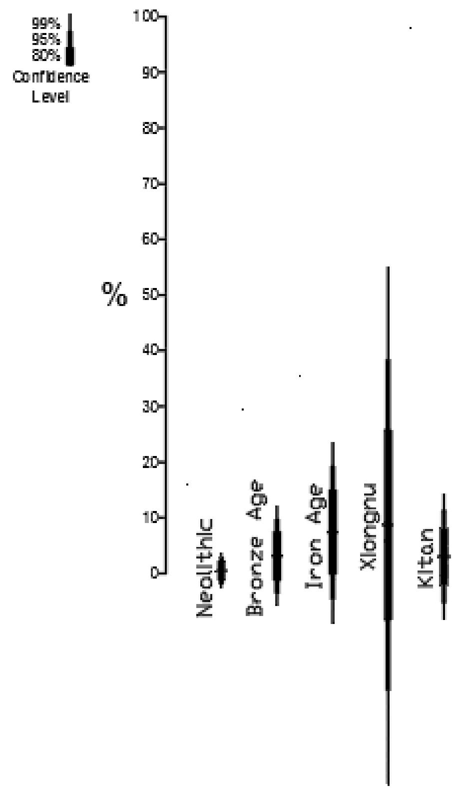


Figure 6.45 Proportion of period area-density index associated with major drainages.

In lakebed and lowland regions, networks of minor drainages form distinct wetland areas, providing important resources for both human and animal populations (Figures 6.30-34). Most of the wetland resources in the study area are small and ephemeral, changing in area and volume from season to season. A catchment analysis was conducted to determine if these resources may have been targeted differently over time (Table 6.5). An examination of 500-m buffers around each period component indicates that catchments around Neolithic sites held a higher proportion of wetland resources than later periods. A decline in proximity to wetland areas after the Neolithic supports our previous finding that these resources were likely an important factor in shaping land use strategies of Neolithic Age foragers. This trend is reflected in both lakebed and lowland zones, but is more pronounced in lowland contexts (Table 6.5b and c).

Table 6.5 Proportion of Wetland Area in 500-m Catchments by Period.

a) All environmental zones

Period	**# Sites**	**Total Area of Site Buffers**	**% Wetland coverage (>99% CI)**
Neolithic	100	78,539,800	4.1
Bronze Age	58	45,553,084	1.7
Iron Age	50	39,269,900	0.94
Xiongnu	41	32,201,318	1.3
Kitan	27	21,205,746	0.91

b) Lakebed

Period	**# Sites**	**Total Area of Site Buffers**	**% Wetland coverage (>99% CI)**
Neolithic	31	24,347,338	2.0
Bronze Age	11	8,639,378	0.6
Iron Age	8	6,283,184	0.7
Xiongnu	3	2,356,194	0.0
Kitan	2	1,570,796	0.0

c) Lowland

Period	**# Sites**	**Total Area of Site Buffers**	**% Wetland coverage (>99% CI)**
Neolithic	14	10,995,572	22.7
Bronze Age	9	7,068,582	10.4
Iron Age	5	3,926,990	8.2
Xiongnu	4	3,141,592	13.0
Kitan	2	1,570,796	9.8

6.4 Distributional Survey Summary

Settlement trends examined in these first sections provide insight to the way people have distributed themselves across the desert-steppe landscape of southeastern Mongolia, allowing us to understand land use strategies of hunter and early herders. First, it is clear that upland regions of the study area were prioritized during all periods. The upland zone of Ikh Nart is characterized by a prominent NE/NW trending granitic batholith that supports a cover of scrub vegetation and contains a series of deeply cut steam beds and springs that drain into the adjacent ancient lakebed. While this area was an important to both hunters and herders, its importance increased in the

Bronze Age as people presumably began to incorporate herding practices. During the Neolith-Bronze Age transition, the area saw not only an increase in utilization (larger proportion of overall population), but also an increase in the intensity of use, reflecting larger groups size or duration of occupation. Adjacent wetland/dune field habitats to the north were exploited to a lesser extent during all periods, though they did play a heightened role during the Neolithic. Use of lakebed/dune field habitats decreased somewhat during the Bronze Age, though they continue to have been targeted by fewer groups, but in a more intensive manner. It should be noted here that these trends are based on the location of extant wetlands and do not take into account buried wetland contexts like those identified at Burgasny Enger and other areas along major stream channels that connect upland and lakebed zones (Rosen et al. 2019) (Section 1.4.3). Preliminary geoarchaeological studies suggest that up to about 4000 years ago, wetland resources in upland contexts were more prevalent than today and were likely an important draw for Bronze Age occupants. Together, these data strongly suggest some degree of continuity of forager lifeways as herding was incorporated, however, an understanding of how these areas were exploited over time (e.g., mobility strategies employed) requires confirmation through artifact analysis, which is the focus of the following section. Beyond the continued emphasis on dune field/wet land habitats during the Neolithic-Bronze Age transition, the role other environmental variables in settlement decisions remains unclear. The study revealed no correspondence between population and aspects of the environment including landform, elevation, winter vegetation, or pasture productivity during the Neolithic; a connection between population and NDVI is stronger during the Bronze Age, with a significant increase in utilization of areas with high NDVI, however, there is no association between NDVI and local population size.

By the Iron Age, selection of upland habitats at the expense of lakebed and lowland zones is clear; a positive correlation between local group size and winter NDVI ranking suggests that people prioritized areas with productive wintertime vegetation, no doubt a critical resource for a developing herding economy. Not surprisingly, the relationship between local group size and winter NDVI persists through the Xiongnu Period, indicating that populations focused primarily on a narrow range of preferred habitats. The link between NDVI and population wanes by the Kitan Period. Interestingly, it is during this era that we see a notable increase in population size across all environmental zones, and a distinct increase in use of areas with lower NDVI suggesting that people were moving into secondary, or less desirable areas as preferred habitats were filled. The lack of correspondence between local group size and NDVI rank, though, may signal that people were moving to these areas not as a result of infilling of preferred areas, but perhaps to target new resources (e.g., other types of vegetation to meet the needs of changing herd composition).

7.0 Study Results: Lithic Artifact Analysis

This chapter begins with a description of findings from analyses of survey artifact assemblages (Section 7.1), including a detailed description of lithic artifacts and an interpretation of results as they pertain to subsistence economy and settlement mobility. These data will help to understand how areas were exploited over time (e.g., different mobility strategies), detecting differences in how, when, and why people moved. The chapter concludes with Section 7.2 which presents results of laboratory analyses of lithic artifacts derived from excavation efforts at Ikh Nart between 2015 and 2017. Combined with survey findings, these data will help to address questions regarding the nature of the transition to herding, the role of foraging lifeways, and their relationship to patterns of environmental change, both natural and social.

7.1 Survey Materials

The survey data presented in the previous section strongly suggest some degree of continuity in forager lifeways as people incorporated herding practices in this desert-steppe environment. Most notable is the primacy of upland regions across all periods. While this area was an important to both hunters and herders, its importance increased significantly in the Bronze Age demonstrated by greater utilization (i.e., larger proportion of overall population) as well as an increase in the local group size or duration of stay (i.e., increased median area-density index). People exploited adjacent wetland/dune field habitats to the north to a lesser extent, though these areas did play a heightened role during the Neolithic. A decline in use of lakebed environs is apparent by the Bronze Age, however, wetland contexts continued to be targeted by groups that were either larger in size or stayed in one place longer than during the Neolithic (as reflected by larger median area-density indices).

In the following section, I apply lithic artifact analysis results to explore differences how people exploited these areas over time as a means to understand changes in how, when, and why people moved. As outlined in Chapter 5, stone tools were subject to in-depth technological studies to compare assemblage and tool class attributes as a way to assess settlement strategies of mobile people over time. The manufacture, use, and discard of lithic tools is a dynamic aspect of cultural systems, tied to other factors such as mobility, subsistence, and access to raw material (Andrefsky 1998). As such, differences between foragers and herders in terms of settlement and subsistence should be marked by parallel change in tool kits. Changes may include the introduction of new technology to facilitate shifts in subsistence strategies; adjustments in tool production to accommodate craft production (Rosen 1997:12); alternations in levels of tool curation (i.e., expedient vs. formal) to meet on-site/off-site needs; and shifting patterns of stone tool discard that reveal differences in how people acquire raw materials. The current analysis employs models of technological organization (Kelly 1988, Nelson 1991, Torrence 1983) to examine linkages between lithic technology and settlement strategies of foragers and herders, focusing on assemblage and tool class attributes thought to be responsive to changes in settlement mobility (i.e., assemblage diversity, tool formality, material conservation).

7.1.1 General Period Trends

Flaked stone tool assemblages from period components are quite diverse, each comprising a mix of highly formalized or labor-intensive technologies (i.e., microblade core/blades, projectile points, bifacial tools, formed flake tools) alongside comparatively expedient forms (i.e., non-microblade cores, simple flake tools, flaked cobble tools). A small number of tools manufactured by way of polishing and/or grinding complete the assemblages (Table 7.1 and Figure 7.1). A comparison of expedient versus formal tool classes shows that Neolithic tool kits were overall more expedient than Bronze Age collections (0.97:1 and 0.68:1, respectively), with a focus on provisioning places as opposed to people (*sensu* Kuhn 1995), possibly signaling low levels of residential mobility and/or predictable access to resources. Bronze Age assemblages, in contrast, are somewhat more formal, indicating heightened residential mobility and/or provisioning of individuals to compensate for decreased predictability in resource access.

Despite a slight trend toward more formalized tool kits in the Bronze Age, there is no discernable difference in overall diversity, indicating no change in how Neolithic and Bronze Age people organized their movements (Table 7.1). Simpson Diversity indices are high across both periods indicating that no tool-class substantially dominates any assemblage; highly diverse tool kits are associated with longer periods of residence where a range of tasks occurred (low residential or tethered mobility).

The following discussion compares compositional trends observed in Neolithic and Bronze Age assemblages, setting aside data from collections that are clearly mixed or too small for meaningful statistical analyses (i.e., Early Bronze Age assemblages).

7.1.2 Tool Class Trends

The broad similarities among tool kits over time are generally reflected in artifact class trends that offer insight to settlement decisions as people took up herding practices across the region. For example, patterning of flake tools (except microblades), which make up the largest proportion of all period assemblages shows that expedient forms (i.e., simple/non-retouched flake tools) dominate both Neolithic and Bronze Age collections when comparted to their more formal counterparts (formed/retouched flake tools). That said, there is a modest decline in use of expedient forms during the Bronze Age and a synchronous significant increase in retouched flakes (> 99% confidence interval), signaling increased investment in tool manufacturing (Figure 7.2). The proportion of microblades identified during the survey does not change appreciably over time.

Interestingly, the shift in investment in formed flake tool manufacture is not reflected in other tool classes. For example, the proportion of highly formalized microblade cores versus other more expedient varieties does not change significantly over time (Figure 7.3). The consistency in tool kit composition is also reflected among biface and projectile point collections, which make up a small portion of period assemblages (Figure 7.4).

Table 7.1 Lithic Tool Assemblages Derived from Archaeological Survey.

	Neolithic		Early Bronze Age		Bronze Age		Total
Tool Class	**Count**	**%**	**Count**	**%**	**Count**	**%**	
Flaked Stone Tools-Expedient							
Cores	71	11.08	5	12.20	37	10.27	**113**
Flake Tools-Simple	216	33.70	12	29.27	105	29.17	**333**
Flaked Cobble Tools	26	4.06	1	2.44	1	0.28	**28**
Flaked Stone Tools-Formal							
Microblade Cores	38	5.93	3	7.32	31	8.61	**72**
Microblades	146	22.78	2	4.88	70	19.44	**218**
Flake Tools-Formed	76	11.86	3	7.32	73	20.28	**152**
Bifaces	59	9.20	13	31.71	29	8.06	**101**
Projectile Points	3	0.47	0	0.00	8	2.21	**11**
Other Stone Tools							
Perforated Stone	0	0.00	1	2.44	2	0.56	**3**
Polished Stone	1	0.16	0	0.00	1	0.28	**2**
Ground Battered Stone	5	0.78	1	2.44	3	0.83	**9**
Total All Classes	**641**	**100**	**41**	**100**	**360**	**100**	**1042**
Simpson Index of Diversity*	**.80**		**.80**		**.81**		
Ratio of Expedient to Formal Flaked Stone Tools	**0.97:1**		**0.86:1**		**0.68:1**		

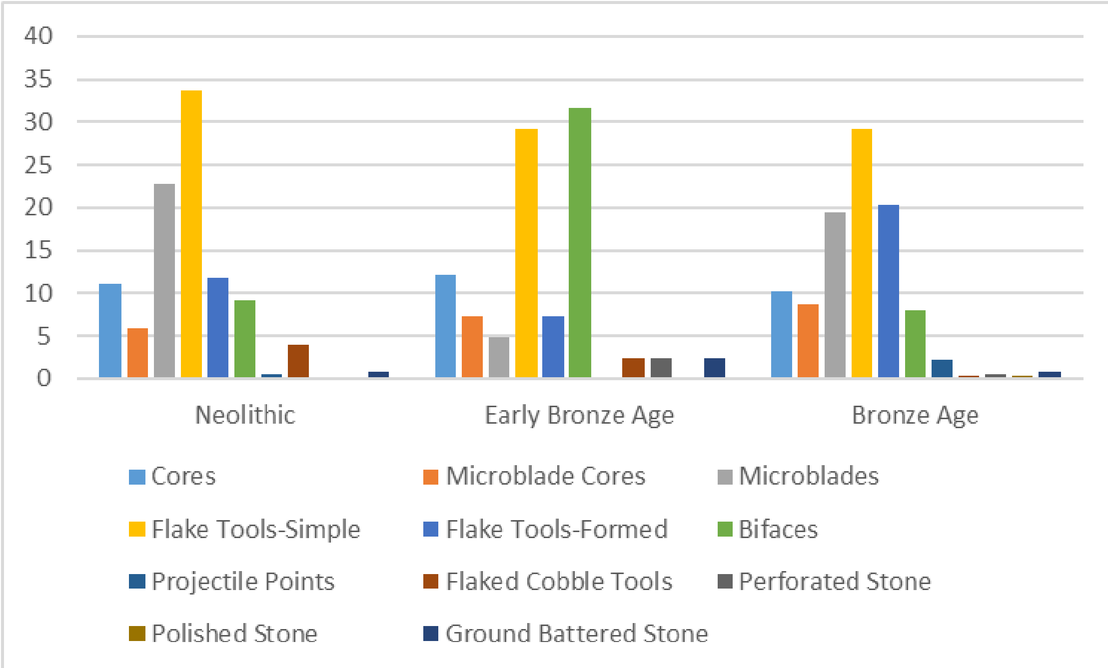


Figure 7.1 Lithic tool assemblages by period.

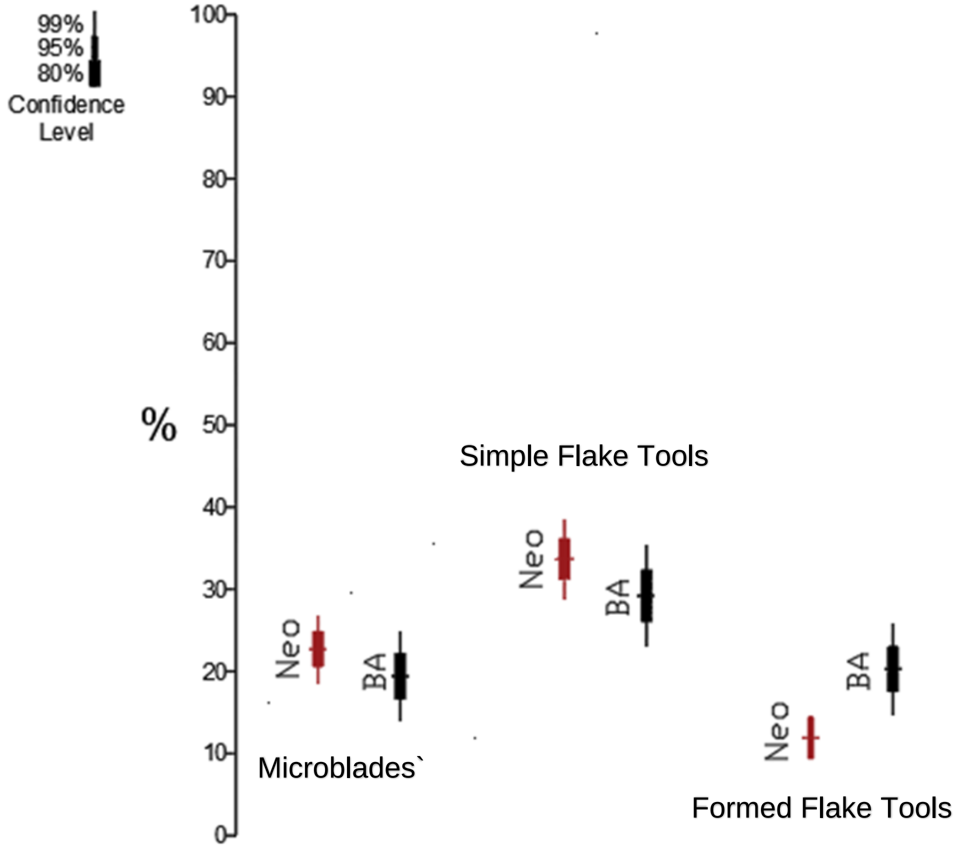


Figure 7.2 Proportion of flake tools by period.

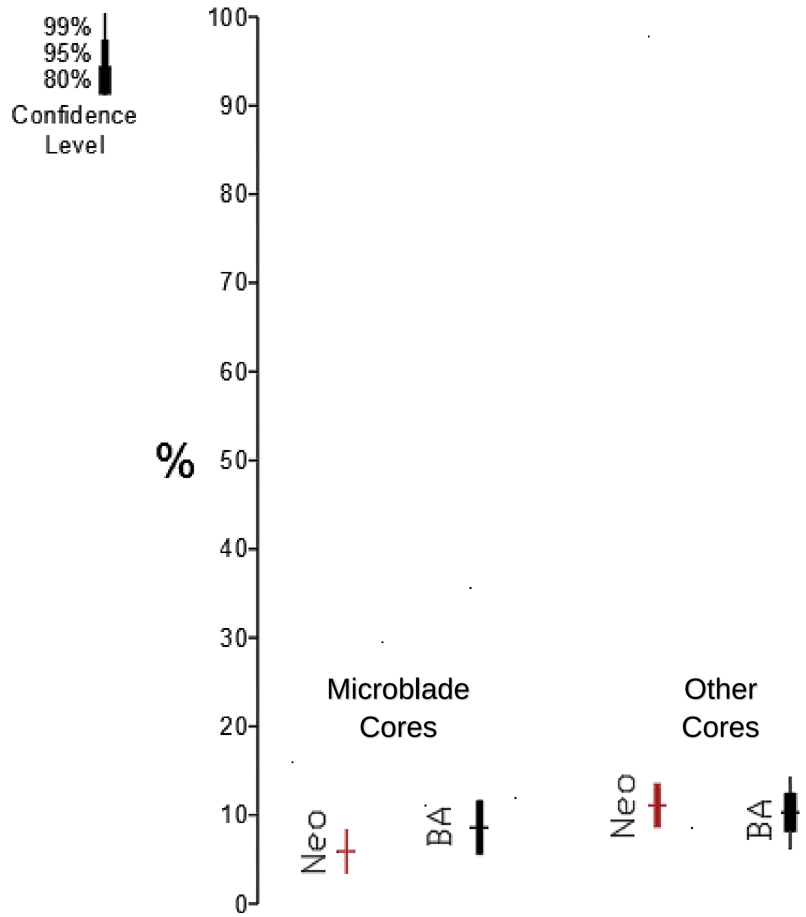


Figure 7.3 Proportion of cores by period.

Further, when we compare the ratio of flake tools to cores over time, we see in the Bronze Age a slight increase in the production of simple and formal flake tools in relation to cores, but at the same time, a decrease in the number of microblades produced from microblade cores (Table 7.2). It is unclear whether this pattern is the result of changes in efficiency of tool production (relative degree of core utilization) or possibly changes in patterns of tool manufacture and use due to changes in mobility frequency (e.g., tools are not made, used, and discarded in the same place). Collection bias may also come into play, with a high likelihood that very small microblades are underrepresented in the assemblage.

Table 7.2 Ratio of Flake Tools to Cores by Manufacturing Trajectory and Period.

Core Reduction Technology	Neolithic	Bronze Age
Core/Flake	4.1	4.8
Microblade	3.8	2.3

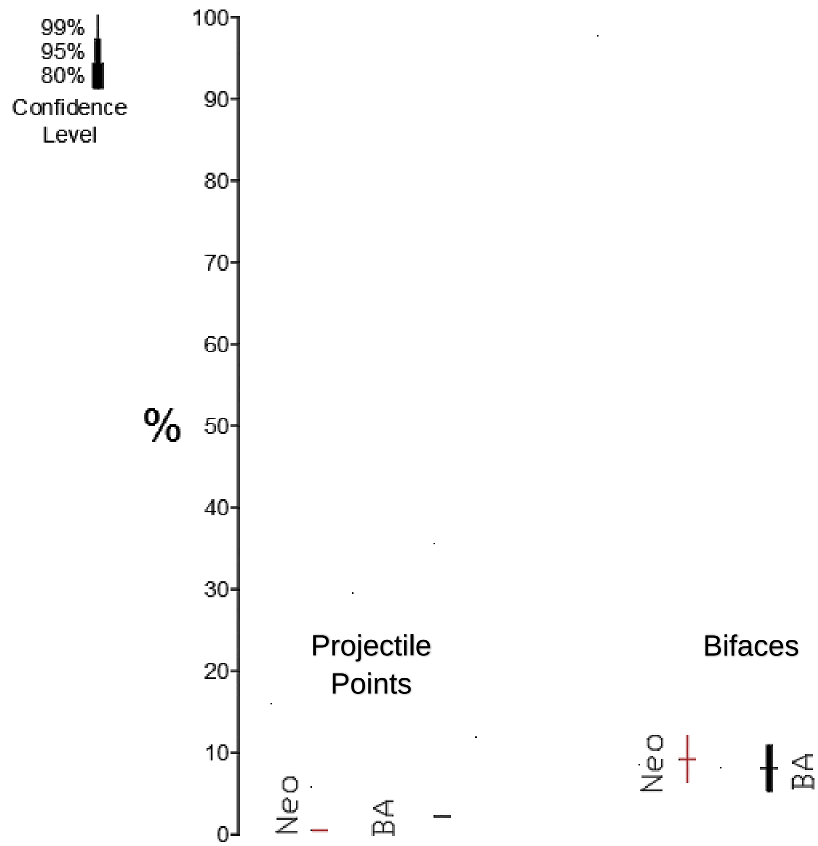


Figure 7.4 Proportion of bifaces and projectile points by period.

Taken together, these data demonstrate broad similarities in technological strategies employed by Neolithic and Bronze Age people, implying continuity in settlement trends across the transition to food production in the desert-steppe. By dividing all flaked stone tool categories into one of three manufacturing trajectories (i.e., core/flake reduction, microblade production, and bifacial tool reduction) it is apparent that for both hunters and early herders, tool manufacturing activities focused on the reduction on cores (microblade and other types) to produce usable flakes including simple and more formalized or retouched implements (Figure 7.5). More labor intensive and formalized trajectories involving the production of bifacial tools were significantly less common in both periods. It appears that Neolithic people, presumably with a foraging focus, relied heavily on the expedient production of usable flakes, with only limited investment in more labor-intensive formal tool production. By the Bronze Age there is increased investment in more heavily retouched flakes, though use of microblade and bifacial technology is unchanged.

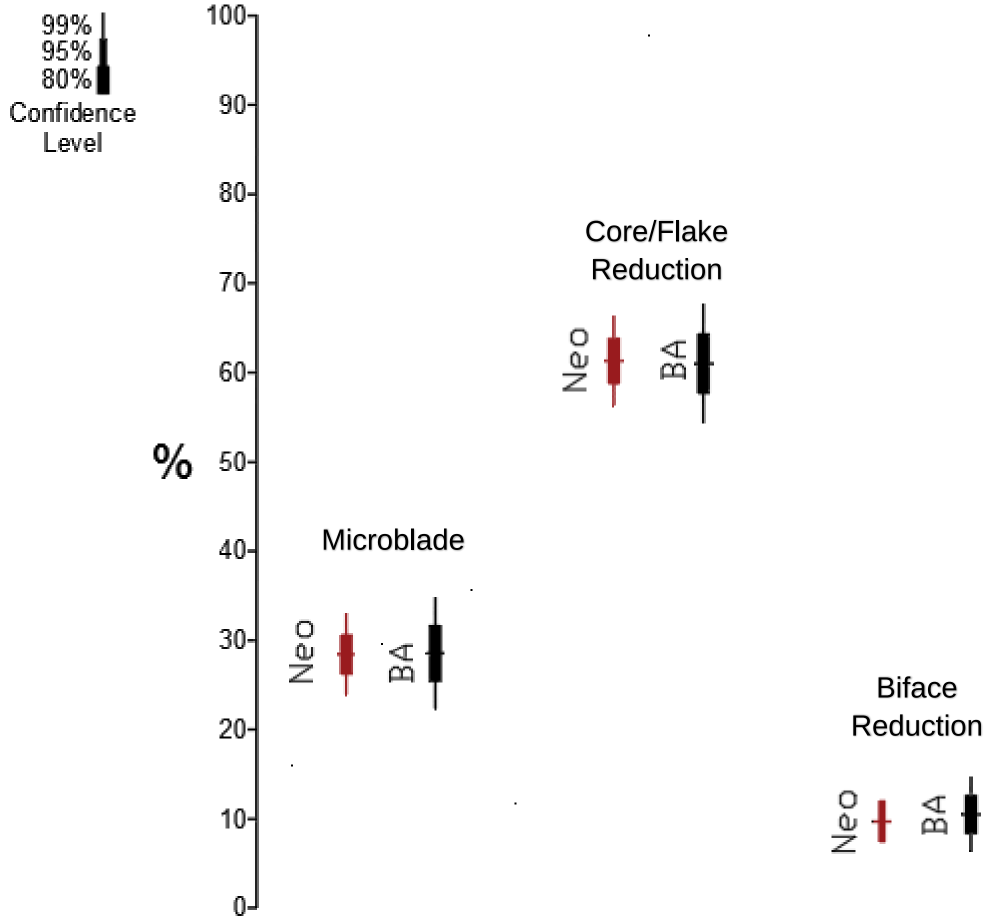


Figure 7.5 Proportion of manufactoring trajectories by period.

7.1.3 Land Use Trends

Tool kits recovered from the three environmental zones largely reflect the broad technological trends described for the period assemblages, with a few key differences that illuminate changes in how hunters and herds provisioned themselves across the transition to food production. The following section examines artifact pattering across environmental zones to discern potential differences in land use over time (Table 7.3). The analysis includes tools from locales identified as residential sites based on evidence for food preparation (groundstone implements and ceramic debris) or multiple types of on-site activities (e.g., hunting, manufacturing, lithic production, manufacturing).

7.1.3.1 Upland

Neolithic and Bronze assemblages from upland settings are remarkably similar, corresponding to the survey data that suggest some level of stability in land use over time (Tables 7.3 and 7.4). The ratio of expedient to formal tools, for example, is similar, reflecting an emphasis on the production of more labor-intensive technologies, including retouched flake tools and to a lesser extent microblade technology. Manufacturing trajectories (Figure 7.6) and flake tool typology (Figure 7.7) are also similar, signaling continuity how the uplands were targeted over time. Similarities among the more infrequent artifact classes including bifaces, projectile points, and cores provide additional evidence for stability in upland land use strategies (Figures 7.8-7.9)

Table 7.3 Residential Lithic Tool Assemblages by Period and Environmental Zone.

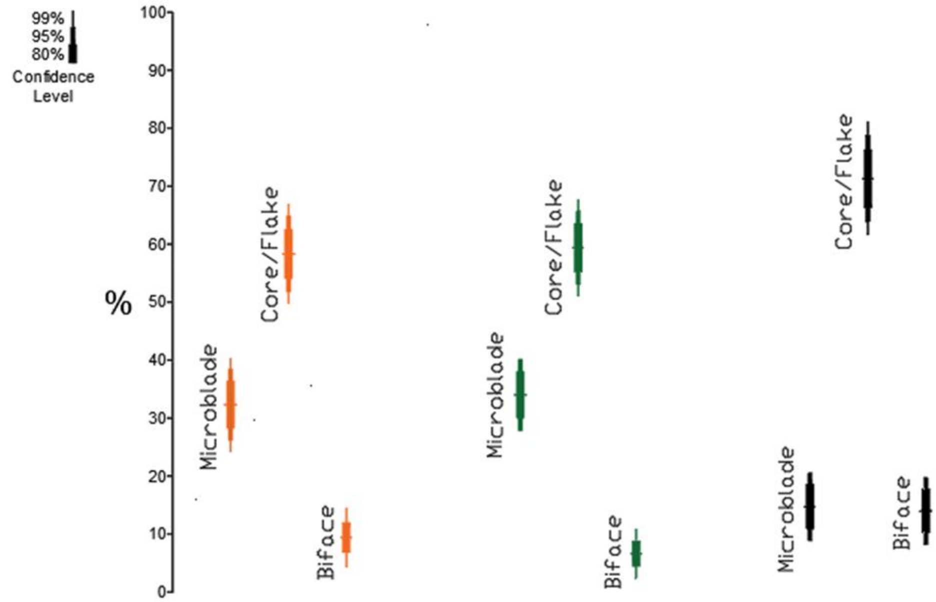
NEOLITHIC	Lakebed		Upland		Lowland		Total
Stone Tool Class	Count	%	Count	%	Count	%	
Expedient Flaked Stone							
Cores	19	8.37	17	7.17	26	18.18	**62**
Flake Tools-Simple	73	32.16	71	29.96	65	45.45	**209**
Flaked Cobble Tools	17	7.49	6	2.53	3	2.10	**26**
Formal Flaked Stonel							
Microblade Cores	9	3.96	20	8.44	7	4.9	**36**
Microblades	63	27.75	62	26.16	14	9.79	**139**
Flake Tools-Formed	21	9.25	44	18.57	8	5.59	**73**
Bifaces	20	8.81	15	6.33	19	13.29	**54**
Projectile Points	1	0.44	0	0	1	0.7	**2**
Other Stone Tools							
Perforated Stones	0	0	0	0	0	0	**0**
Polished Stones	1	0.44	0	0	0	0	**1**
Ground/Battered Stone	3	1.32	2	0.84	0	0	**5**
Total All Tools	**227**	**100**	**237**	**100**	**143**	**100**	**607**
Simpson Index of Diversity.	**.79**		**.79**		**.73**		
Expedient:Formal	**0.96:1**		**0.68:1**		**1.92:1**		

BRONZE AGE	Lakebed		Upland		Lowland		Total
Stone Tool Class	Count	%	Count	%	Count	%	
Expedient Flaked Stone							
Cores	13	11.3	22	10.38	2	6.06	**37**
Flake Tools-Simple	31	26.95	60	28.3	14	42.42	**105**
Flaked Cobble Tools	0	0.00	0	0.00	1	3.03	**1**
Formal Flaked Stone							
Microblade Cores	6	5.22	23	10.85	2	6.06	**31**
Microblades	28	24.35	42	19.81	0	0	**70**
Flake Tools-Formed	26	22.61	43	20.28	4	12.12	**73**
Bifaces	7	6.09	14	6.6	8	24.24	**29**
Projectile Points	2	1.74	5	2.36	1	3.03	**8**
Other Stone Tools							
Perforated Stones	0	0.00	1	0.47	1	3.03	**2**
Polished Stones	1	0.87	0	0.00	0	0.00	**1**
Ground/Battered Stone	1	0.87	2	0.94	0	0.00	**3**
Total All Tools	**115**	**100**	**212**	**100**	**33**	**100**	**360**
Simpson Index of Diversity	**.80**		**.82**		**.76**		
Expedient:Formal	**0.64:1**		**0.65:1**		**1.13:1**		

Table 7.4 Summary of Flakedstone Characteristics by Period and Environmental Zone.

	Neolithic	Bronze Age	Change Over Time
Lakebed			
Technological Profile	Core/Flake reduction dominant. Microblade reduction > biface reduction.	Core/Flake reduction dominant. Microblade reduction > biface reduction.	Slight increase in core/flake reduction (80% CI). No change in microblade or biface manufacturing.
Expedient : Formal Tools	0.96:1 (slightly favors formal).	0.64:1 (highly favors formal).	Increase in tool assemblage formality.
Flake Tool Profile	Near equal proportions of simple flake tools and microblades. Few formed flake tools.	Equal proportions of all flake tool types.	Formed flake tools increase significantly (>99% CI)
Cores	More non-microblade cores than microblade cores.	More non-microblade cores than microblade cores.	No change
Groundstone	1.32% of assemblage.	0.87% of assemblage.	Decrease in proportion groundstone implements.
Upland			
Technological Profile	Core/Flake reduction dominates. Microblade reduction>biface reduction.	Core/Flake reduction dominates. Microblade reduction>biface reduction.	No change.
Expedient : Formal Tools	0.68:1 (highly favors formal).	0.65:1 (highly favors formal).	Slight increase in tool assemblage formality.
Flake Tool Profile	Slightly more simple flake tools compared to other types. More microblades compared to retouched flakes.	Slightly more simple flake tools compared to other types. Near equal formal retouched flakes and microblades.	Very little change, slight decrease in microblades (95% CI).
Cores	Near equal proportion of cores and microblade cores.	Near equal proportion of cores and microblade cores.	No change in core types, but small increase in proportion of cores in assemblages (80% CI).
Groundstone	0.85% of assemblage.	0.94% of assemblage.	Little change.
Lowland			
Technological Profile	Core/Flake reduction dominates. Low proportion of biface and microblade reduction.	Core/Flake reduction dominates. Biface reduction increase while, microblades decrease.	Moderate decrease in microblade reduction and increase in bifacial tool reduction (95% CI).
Expedient : Formal Tools	1.92:1 (strongly favors expedient tools.	1.13 (slightly favors expedient tools.	Expedient tool dominate. Slight increase assemblage formality over time.
Flake Tool Profile	Simple flake tools dominate. Fewer, but near equal formed flake tools and microblades.	Simple flake tools dominate. Formed flake tools more common, and microblades more rare.	Moderate increase in formed flake tools (95% CI), and significant drop in microblades (>99% CI).
Cores	Other cores more dominant than microblade cores (>99% CI).	Near equal proportions of core types.	Significant drop in non-microblade cores (95% CI).
Groundstone	None	None	No change

a) Neolithic



b) Bronze Age

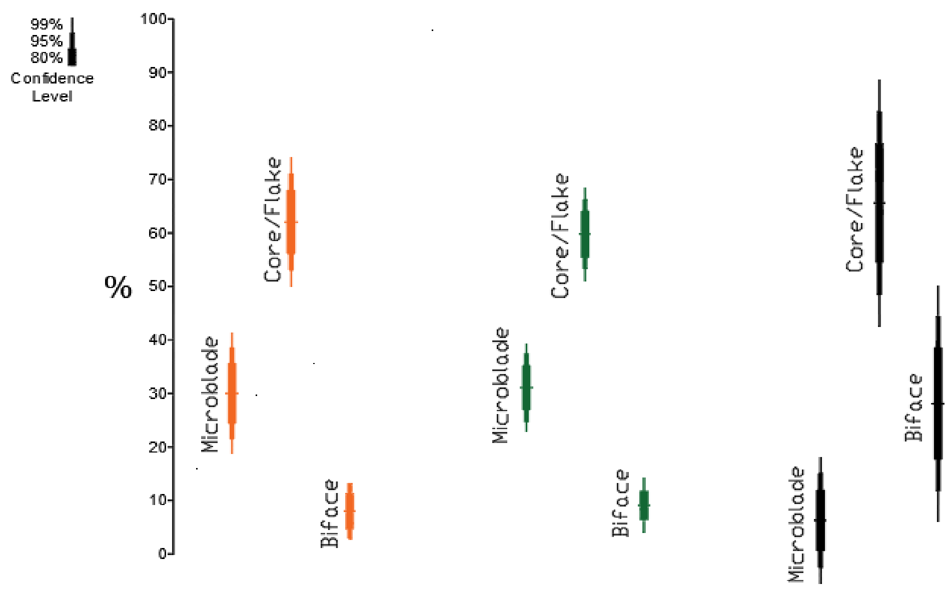
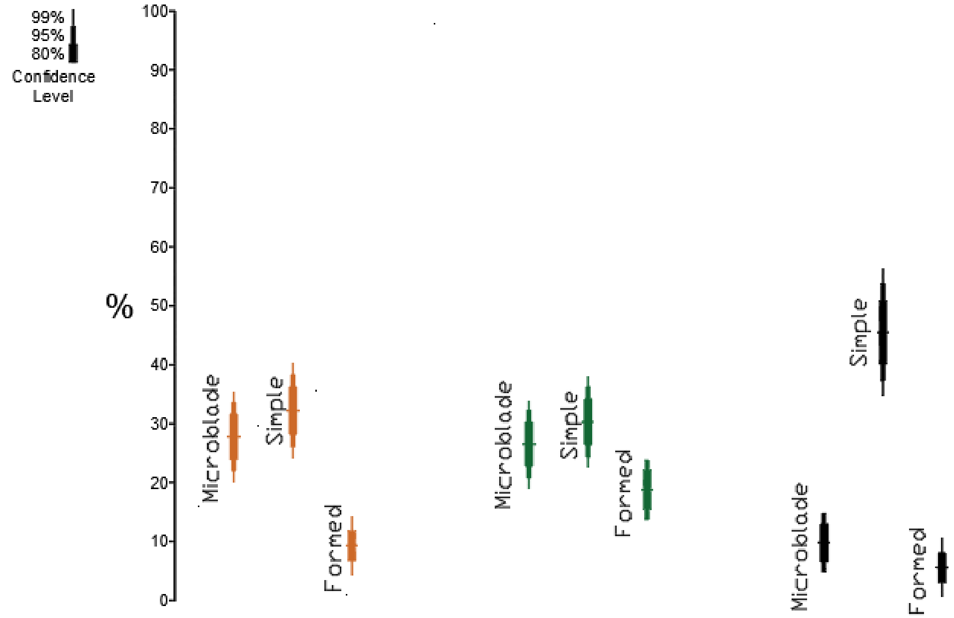


Figure 7.6 Proportion of manufacturing trajectories by environmental zone. Lakebed, orange bullets on left; Upland, green bullets center; Lowland, black bullets on right.

Core/Flake Reduction= Simple, formed flake tools, cores. Microblade Reduction=Microblade cores, microblades. Biface Reduction= Bifacial tools, projectile points.

a) **Neolithic**



b) **Bronze Age**

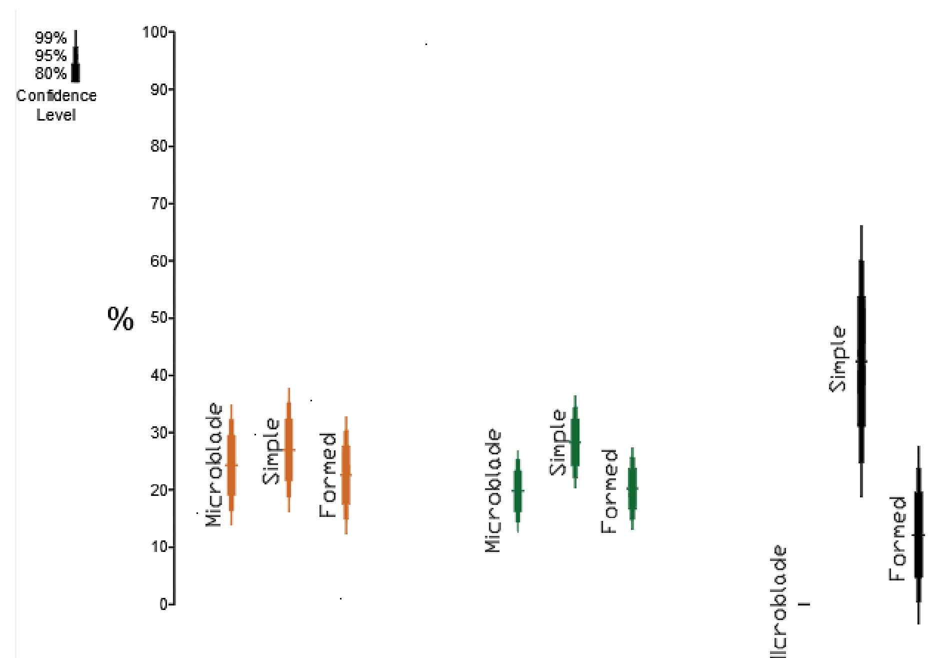
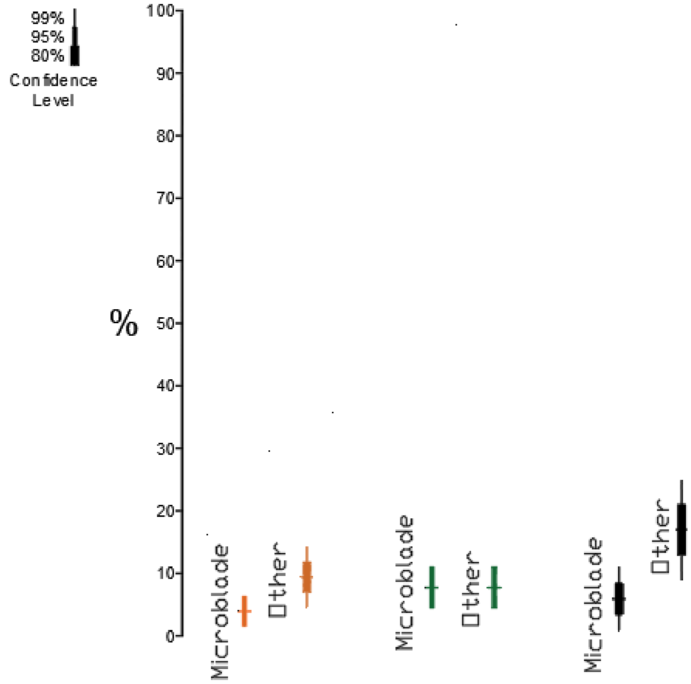


Figure 7.7 Proportion of flake tools by environmental zone. Lakebed, orange bullets on left; Upland, green bullets center; Lowland, black bullets on right. MB=Microblade; SFT=Simple Flake Tool; FFT=Formed Flake Tool.

a) **Neolithic**



b) **Bronze Age**

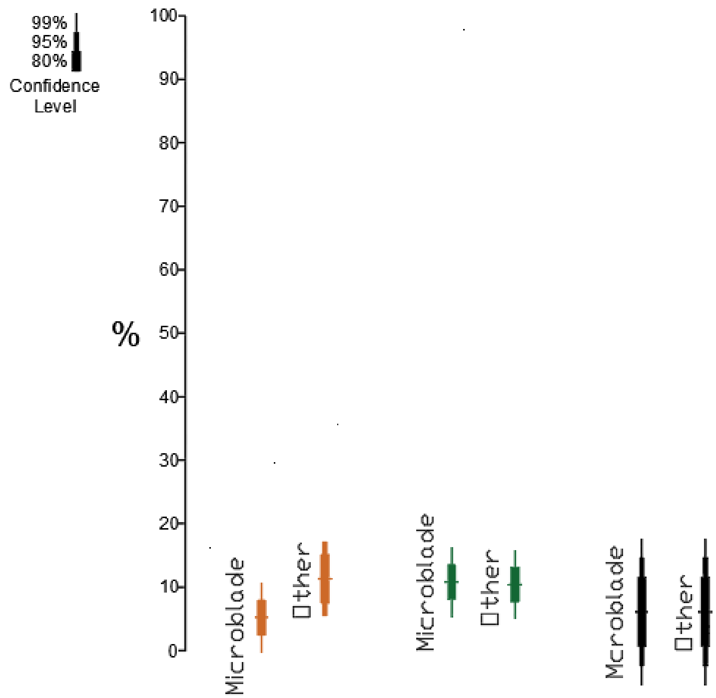


Figure 7.8 Proportion of core types by environmental zone..Lakebed, orange bullets on left; Upland, green bullets center; Lowland, black bullets on right. MBC=Microblade Cores; OTH=Other Cores.

a) Neolithic

b) Bronze Age

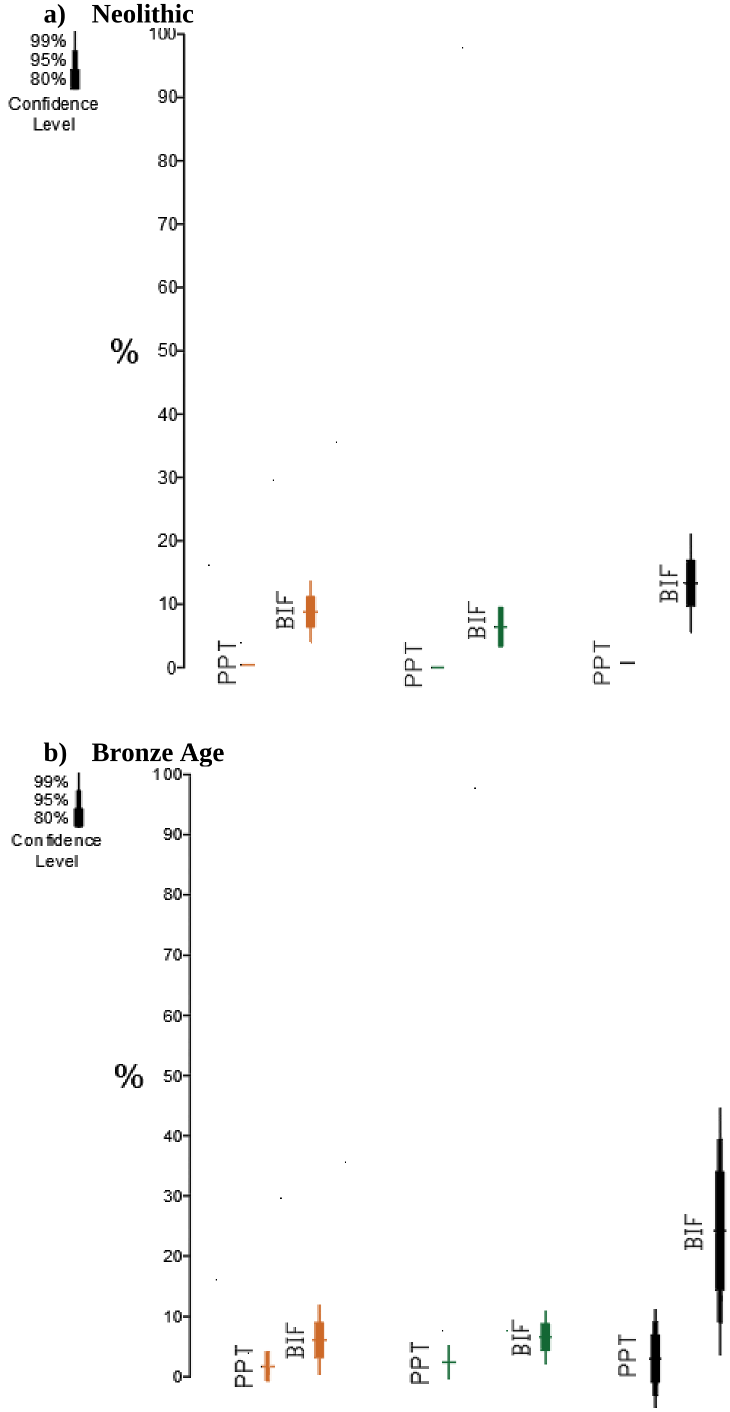


Figure 7.9 Proportion of projectile points and bifaces by environmental zone. Lakebed, orange bullets on left; Upland, green bullets center; Lowland, black bullets on right. . PPT=Projectile Point; BIF=Biface.

7.1.3.2 Lakebed

Similar to the upland record, lakebed manufacturing trajectories are dominated by core/flake reduction, though some changes in tool use are evident. By the Bronze Age there is a small increase (with very little statistical significance) in core/flake reduction (Figure 7.6) and a notable increase in the overall formality of assemblages, driven primarily by a significant increase in retouched flakes (Figure 7.7). Patterns suggest only minor shifts in how lakebed environs were targeted during the Bronze Age, closely resembling trends observed in upland contexts. In other words, across the Neolithic and Bronze Age, lakebed and upland zones were targeted in similar ways. This interpretation corresponds with survey data that suggests that while lakebed environments saw a decline in utilization during the Bronze Age (decline in proportion of total population), the area continued to be targeted by fewer groups, either larger in size or saying for longer periods, mirroring patterns observed in upland zones.

7.1.3.3 Lowland

Lowland areas saw the most dramatic shift in tool use, with a decided increase in assemblage formality over time, driven largely by a significant rise in biface technology (Figure 7.6) and a modest increase in retouched flakes (Figure 7.7). Across both periods, lowland flaked stone tool signatures are divergent from lakebed and upland zones, most notably a dearth of microblade tools. Inter-zone differences suggest that for all periods, lowlands were targeted in different ways, or for different purposes. The absence of groundstone implements in lowland assemblages supports this interpretation. The sparse collection of groundstone collected from the survey derived solely from lakebed and upland contexts, making up less than 2% of period assemblages (Table 7.4).

7.1.4 Tool Attributes

The following section examines attributes of select tool classes from residential sites to contextualize broad assemblage trends, and importantly to make inferences about the nature of settlement decisions as people began to take up herding lifeways. Artifact analysis datasheets are on file at the University of Pittsburgh's Comparative Archaeology Database (http://www.cadb.pitt.edu).

7.1.4.1 Bifaces

Non-hafted bifacial tools constitute a small proportion of assemblages across all period contexts and environmental zones, making up 9-13% of flaked stone tool kits. While not the dominant tool class in any context, differences in tool and assemblage characteristics reveal that bifaces were incorporated into tool kits in diverse ways, suggesting differences in how habitats were targeted (Table 7.5 and Figure 7.10).

7.1.4.1.1 Upland

During the Neolithic, the biface manufacturing profile for upland habitats shows a relatively even distribution of manufacturing stages present (slightly more late-stage forms), indicating all that all phases of manufacture occurred (Table 7.5 and Figure 7.10a). This observation is generally supported by associated manufacturing debris that reflects both early and late-stage biface reduction (e.g., pressure flaking), 11-46% and 7-9%, respectively (Table 7.6). Most of the bifaces are broken, though less than a quarter of the assemblage exhibit evidence for reworking or recycling, signaling little concern for tool conservation (Table 7.8). An abundance of biface manufacturing debris (19-49% of debitage) from contemporaneous upland sites belies the paucity of bifaces or bifacial implements assigned to this period, suggesting that the more serviceable or whole implements were transported off site (Table 7.6). Biface manufacturing residues were commonly selected for use as simple or retouched flake tools. Flake tools derived from non-microblade and microblade cores make for a diverse technological profile (Figure 7.11a).

During the Bronze Age, late-stage forms significantly dominate biface assemblages from upland zones (> 99% confidence interval). Patterns are not substantially different from the Neolithic biface stage profile (Figure 7.10b); the manufacturing debris profile continues to present a preponderance of biface manufacturing residues (40% of flakes) (Table 7.6). A moderate increase in concern for material conservation is evidenced by an increase in evidence for reworking or recycling (95% CI). This is contradicted by other evidence for tool stone conservation, such as amount of retouch on flake tools, suggests an overall decrease in conservation efforts in the uplands over time (Table 7.9).

In contrast to the Neolithic sample, cortex is absent on from Bronze Age upland bifaces suggesting pre-reduced implements were imported to the area, with the earliest stages of manufacture and retooling activities occurring elsewhere (Table 7.7). In this context, a significant uptick in the proportion of flaked tools made from biface thinning debris may indicate imported bifacial implements served as cores for the production of usable flake tools (Figure 7.11b).

Together, biface patterning signals minimal change in how uplands were used during the transition to food production, primarily related to manufacture-use-discard trajectories: during the Neolithic, all stages of manufacture and use occurred locally, though by the Bronze Age, manufacturing appears to have occurred elsewhere to some extent.

7.1.4.1.2 Lakebed

Neolithic lakebed patterns are notably different from contemporaneous upland assemblages, holding a higher proportion of middle stage forms (99% CI), and fewer late-stage forms (95% CI) (Figure 7.10). Percentage of cortex present (Table 7.7a) and predominance of biface thinning debris (20-46%) are similar to upland bifaces, indicating some degree of local manufacture and use, with usable complete forms transported off site (Table 7.6). Almost half of bifaces found in lakebed contexts exhibit evidence of recycling, significantly higher than those from uplands (95-99% CI), signifying a high degree of concern for tool stone conservation (Table 7.8). A single projectile point increases the proportion of late stage implements in lakebed areas, however, unlike non-hafted tools, it was not subjected to recycling or repair. Biface manufacturing debris was commonly selected for use as simple or retouched flake tools, making up almost 50% of all flake tools (Figure 7.11a).

In all, the relatively uneven biface manufacturing profile and heightened evidence for material conservation observed in Neolithic lakebed contexts seem to suggest higher levels of residential mobility compared to contemporaneous upland settings.

The collection of bifaces from Bronze Age lakebed contexts is very small; while this certainly impedes meaningful temporal and spatial comparisons, some trends are apparent. For example, it is evident that the lakebed manufacturing profile is truncated with no evidence for early-stage reduction. Middle and late stages are represented equally (Figure 7.10b); though the absence of cortex suggests that tools were imported on site in pre-reduced form (Table 7.7b). As with the Neolithic sample, biface manufacturing debris was commonly selected use as flake tools (Figure 7.11b). None of the items appear to have been reworked or recycled (Table 7.8), though evidence for conservation is apparent in the collection of formed flake tools which show a significant increase in retouch over time (95% CI) in lakebed contexts (Table 7.9).

7.1.4.1.3 Lowland

Similar to lakebed environs, the Neolithic lowland biface assemblage possesses elevated proportions of middle stage forms compared to early and late stage (95% CI and >99% CI, respectively), reflecting an uneven manufacturing trajectory. Evidence for material conservation is low, with recycling or tool maintenance evident on less than 16% of the tools (Table 7.8); a relatively high proportion of whole or mostly intact tools supports this interpretation (Table 7.5). Interestingly, early-stage forms from the lowlands exhibit less cortex than those from other areas (Table 7.7a), and along with the aforementioned tool trends suggest that bifaces arrived in a pre-reduced form rather than manufactured locally. Comparatively low proportions of early biface thinning debris from period sites (less than 20%) supports this interpretation (Table 7.6). Similar to the lakebed, biface manufacturing debris was commonalty chosen for the production of simple and retouched flake tools than other flake types (Figure 7.11a).

The Bronze Age biface sample is small, though it makes up 25% of the lowland tools, significantly higher than any other temporal or spatial context. All manufacture stages are present (Figure 7.10b); cortex is present on all early and middle stage forms indicating some degree of local manufacture (Table 7.7b). Similar to all other contexts, biface manufacturing debris was commonly used for flake tool produced (Figure 7.11b), though interior flakes from non-microblade cores were used to a similar extent. Emphasis on reworking or recycling (63% of assemblage) signals heightened concern for tool conservation from the previous period (99% CI) (Table 7.8); trends are significantly divergent from upland and lakebed environs during this period (95% CI and > 99% CI, respectively).

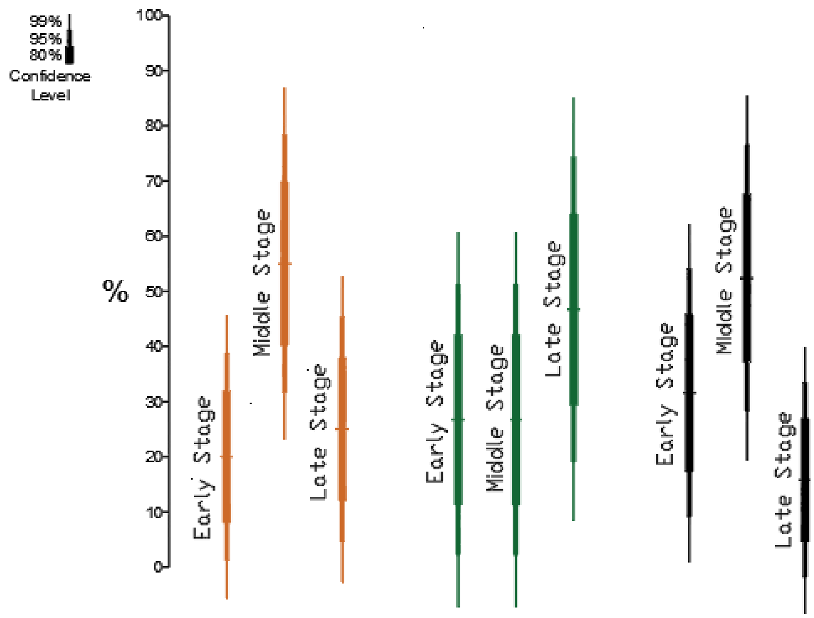
Table 7.5 Bifaces: Select Attributes by Period and Environmental Zone.

	Lakebed Neolithic (n=20)		Lakebed Bronze (n=7)		Upland Neolithic (n=15)		Upland Bronze (n=14)		Lowland Neolithic (n=19)		Lowland Bronze (n=8)	
Condition	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**
Whole/Near Complete	3	15.00	1	14.29	2	13.33	4	28.57	4	21.05	2	25.00
End	9	45.00	4	57.14	7	46.67	3	21.43	8	42.11	4	50.00
Medial	4	20.00	2	28.57	2	13.33	3	21.43	2	10.53	1	12.50
Margin	4	20.00	0	0.00	4	26.67	3	21.43	5	26.32	1	12.50
Indet.	0	0.00	0	0.00	0	0.00	1	7.14	0	0.00	0	0.00
Stage												
1 (Early)	0	0.00	0	0.00	1	6.67	0	0.00	1	5.26	0	0.00
2 (Early)	4	20.00	0	0.00	3	20.00	3	21.43	5	26.32	2	25.00
3 (Middle)	11	55.00	4	57.14	4	26.67	2	14.29	10	52.63	2	25.00
4 (Late)	2	10.00	2	28.57	5	33.33	2	14.29	0	0.00	1	12.50
5 (Late)	3	15.00	1	14.29	2	13.33	6	42.86	1	5.26	2	25.00
9 (Indet.)	0	0.00	0	0.00	0	0.00	1	7.14	2	10.53	1	12.50
%cortex												
0	15	75.00	7	100.00	12	80.00	13	92.86	13	68.42	4	50.00
1 (1-25%)	3	15.00	0	0.00	2	13.33	0	0.00	3	15.79	4	50.00
2 (26-50%)	2	10.00	0	0.00	1	6.67	0	0.00	2	10.53	0	0.00
3 (51-90%)	0	0.00	0	0.00	0	0.00	1	7.14	0	0.00	0	0.00
4 (91-100%)	0	0.00	0	0.00	0	0.00	0	0.00	1	5.26	0	0.00
9	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
With/Thickness Ratio	**Average**		**Average**		**Average**		**Average**		**Average**		**Average**	
	3.3		3.5		4		3.2		2.7		3.2	
Reworking	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**
Present	9	45.00	0	0.00	3	20.00	5	35.71	3	15.79	5	62.50
Absent	11	55.00	7	100.00	12	80.00	9	64.29	16	84.21	3	37.50
Use Wear												
Present	4	20.00	2	28.57	10	66.67	8	57.14	7	36.84	3	37.50
Absent	16	80.00	5	71.43	5	33.33	6	42.86	12	63.16	5	62.50

Table 7.6 Debitage: Technological Profile by Environmental Zone and Period.

	Decortication	Interior	Microblade	Biface thinning (Early/Late)	Pressure	Indeterminate
Lakebed						
Neolithic (Site A024)	5.15	7.22	3.03	44.33 (26.80/11.30)	7.22	32.99
Neolithic (Site A077)	7.19	2.16	4.32	22.30 (13.67/6.83)	10.07	53.95
Neolithic (Site A203)	13.31	2.92	4.22	46.10 (23.70/16.56)	4.55	28.9
Bronze Age (Site A003)	10.45	2.99	7.46	29.85 (19.40/10.45)	5.97	43.29
Bronze Age (Site A117)	14.29	2.38	0	36.90 (21.43/9.52)	8.33	38.09
Upland						
Neolithic (Site B073)	1.54	3.08	0	49.23 (46.15/3.08)	0	46.15
Neolithic (Site B014)	3.08	4.62	1.54	18.46 (10.77/6.15)	9.23	63.08
Neolithic (B080)	12.27	6.75	14.11	26.38 (20.86/4.91)	6.75	33.75
Bronze Age (Site B072)	7.25	7.73	4.83	40.10 (28.02/4.35)	8.7	31.4
Lowland						
Neolithic (Site C192)	20.69	14.66	1.15	16.67 (14.08/1.72)	1.15	45.69
Neolithic (Site C248)	48.33	1.67	0	25.00 (20.00/3.33)	0	25.01

a) **Neolithic**



b) **Bronze Age**

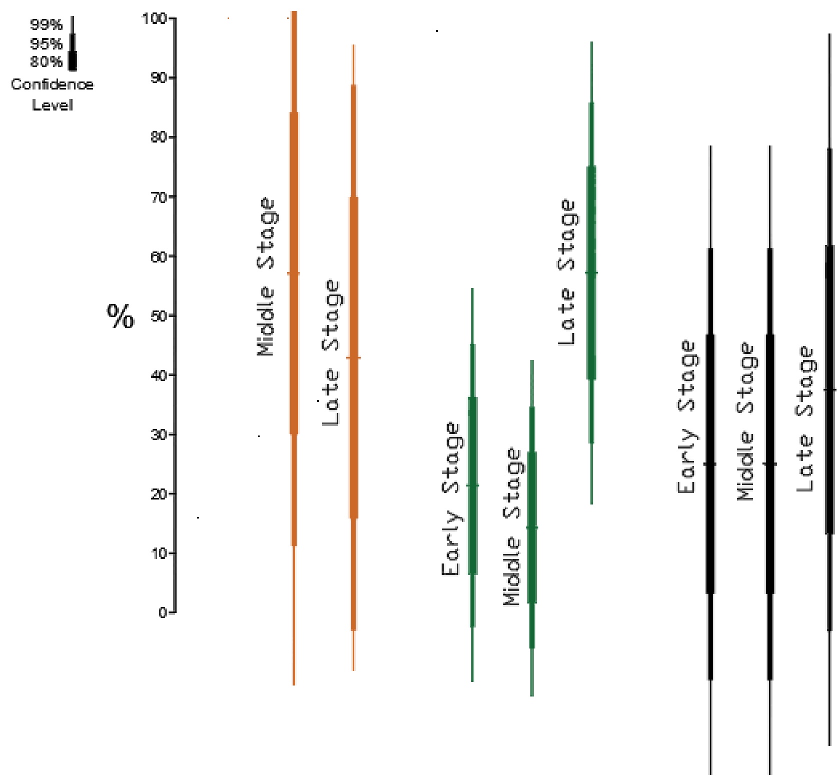


Figure 7.10 Bifaces: Manufacturing stage profile by environmental zone. Lakebed, orange bullets on left; Upland, green bullets center; Lowland, black bullet on right.

Table 7.7 Bifaces: Proportion of Cortex by Stage and Environmental Zone.

a) Neolithic

	Lakebed			Upland			Lowland		
Biface Stage	**Early Stage (*n*=4)**	**Middle Stage (*n*=11)**	**Late Stage (*n*=5)**	**Early Stage (*n*=5)**	**Middle Stage (*n*=7)**	**Late Stage (*n*=7)**	**Early Stage (*n*=6)**	**Middle Stage (*n*=10)**	**Late Stage (*n*=1)**
Cortex Present									
0% Cortex	25.00	81.80	100.00	33.33	71.40	100.00	50.0	54.50	100.00
1-25% Cortex	25.00	18.20	0.00	33.33	28.60	0.00	16.66	36.40	0.00
26-50% Cortex	50.00	0.00	0.00	33.33	0.00	0.00	16.66	9.10	0.00
51-90% Cortex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
91-100% Cortex	0.00	0.00	00.00	0.00	0.00	0.00	16.66	0.00	0.00
Total	**100.00**	**100.00**	**100.00**	**99.99**	**100.00**	**100.00**	**99.98**	**100.00**	**100.00**

Does not include tools unidentifiable as to stage.

b) Bronze Age

	Lakebed			Upland			Lowland		
Biface Stage	**Early Stage (*n*=0)**	**Middle Stage (*n*=4)**	**Late Stage (*n*=3)**	**Early Stage (*n*=3)**	**Middle Stage (*n*=2)**	**Late Stage (*n*=8)**	**Early Stage (*n*=2)**	**Middle Stage (*n*=2)**	**Late Stage (*n*=3)**
Cortex Present									
0% Cortex	0.00	100.00	100.00	100.00	100.00	100.00	0.00	0.00	100.00
1-25% Cortex	0.00	0.00	0.00	0.00	0.00	0.00	100.00	100.00	0.00
26-50% Cortex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51-90% Cortex	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00
91-100% Cortex	0.00	0.00	00.0	0.0	0.00	0.00	0.00	0.00	0.00
Total	**0.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

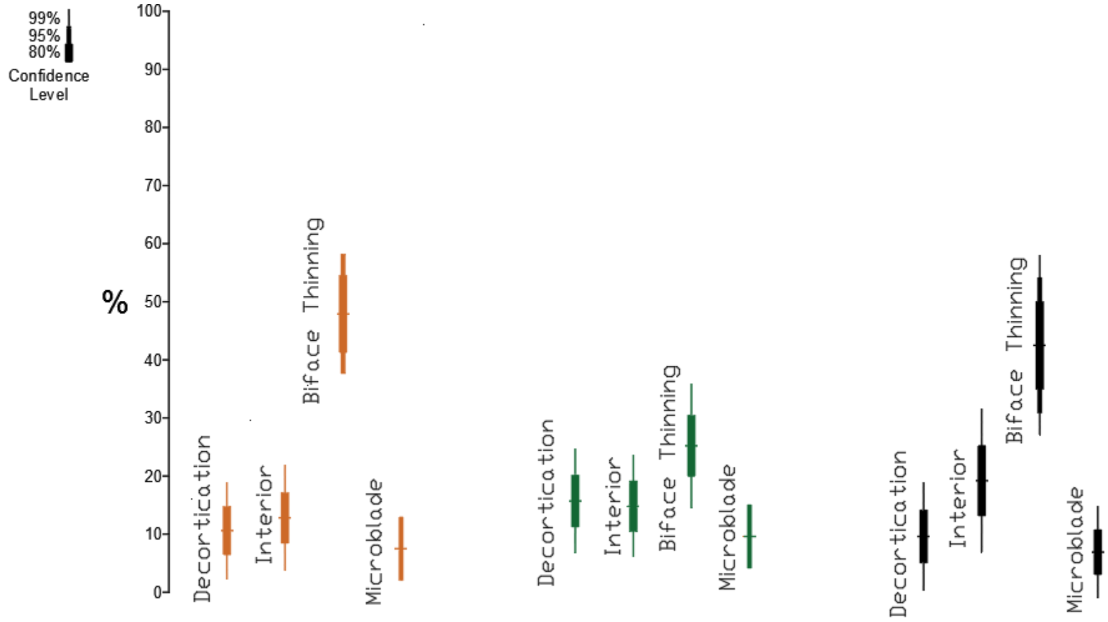
Table 7.8 Bifaces: Proportion with Evidence for Recycling or Reworking by Period and Environmental Zone (w/confidence intervals).

Survey Area	Proportion	80% CI	95%CI	99%CI
Lakebed Neolithic	45.0	±14.8	±23.3	±31.8
Lakebed Bronze Age	0	0	0	0
Upland Neolithic	20.0	±13.9	±22.1	±30.8
Upland Bronze Age	35.7	±17.3	±27.7	±38.6
Lowland Neolithic	15.8	±11.1	±17.6	±24.1
Lowland Bronze Age	62.5	±24.2	±40.5	±60.0

Table 7.9 Formed Flake Tools: Average Retouch Index by Period and Environmental Zone (w/confidence intervals).

Survey Area	Average Retouch Index	80% CI	95%CI	99%CI
Lakebed Neolithic	0.71	±0.06	±0.10	±.14
Lakebed Bronze Age	0.80	±0.04	±0.06	±.08
Upland Neolithic	0.83	±0.02	±0.03	±.05
Upland Bronze Age	0.78	±0.03	±0.05	±.07
Lowland Neolithic	0.79	±0.08	±0.13	±.19
Lowland Bronze Age	0.84	±0.11	±0.21	±.38

a) **Neolithic**



b) **Bronze Age**

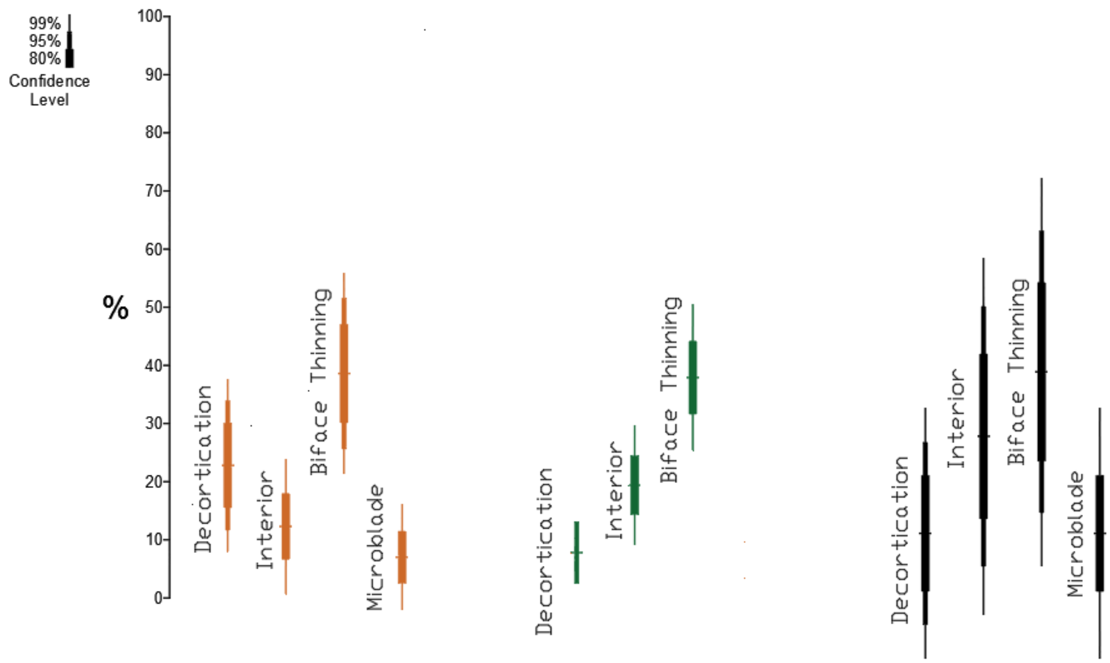


Figure 7.11 Simple and formed flake tools: flake types by environmental zone. Lakebed, orange bullets on left; Upland, green bullets center; Lowland, black bullet on right.

7.1.4.2 Cores (Non-microblade)

Similar to bifaces, the collection of non-microblade cores reveals important spatial and temporal patterns that signal differences in how habitats were exploited over time (Table 7.10). Variation among the core assemblages were minimal, limited to differences in the amount of cortex present (Figure 7.12), and number of flake removals per platform (Table 7.11). The range of core types, size (i.e., volume), origin of parent material, and investment in core preparation is similar across all regions (Figure 7.13 and Figure 7.14).

7.1.4.2.1 Upland

Neolithic cores from the uplands exhibit very little cortex, with over two-thirds having <25% coverage. The mean volume measurement is comparable to all other contexts, however, intensity of reduction is comparatively low, showing the fewest flake removals/platform (Table 7.11).

In the Bronze Age, we see a significant increase in intensity of core reduction (>99% CI) in upland areas (Table 7.11); a contemporaneous increase in the use of core/flake reduction interior debris for the flake tools supports this interpretation (99% CI, Figure 7.11). Alongside a modest uptick in evidence for recycled bifacial tools, core patterning suggests there was increased concern for tool conservation (Table 7.8).

7.1.4.2.2 Lakebed

During the Neolithic, Lakebed cores differ somewhat from upland contexts in terms of amount of cortex present (higher amount), and intensity of reduction (more flake removals per platform) which may signal higher labor investment or concern for tool stone conservation (Table 7.11 and Figure 7.12). Patterns are consistent with corresponding biface collections that show somewhat elevated concern for tool conservation in lakebed environs compared to uplands during the Neolithic (Table 7.8). The scarcity of decortication debris from both upland and lakebed sampled sites (2-13% of manufacturing debris) suggests that unlike bifaces, people did not prioritize core manufacturing, rather focused on reduction of imported pre-reduced forms (Table 7.6).

During the Bronze Age, lakebed cores exhibit less cortex than those assigned to the Neolithic, similar to those from upland areas, suggesting that items were imported in pre-reduced form rather than manufactured locally (Figure 7.12). Low proportions of decortication debris from period sites in both upland and lakebed areas (<14%) confirms this interpretation (Table 7.6).

By the Bronze Age, we observe a remarkable similarity in core assemblages from lakebed and upland settings (Figure 7.12). As indicated by general assemblage trends in the previous section, patterns suggest a shift in how lakebed environs were targeted during the Bronze Age, approximating trends observed in upland contexts. To some extent, this trend is evident in flake tool profiles for both upland and lakebed environs, which demonstrate similar levels of utilization of biface manufacturing debris compared to core flake reduction debris (decortication and interior flakes combined) (Figure 7.11b). In concert with individual tool trends (cores, bifaces), patterns suggest that by the Bronze Age, lakebed and upland zones appear to have been targeted in similar ways. As discussed previously, this impression corresponds with survey data that suggests lakebed environments saw a decline in utilization during the Bronze Age (decline in proportion of population using these area), though the area continued to be targeted by few groups, either larger in size or staying for longer periods, similar to patterns observed in upland zones.

7.1.4.2.3 Lowland

Lowland cores assigned to the Neolithic show a moderate level of reduction compared to the uplands (Table 7.11); however, they also exhibit significantly more cortex (99% CI, Figure

6.59) signaling local production accompanied by low concern for tool stone conservation. This interpretation is supported by a biface assemblage that shows only minimal evidence for recycling (Table 7.8). Elevated proportions of decortication flakes from lowland contexts (20-48% of manufacturing debris) strongly imply that local production of cores, further demonstrating differences in how each of the environmental zones were used during this era (Table 7.6). Across all zones, flake tools were made predominately from biface manufacturing debris (Figure 7.11a), signaling that core/flake reduction was not a significant activity.

By the Bronze Age, cores are less common in lowland sites. Most have low cortex coverage, indicating import of pre-reduced forms.

Table 7.10 Select Core Attributes by Period and Environmental Zone.

	Lakebed Neolithic (n=19)		Lakebed Bronze (n=13)		Upland Neolithic (n=17)		Upland Bronze (n=22)		Lowland Neolithic (n=26)		Lowland Bronze (n=2)	
Condition	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**
Whole/Near Complete	10	52.63	12	92.31	11	64.71	16	72.73	15	57.69	1	50.00
End	0	0.00	0	0.00	3	17.65	1	4.55	6	23.08	0	0.00
Medial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Margin	0	0.00	0	0.00	2	11.76	4	18.18	5	19.23	0	0.00
Indet.	9	47.37	1	7.69	1	5.88	1	4.55	0	0.00	1	50.00
Core Type												
1 (Unidirectional)	3	15.79	3	23.08	3	17.65	3	13.64	10	38.46	0	0.00
1A (Bladelet)	1	5.26	4	30.77	3	17.65	6	27.27	1	3.85	0	0.00
3 (Bi-directional)	2	10.53	0	0.00	2	11.76	0	0.00	1	3.85	1	50.00
4 (Multi-directional)	4	21.05	5	38.46	7	41.18	13	59.09	8	30.77	1	50.00
5 (Bifacial)	2	10.53	1	7.69	1	5.88	0	0.00	3	11.54	0	0.00
6 (Bipolar)	1	5.26	0	0.00	0	0.00	0	0.00	1	3.85	0	0.00
9 (Indet.)	6	31.58	0	0.00	1	5.88	0	0.00	2	7.69	0	0.00
Cortex												
0	4	21.05	4	30.77	7	41.18	6	27.27	3	11.54	1	50.00
1 (1-25%)	5	26.32	5	38.46	4	23.53	9	40.91	6	23.08	1	50.00
2 (26-50%)	5	26.32	2	15.38	5	29.41	3	13.64	6	23.08	0	0.00
3 (51-90%)	3	15.79	2	15.38	1	5.88	4	18.18	6	23.08	0	0.00
4 (91-100%)	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
9 (Indet.)	2	10.53	0	0.00	0	0.00	0	0.00	5	19.23	0	0.00
Original Form												
1 (Cobble)	2	10.53	0	0.00	0	0.00	4	18.18	0	0.00	0	0.00
2 (Globular Cobble)	2	10.53	1	7.69	3	17.65	2	9.09	2	7.69	0	0.00
3 (Angular Cobble)	3	15.79	1	7.69	1	5.88	2	9.09	4	15.38	0	0.00
4 (Shatter)	3	15.79	3	23.08	4	23.53	5	22.73	4	15.38	1	50.00
5 (Split Cobble)	0	0.00	1	7.69	1	5.88	1	4.55	1	3.85	0	0.00
6 (Large Flake)	0	0.00	0	0.00	0	0.00	1	4.55	3	11.54	1	50.00
(Round Cobble/Pebble)	1	5.26	1	7.69	1	5.88	0	0.00	0	0.00	0	0.00
9 (Indet.)	8	42.11	5	38.46	7	41.18	6	27.27	12	46.15	0	0.00
10 (Biface)	0	0.00	1	7.69	0	0.00	1	4.55	0	0.00	0	0.00
Volume (cubic mm)	**Median**		**Median**		**Median**		**Median**		**Median**		**Median**	
	30323.86		20049.6		25949.18		23704.9		25236.2		23401.6	
Platform Metrics	**Average**		**Average**		**Average**		**Average**		**Average**		**Average**	
Platform #	1.2		1.5		1.4		1.9		1.4		1.5	
# Flakes/Platform	4.8		4.2		3.3		4.9		4.2		3.7	
Flake Length (mm)	20.07		23.96		23.07		21.84		11.21		15.89	
Platform Type	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**
1 (Cortical)	7	29.17	3	15.79	4	16.67	5	22.73	13	39.39	0	0.00
2 (Interior)	10	41.67	15	78.95	13	54.17	11	50.00	13	39.39	1	50.00
3 (Prepared)	2	8.33	1	5.26	0	0.00	5	22.73	4	12.12	0	0.00
4 (Cortical and Interior)	2	8.33	0	0.00	2	8.33	0	0.00	0	0.00	1	50.00
9 (Indet.)	3	12.50	0	0.00	5	20.83	1	4.55	3	9.09	0	0.00

Table 7.11 Cores: Average # Flake Scars/Platform by Period and Environmental Zone (w/confidence intervals).

Survey Area	Average # Flake Scars per Platform	80% CI	95%CI	99%CI
Lakebed Neolithic	4.8	±1.06	±1.66	±2.25
Lakebed Bronze Age	4.2	±0.87	±1.37	±1.88
Upland Neolithic	3.3	±0.47	±0.73	±0.98
Upland Bronze Age	4.9	±0.68	±1.05	±1.41
Lowland Neolithic	4.2	±0.52	±0.82	±1.10
Lowland Bronze Age	3.7	±2.51	±10.37	±52.00

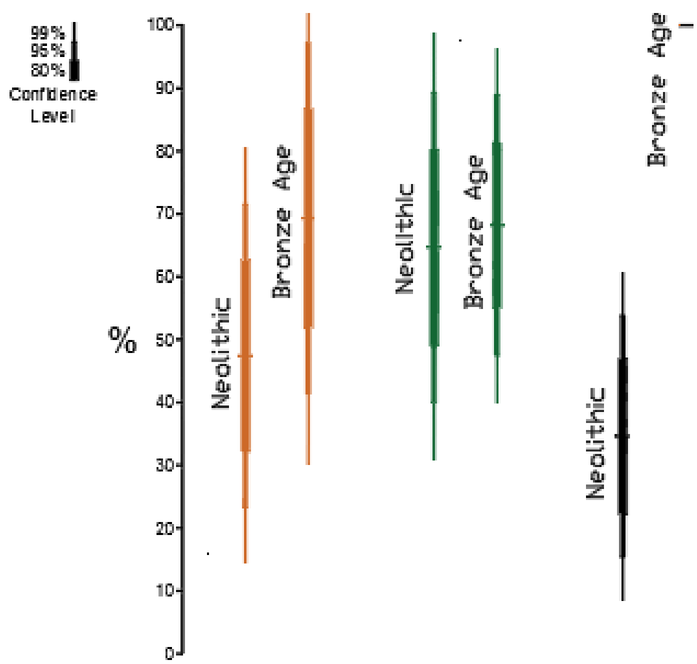


Figure 7.12 Proportion of cores with low cortex coverage (0-25%). Lakebed, orange bullets on left; Upland, green bullets center; Lowland, black bullet on right.

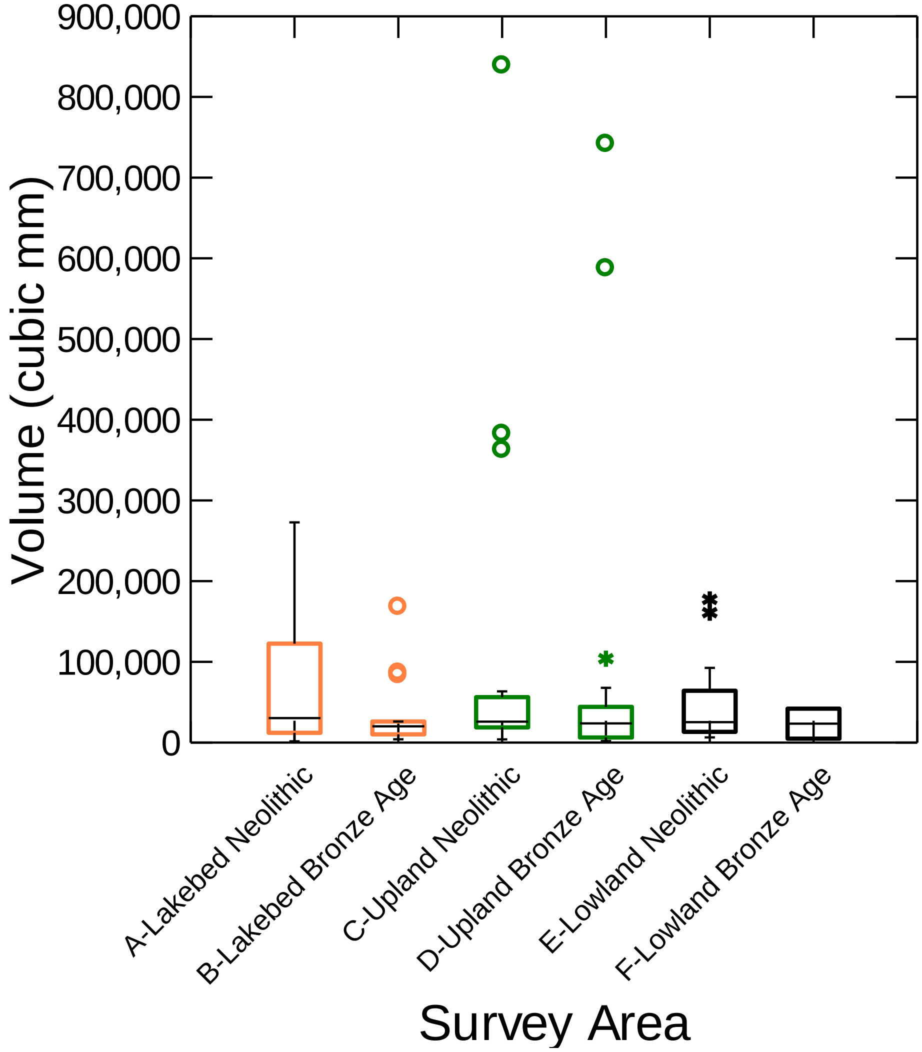


Figure 7.13 Median core volume by period and environmental zone.

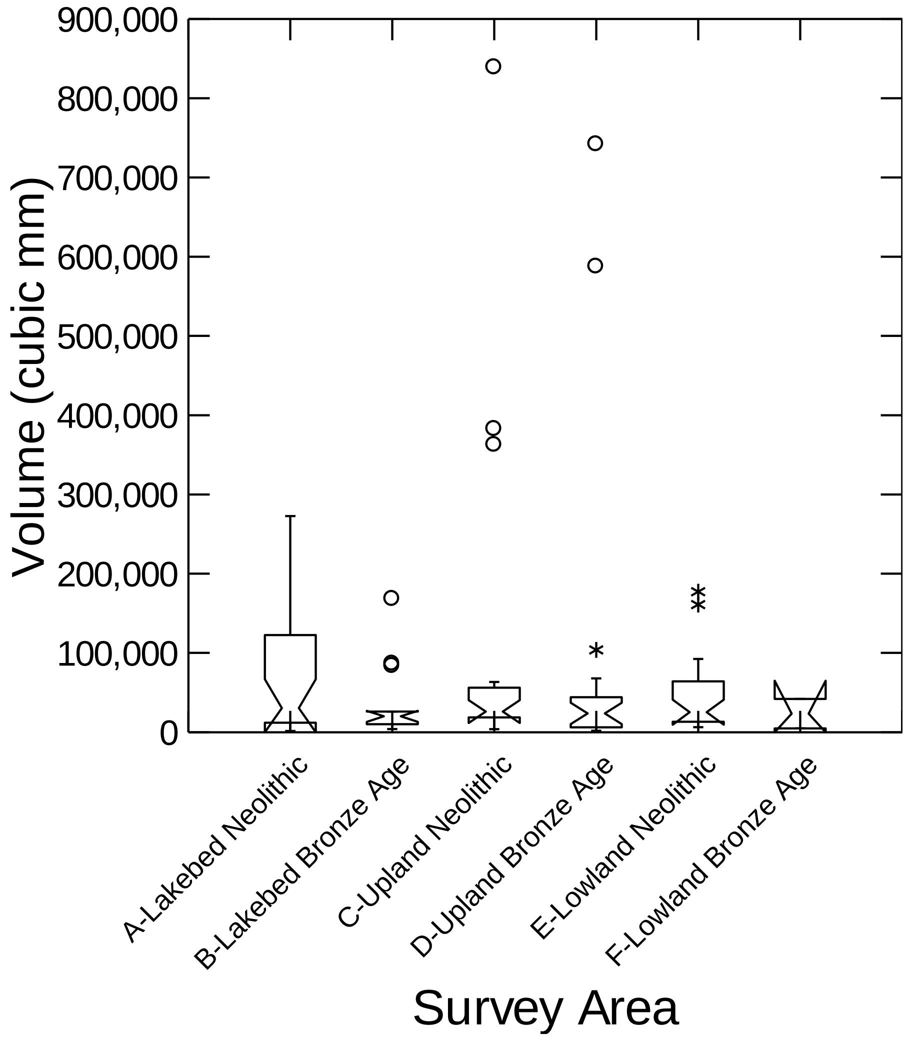


Figure 7.14Median core volume by period and environmental zone (95% CI).

7.1.4.3 Microblade Cores

In several respects, pattering among microblade cores mirror those of the other core forms, indicating an increased intensity of core reduction in upland zones over time (Table 7.12). For example, Neolithic microblade cores across all zones exhibit similar reduction patterns, including the number of flakes per platform and average flake length (Tables 7.13 and 7.14), though inter-zonal differences are apparent in core size and morphological type. Neolithic upland cores are notably larger than those from either lakebed or lowland assemblages (Figures 7.15a and 7.16a), dominated by wedge-shaped forms, with few conical and cylinder-shaped types (Figure 7.17). Conversely, conical forms dominate lakebed and lowland assemblages, and are decidedly smaller than their upland counterparts.

By the Bronze Age, upland microblade cores are significantly smaller than those from surrounding areas (95% CI) and are also more heavily worked (increase in average # flake scars/platform) (Table 7.13). Overall, upland Bronze Age microblade cores are also smaller and more heavily reduced than those from Neolithic contexts, implying a high degree of material conservation during this time. Interestingly, a comparison of microblades from Neolithic and Bronze Age upland contexts demonstrate a significant increase in edge retouch over time (95% CI), further supporting this interpretation (Table 7.15).

Table 7.12 Select Microblade Core Attributes by Period and Environmental Zone.

	Lakebed Neolithic (n=9)		Lakebed Bronze (n=6)		Upland Neolithic (n=20)		Upland Bronze (n=23)		Lowland Neolithic (n=7)		Lowland Bronze (n=2)	
Condition	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**$**
Whole/Near Complete	7	77.78	5	83.33	10	50.00	18	78.26	5	71.43	2	100.00
End	0	0.00	0	0.00	5	25.00	3	13.04	1	14.29	0	0.00
Medial	0	0.00	0	0.00	0	0.00	1	4.35	0	0.00	0	0.00
Margin	2	22.22	1	16.67	5	25.00	1	4.35	1	14.29	0	0.00
Core Sub-type												
Indet. (2)	3	33.33	1	16.67	6	30.00	4	17.39	1	14.29	0	0.00
Wedge (2A)	2	22.22	4	66.67	10	50.00	6	26.09	3	42.86	0	0.00
Conical (2C and 2E)	4	44.44	1	16.67	3	15.00	10	43.48	3	42.86	2	100.00
Cylinder (2D and 2F)	0	0.00	0	0.00	1	5.00	3	13.04	0	0.00	0	0.00
Cortex												
0	8	88.89	5	83.33	15	75.00	22	95.65	6	85.71	1	50.00
1 (1-25%)	0	0.00	1	16.67	4	20.00	1	4.35	1	14.29	1	50.00
2 (26-50%)	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
3 (51-90%)	1	11.11	0	0.00	1	5.00	0	0.00	0	0.00	0	0.00
4 (91-100%)	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
9 Indet.	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Volume (cubic mm)	**Median**		**Median**		**Median**		**Median**		**Median**		**Median**	
	5602.43		12393.95		11160.85		2150.48		5904		5128.9	
Platform Metrics	**Average**		**Average**		**Average**		**Average**		**Average**		**Average**	
# Flakes/Platform	6.4		5.3		6.4		7.7		5.5		5.3	0.00
Flake Length (mm)	28.1		30.48		29.38		28.56		25.78		23.9	0.00

Table 7.13 Microblade Cores: Average # Flake Scars/Platform by Period and Environmental zone (w/confidence intervals)

Survey Area	Average Flakes/Platform	80% CI	95%CI	99%CI
Lakebed Neolithic	6.40	±0.95	±1.56	±2.24
Lakebed Bronze Age	5.30	±2.06	±3.74	±6.20
Upland Neolithic	6.40	±0.84	±1.33	±1.81
Upland Bronze Age	7.70	±0.71	±1.11	±1.51
Lowland Neolithic	5.50	±0.99	±1.72	±2.70
Lowland Bronze	5.30	±3.50	±8.00	±18.40

Table 7.14 Microblade Cores: Average Flake Length by Period and Environmental Zone (w/confidence intervals).

Survey Area	Average Flake Length (mm)	80% CI	95%CI	99%CI
Lakebed Neolithic	28.1	±3.38	±5.52	±7.94
Lakebed Bronze Age	30.48	±6.79	±12.30	±20.38
Upland Neolithic	29.38	±3.53	±5.61	±7.76
Upland Bronze Age	28.56	±3.64	±5.77	±7.92
Lowland Neolithic	25.78	±4.47	±7.79	±12.21
Lowland Bronze	23.90	±13.72	±31.30	±72.20

Table 7.15 Microblades: Average Retouch Index by Period and Environmental Zone (w/confidence intervals).

Survey Area	Average Retouch Index	80% CI	95%CI	99%CI
Lakebed Neolithic	0.03	±0.03	±0.04	±0.05
Lakebed Bronze Age	0.12	±0.07	±0.11	±0.15
Upland Neolithic	0.01	±0.01	±0.02	±0.02
Upland Bronze Age	0.08	±0.05	±0.07	±0.10
Lowland Neolithic	0.06	±0.09	±0.14	±0.19

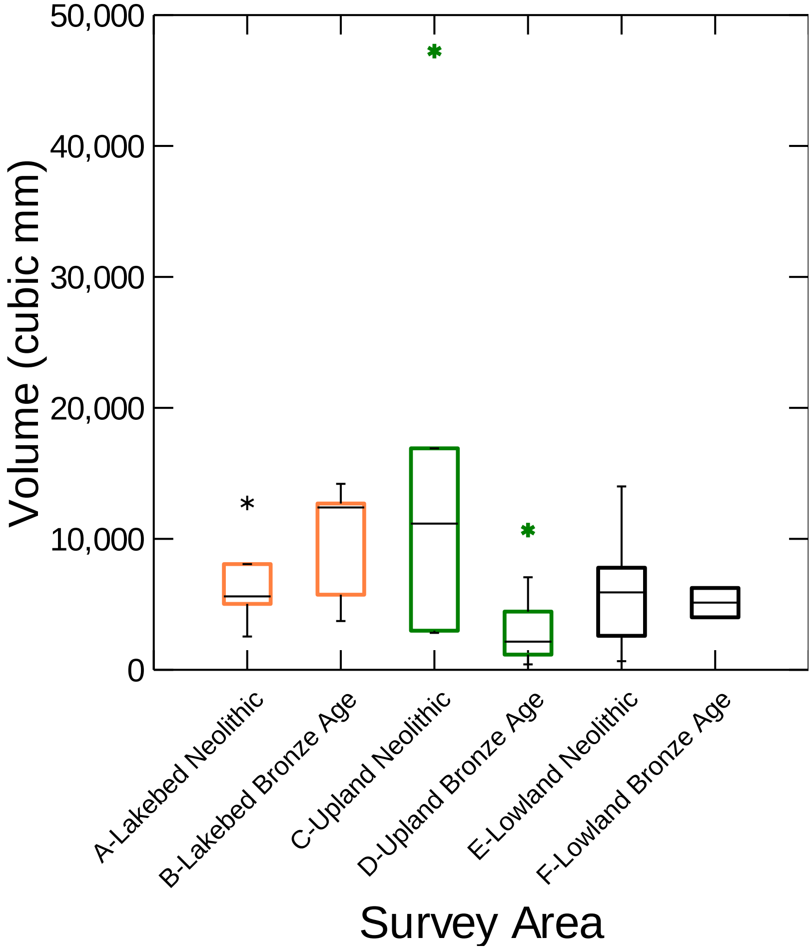


Figure 7.15 Median microblade core volume by period and environmental zone.

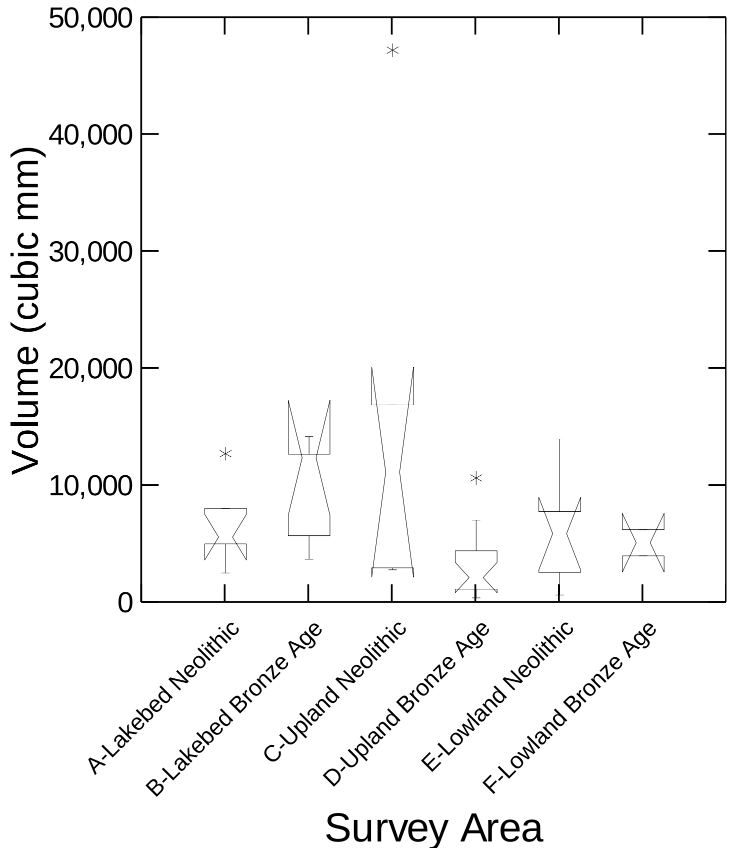
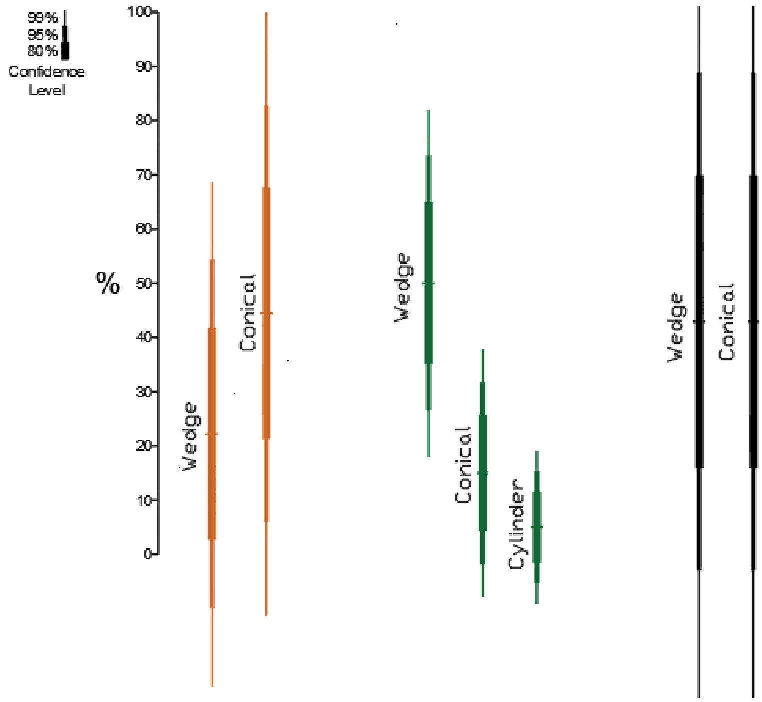


Figure 7.16 Median microblade core volume by period and environmental zone (95% CI).

a) **Neolithic**



b) **Bronze Age**

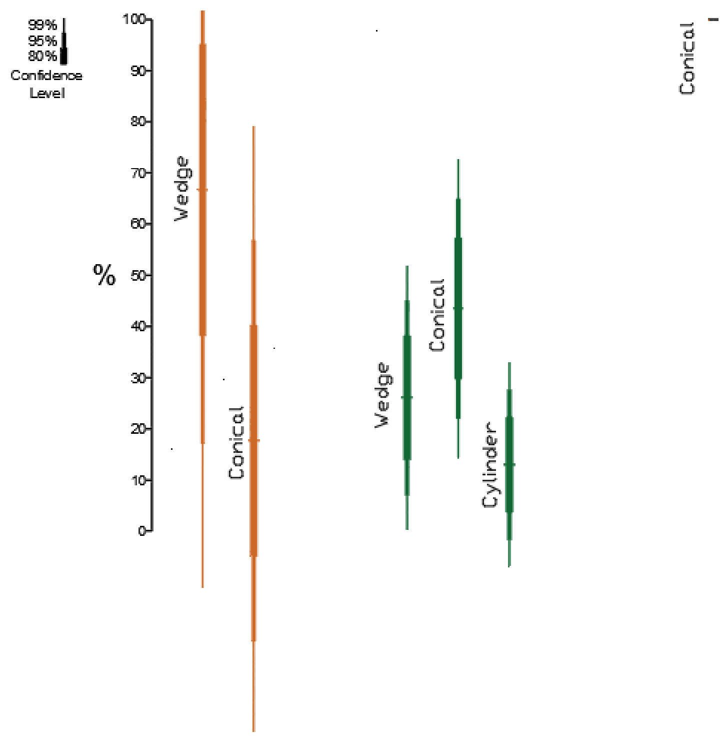


Figure 7.17 Microblade core morphology by environmental zone. Lakebed, orange bullets on left; Upland, green bullets center; Lowland, black bullet on right.

7.1.5 Summary of Surface Lithic Artifact Analysis

Table 7.16 summarizes lithic artifact attributes across environmental zones over time. In conjunction with previously described assemblage patterning (Table 7.4) provide a solid basis from which to evaluate technological trends as people presumably took up food production in Mongolia's desert-steppe.

7.1.5.1 Upland

Technological characteristics of upland assemblages demonstrate notable continuity across the Neolithic and Bronze Age, generally supporting the survey demographic data that indicate the primacy of upland habitats for both hunters and herders (Section 6.1). Technological stability is illustrated by the persistence of core/flake reduction activities; continued reliance on a variety of core types; and sustained use of a suite of simple and formed flake tools including microblades. Together, assemblage traits suggest that during the Neolithic and Bronze Age, people we generally carrying out the same types of tasks. The small but informative biface collections suggest that while people were making and using the same kinds of tools across the transition to herding, the Bronze Age saw a shift in biface production, where tools were no longer made and used in the same location, rather were likely imported to upland contexts in pre-reduced form.

Alongside evidence for a truncated biface manufacturing sequence in the uplands, by the Bronze Age there is heightened evidence for tool stone conservation including repair and recycling of bifaces (increasing from 20% to 35% of assemblage), and increased core reduction(Table 7.16). A decrease in the amount retouch on formed flake tools (which are more abundant than either biface or cores) counters this interpretation.

While shortened manufacturing trajectories and tool conservation are often associated with heightened levels of residential mobility, the pattern could also be explained by a shift in manufacturing away from residential sites, perhaps embedded in logistical movements associated with other resource procurement activities. This interpretation fits well with the increased median area-density index during the Bronze Age, signaling an intensive focus on upland resources by groups who were larger in size, staying for longer periods, or returning to the same local more frequently (Table 6.2i). The modest or contradictory of evidence for material conservation in either period signals that no matter where manufacturing occurred, people did not anticipate restricted access to quality raw material, suggesting they were not moving far or were confident in the availably of quality lithic material.

7.1.5.2 Lakebed

Demographic data indicate a significant shift away from lakebed environs during the Bronze Age (Table 6.2g), though intensity of use (larger group size or length of duration) increase to match that observed in the upland zone. Other assemblage traits- further reflect shifts that mirror those of the upland, including an increase in reliance on formed flake tools and investment in retouch of microblades. Tool conservation becomes notably less important during the Bronze Age (reduction in proportion of recycled biface, reduction in intensity of microblade core reduction), even lower than that noted in upland zones (Table 7.16). Together, demographic data and tool and assemblage characteristics do seem to point to a convergence of settlement tends during the Bronze shifting from high residential mobility with some concern for tool stone conservation to, fewer but longer term encampments, with little concern for economizing lithic tool manufacture and use.

7.1.5.3 Lowland

Lowland areas saw the most notable change in land use between the Neolithic and Bronze Age, including reduction in use (proportion of period area-density index) accompanied by a significant increase in bifacial tools (Table 7.4) and reduced reliance on microblade technology. Lowland biface attributes strengthen the interpretation of significant change in how lowland areas were targeted over time; during the Neolithic, pre-reduced bifaces were likely transported to the region with little concern for tool stone conservation, however, by the Bronze Age, all stages of manufacture are observed, with most showing high investment in recycling/conservation.

These data, in concert with demographic data that signal both a decline in the proportion of population and a decrease in local group size or duration of stay (median area-density index) demonstrate a significant shift in how lowlands were exploited over time. Clearly, few people inhabited these areas, though a broader range of manufacturing activities were carried out, with a strong emphasis on maintaining and repairing bifacial tools. Lowland tool kits are less diverse than those from other contexts, and along with a paucity of groundstone, suggest that these areas were targeted for a specific purpose, perhaps hunting activities.

Table 7.16 Summary of Flaked Stone Tool Attributes by Area and Period.

a) Lakebed

	Neolithic	Bronze Age	Change Over Time
Bifaces	<10% of assemblage; All stages present (middle dominant); Half of early stage forms have low cortex coverage (<25%); 45% of tools recycled.	<10% of assemblage; No early stage tools; No cortex on early/middle forms; No recycling.	Neolithic: manufacture and maintenance of bifaces w/ some concern for tool conservation. Bronze Age: pre-reduced tools imported w/ little investment in recycling/conservation.
Cores	< 10% assemblage; ~47% have low cortex (< 25%); 4.8 flake scars/platform.	10% of assemblage; ~ 70 have low cortex coverage (< 25%); 4.2 flake scars/platform.	Minor changes over time; Neolithic cores locally manufactured. Bronze Age: likely imported pre-reduced form.
Microblade Cores	Less than 10% assemblage; Conical cores dominant; Small in size; 6.4 flakes/platform	< 10% assemblage; Wedge shaped dominate; Larger in size; 5.3 flakes/platform	Increases core size, shift in morphology. Decrease in efficiency/utilization.
Microblades	About 28% assemblage; very low retouch (Index 0.03)	About 24% assemblage; low retouch (Index 0.12)	Significant increase in retouch (>99% CI)
Formed Flake Tools	< 10% of assemblage; Made primarily on biface thinning flakes; High retouch (Index 0.71).	~ 25% of assemblage; Decrease use of biface thinning flakes/ increase in decortication; High retouch (Index 0.8).	Increase use over time, with increase in retouch over time (95%CI);
Simple Flake Tools	~ 32% of assemblage; Made mostly on biface thinning flakes.	~ 27% of assemblage; Made primarily on biface thinning flakes.	Little change over time

b) Upland

Bifaces	< 10% of assemblage; All manufacturing stages present; Two-thirds have low cortex coverage (<25%); 20% show recycling.	< 10% of assemblage; Late stage dominates; No cortex; 35% show recycling.	Neolithic: bifaces manufactured and used locally. Little concern for material conservation. Bronze Age: truncated manufacturing sequence develops, pre-reduced forms imported; material conservation increases.
Cores	Less than 10% of assemblage; 65% have low cortex coverage (<25% coverage); 3.3 flake scars/platform.	~10% of assemblage; ~ 68% have low cortex (< 25%); 4.9 flake scars/platform.	Increase in intensity of core reduction over time (99% CI), possibly signaling tool stone conservation or manufacturing efficiency.
Microblade Cores	Less than 10% of assemblage; Wedge shape dominates; Large in size; 6.4 flakes/platform	~10% of assemblage; Conical forms dominate Small in size; 7.7 flakes/platform.	Decrease in size and increase in number of flake scars/platform (95% CI). Overall increased material conservation over time.
Microblades	26% of assemblage; Very low retouch (Index 0.01)	20% of assemblage; Low retouch (Index 0.08).	Significant increase in retouch (95% CI)
Formed Flake Tools	~20% of assemblage; High retouch (Index 0.83); Tools made on biface thinning and interior flakes; few decortication.	~ 20% of assemblage; High retouch (Index 0.78); Tools make primarily on biface thinning.	Modest decrease in retouch (95% CI)
Simple Flake Tools	~ 30% of assemblage; Tools made primary on biface thinning and decortication flakes.	~ 28% of assemblage; Tools made on biface and interior flakes.	

Table 7.16 Summary of Flaked Stone Tool Attributes by Area and Period (Continued).

c) Lowland

	Neolithic	**Bronze Age**	**Change Over Time**
Bifaces	~13% assemblage; Middle stage forms dominate; Two-thirds of early forms have low cortex coverage (<25%); Very limited evidence for recycling (16%).	~ 25% of assemblage; Even manufacturing profile; All early forms have low cortex coverage (<25%); ~ 65% exhibit recycling.	Neolithic focus on maintenance of imported pre-reduced tools. Little concern for material conservation. In Bronze Age, all stages of manufacture, high investment in recycling/conservation.
Cores	~ 18% of assemblage; About one-third of collection has low coverage (< 25% cortex); 4.2 flake scars/platform.	~ 6% of assemblage; all cores have low cortex coverage; 3.7 flake scars/platform.	In Neolithic cores likely manufactured on site/local, discarded on site. By Bronze Age, cores imported on site, exported off site after flake production. No change in reduction efficiency (no exhausted cores)
Microblade Cores	< 10% of assemblage; Slightly equal wedge and conical forms; small sized cores; 5.5. flakes/platform.	< 10% of assemblage; Conical forms only; small sized cores; 5.3 flakes/platform.	No change over time. Likely manufactured elsewhere.
Microblades	Less than 10% of assemblage	None	
Formed Flake Tools	< 10% of assemblage; High retouch (Index 0.79); Made primarily on biface thinking flakes.	About 12% of assemblage; High retouch (Index 0.84); Decrease in manufacture on biface thinning/increase decortication and interior	Small increase in retouch (80% CI)
Simple Flake Tools	~ 45% of assemblage; tools made predominately biface thinning, but also decortication, interior, and microblade	~ 45% of assemblage; tools made predominately biface thinning, but also decortication, interior, and microblade	No change

7.2 Lithic Artifact Analyses: Excavated Materials

The following section details an analysis of stone tools and manufacturing debris recovered from archaeological excavations at site IKH-09. As detailed in Section 5.3, the extensive artifact scatter is located in Burgasny Egner, a broad spring fed valley situated within the upland zone of Ikh Nart Nature Reserve. Investigations at this site in 2016 and 2017 examined nearly 9.0 cubic meters of site matrix, producing a broad range of materials including lithic tools and manufacturing debris, earthenware ceramics, faunal remains, and macro and micro-botanical remains. To date, IKH-09 is the only excavated site in the region to provide sufficient artifact samples for comparison with survey assemblages amassed during this project.

Excavations at IKH-09 exposed four stratagraphic units, each distinguished by differences in sediment composition, compaction, color and texture (see Table 1.2). To date, no radiocarbon assays are available for analysis, therefore, chronometric ordering is based solely on the presence/absence of temporally diagnostic ceramics (Table 7.17). The small associated faunal assemblage is presented in Table 7.18.

Table 7.17 IHK-09: Chronological Ordering of Stratigraphic Units.

	Stratum 1/2 Late Bronze/Iron		Stratum 3 Early-Middle Bronze Age		Stratum 4 Neolithic	
Excavated Volume (m^3)*	4.4		2.6		1.6	
Ceramic	**Count**	**Density****	**Count**	**Density****	**Count**	**Density****
Bronze Age	5	1.1	5	1.9	0	0.0
Late Bronze Age	1	0.2	0	0.0	0	0.0
Iron Age	1	0.2	0	0.0	0	0.0

***Excavations conducted in 2016 and 2017: Test Excavation Units 1-7 (2m X 2m). ** count/m^3 .**

Table 7.18 IKH-09:Faunal Remains by Component.

	Stratum 1/2 Late Bronze/Iron		Stratum 3 Early-Middle Bronze Age		Stratum 4 Neolithic	
Excavated Volume (m^3)*	**0.45**		**0.50**		**0.35**	
	Count/Wt. (g)	**Density** (#/Wt),**	**Count/Wt. (g)**	**Density** (#/Wt.)**	**Count/Wt. (g)**	**Density** (#/Wt))**
Faunal	1/0.1	2.22/0.22	53/39.9	106/79.6	11/0.3	31.4/0.86

***Excavations conducted in 2016 and 2017; 1m X 1m sample quads from Test excavation Units 2,4,5,6,7. ** count per m^3 / Weight/ per m^3 .**

7.2.1 IKH-09 Lithic Analysis Results

Flaked stone tool assemblages from all excavated period components are remarkably narrow, made up of high proportions of microblades (95-98%) mixed with a few cores, flake tools, and bifacial implements (Table 7.19).

Tool kits across all periods have very low diversity indices (< 0.1) and are decidedly formal in nature (Table 7.19). Low diversity tool kits are commonly associated with shorter periods of residence (high residential mobility), reflecting the provisioning of individuals (as opposed to provisioning places) to compensate for reduced access to (or predictability of) important subsistence or material resources (*sensu* Kuhn 1995). Alternatively, highly formalized and narrow assemblages could reflect special use sites (non-residential), where activities focused on a limited range of activities associated with resource procurement, manufacturing, or processing. A notable absence of other tool types (ground or polished stone tool classes) lends support to this interpretation, however, low quantities of pottery and faunal remains suggest the locale was more likely the focus of short-term residential occupation for all periods represented.

Table 7.19 IKH-09: Lithic Artifact Assemblage by Component (TEUs 1-7).

	Stratum 1/2 Late Bronze/Iron		Stratum 3 Early-Middle Bronze Age		Stratum 4 Neolithic	
Excavated Volume (m^3)*	4.4		2.6		1.6	
Lithic Tool Class						
	Count	**%**	**Count**	**%**	**Count**	**%**
Expedient						
Cores	1	0.28	1	0.26	1	0.42
Flake Tools-Simple	3	0.85	3	0.79	2	0.85
Formal						
Microblade Cores	1	0.28	7	1.83	1	0.42
Microblades	346	97.75	365	95.56	232	98.31
Flake Tools-Formed	2	0.56	5	1.30	0	0.00
Bifaces	0	0.00	1	0.26	0	0.00
Projectile Points	1	0.28	0	0.00	0	0.00
Total All Lithic Classes	**354**		**382**		**236**	
Tool Density (#/m^3)	**80.5**		**146.9**		**147.5**	
Simpson Index of Diversity*	**.04**		**.09**		**.03**	
Ratio of Expedient to Formal Tools	**0.01:1**		**0.01:1**		**0.01:1**	
Retouch Index (Microblades)	**0.04**		**0.02**		**0.00**	

Component assemblages from this upland setting are remarkably similar in several aspects including tool assemblage profile and ratios of expedient to formal tools, suggesting evidence for continuity in how people targeted upland areas over time. Overall tool density is unchanged from the Neolithic to the mid Bronze Age, however, is greatly reduced in the uppermost component.

Most tool classes were too small in number to explore attributes associated with settlement trends; only microblade samples were sufficient for comparative analyses. Continuity in the period assemblages is reflected in the microblade tools as well, being equally abundant across all periods.

Microblade retouch is rare among all period collections, with indices measuring less than 0.05 for all periods, suggesting low investment in tool conservation.

Debitage profiles across the period components further demonstrate continuity in how uplands were used, specificity in how manufacturing activities were incorporated. The earliest phases of tool manufacture involving decortication of parent lithic material are low during all periods, indicating that these activities were conducted elsewhere. In contrast, tool shaping and finishing (biface thinning and pressure flaking debris) are prominent in all periods. . The only notable change over time an increase in biface manufacturing during the Bronze Age and later times (within the 95% CI). Also notable is the substantial increase in the density of lithic debitage and the ratio of debitage to tools between the Neolithic and Bronze Age (Table 7.20) when herding was presumably introduced. In conjunction with largely unchanging technological profiles, this increased evidence for tool manufacture/maintenance suggests that while on-site activities were unchanged over time, there was a notable increase in intensity of site use. The observed increase in intensity of use across the Neolithic-Bronze Age transition could have been the result of larger size groups, longer term occupations, or increased repetitive reuse. In light of the highly formal and narrow assemblage the increased short term use seems more plausible. In other words, settlement trends of both hunters and early herders likely focused on short term occupations with a high degree of residential mobility, though may have increased during the early to mid-Bronze Age. The intensity of site use appears to have dropped by the Late Bronze Age as reflected in the reduction tool density, debitage density, and ratio of debitage to tools.

Table 7.20 IKH-09: Debitage Technological Profile by Component (sample quads from TEUs 2,4,5,6,7).

	Stratum 1/2 Late Bronze/Iron		Stratum 3 Early-Middle Bronze Age		Stratum 4 Neolithic	
	Count	**%**	**Count**	**%**	**Count**	**%**
Flake Size						
1	23	34.33	93	41.52	15	53.57
2	38	56.72	111	49.55	13	46.43
3	6	8.96	18	8.04	0	0.00
≥4	0	0.00	2	0.89	0	0.00
Total	**67**		**224**		**28**	
Flaked Type	**Count**	**%**	**Count**	**%**	**Count**	**%**
Decortication						
Primary (1)	1	1.49	1	0.45	0	0.00
Secondary (2)	0	0.00	2	0.89	0	0.00
Cortical Fragment (12)	2	2.99	3	1.34	1	3.57
Subtotal		**4.48**		**2.68**		**3.57**
Interior						
Simple (3)	3	4.48	13	5.80	2	7.14
Complex (4)	1	1.49	0	0.00	0	0.00
Simple Fragment (13)	0	0.00	1	0.45	0	0.00
Subtotal		**5.97**		**6.25**		**7.14**
Microblade Reduction						
Linear Interior (5,10)	4	5.97	4	1.79	0	0.00
Subtotal		**5.97**	**0**	**1.79**		**0.00**
Biface Thinning						
Early (7)	8	11.94	21	9.38	0	0.00
Late (8)	2	2.99	7	3.13	0	0.00
Fragment (15)	1	1.49	6	2.68	2	7.14
Subtotal		**16.42**		**15.18**		**7.14**
Pressure Flaking						
Pressure (9,17)	9	**13.43**	39	**17.41**	6	**21.43**
Other						
Indet. Perc. (16,20,24)	18	**26.87**	54	**24.11**	4	**14.29**
Cortical Shatter (18)	0	**0.00**	1	**0.45**	0	**0.00**
Angular Perc. (19)	1	**1.49**	3	**1.34**	0	**0.00**
Indeterminate (21)	17	**25.37**	69	**30.80**	13	**46.43**
Excavated Volume (cubic m)	**0.45**		**0.5**		**0.35**	
Density (Flakes /m^3)	**148.9**		**448.0**		**80.0**	

7.3 Comparison of Survey and Excavation Contexts

Having datasets from both surface and excavated contexts, the upland region of the study area provides the best context to determine if there were distinct differences in how hunters and herders exploited areas over time; in other words, can we detect different mobility strategies across the Neolithic-Bronze Age transition? While this question is addressed in Chapter 8 (Synthesis of Findings and Discussion of Research Questions), it is important that we first examine some of the difficulties in comparing these datasets and provide a justification for associating them in this analysis.

Direct comparison of upland assemblages (excavated materials from IKH-09 and survey surface collections) is extremely challenging, made difficult by several factors. The first is collection methodology; differences in artifact collection approaches (excavation vs surface collection) render direct comparison between IKH-09 and the survey assemblages problematic. Small artifacts are far more likely to be missed by surface collection efforts, even if collections units are small and intensively scrutinize; the likelihood of missing small or highly fragmented specimens (microblades, pressure flaking debitage) during a survey collection is much higher than if site matrix is screened. Collection bias is compounded by the different types of disturbances that impact surface and subsurface deposits. For example, surface erosion (horizontal displacement) may disproportionally affect small, light wight surface artifacts (compared to larger/heavier artifacts). In buried contests, objects of any size may be impacted in other ways (vertical movement within matrix), the result of bioturbation or freeze/thaw action. Also, surface collections are uniquely susceptible to intentional culling by people interested in reusing/refurbishing old artifacts, modern "pot-hunters" targeting interesting "finds", or by archaeologists who collect diagnostic or representative samples during site recording efforts. Also problematic is the case that patterns gleaned from IKH-09 represent the activities of people at one specific location over time, whereas the survey data reflect an even more coarse-grained aggregate of behavior across the varied upland landscape.

Indeed, in the absence of excavation at the survey sites, it's impossible to know whether differences between the surface and subsurface collections are the result of collection bias or can be attributed to the ancient human behavior we seek to understand. Looking broadly at the datasets, dramatic differences in tool kits suggest something other than collection bias is at play. The aggregated surface collections from Neolithic and Bronze Age settings are far more diverse than those from excavated contexts at IKH-09; it seems unlikely that microblades in surface contexts are that underrepresented. Within the matrix at IKH-09, the low frequency of tool types normally represented in the surface collections is also counter intuitive to a collection bias explanation. It seems more plausible that differences relate to scale (single site compared to the average of multiple sites).

A better way to relate the study assemblages is to compare interpretations derived from analyses. For example, the strong evidence for continuity in technological organization across the Neolithic-Bronze Age transition at IKH-09 is also expressed in the surface collections spanning the same periods. The actual tool profiles are vastly different (diverse with a mix of formal and expedient tools versus narrow with mostly formalized too types), but both signal technological continuity as foragers presumably took up herding. An expanded discussion of these datasets is provided in Section 8.23.

8.0 Synthesis of Findings and Discussion of Research Questions

8.1 Settlement Patterns and Population Dynamics

Settlement patterns presented in Sections 6.1 and 6.2 provide insight to the way humans have distributed themselves across the desert-steppe of southeastern Mongolia, allowing us to understand land use strategies of hunters and herders. The survey data provide critical information to answer the most basic (and necessary) research question posed for this study: *Where did people live before, during and after the transition to a herding economy* (Research Question 1)? Further, incorporation of population data through the development of area-density indices allows us to understand how preferences articulate with demographic changes across the economic shift to understand the factors that shaped settlement decisions, and the forces that underlie social change. For the current study, we are interested in understanding the role of foraging lifeways on the development of mobile pastoralism, specifically, *what impact, if any, did the adoption of herding have on foraging lifeways* (Research Question 3)? Was the transformation to herding the product of gradual in-situ development and conservation of existing forager lifeways, or does it represent a more rapid replacement/reorganization of a foraging economy either by extant foragers or new herding groups?

Settlement data from this study reveal distinct trends that go a long way in answering the first question about land use patterning; viewing these trends through the lens of the Ideal Free Distribution (IFD) helps us to understand the role of foraging lifeways in the transition to herding. Following the expectations of behavioral optimization and habitat suitability models (Bird and O'Connell 2006; Fretwell and Lucas 1970), we predict that if foraging lifeways were prioritized across the initial transition to herding, we should see continuity in settlement patterning within the survey datasets. Specifically, we expect that favored habitats of Neolithic/Oasis 2 foragers (ca. 8000-5500 BP) will continue to be occupied until they are no longer available, with subsequent Bronze Age/Oasis 3 (ca. 4500-3000 BP) populations settling in secondary habitats as favored places are in-filled. Conversely, a more abrupt replacement/reorganization of a foraging economy with one more committed to food production is signaled when population in-filling patterns do not correlate with established habit preferences of earlier foragers. A shift in habitat selection in the absence of population growth may also signal a reordering of preferences to reflect changing economic priorities. Patterns may also signal that movement was no longer predicated solely on access to forage and water but reflect other economic or socio-political concerns such as access to goods that increase wealth or status (pasture for larger herds, ritual sites, trade networks). Here, we might also expect to see changes in some aspects of settlement strategies such as frequency of residential moves.

In reviewing the present survey data, it is clear that upland regions of the study area were prioritized during all periods and were likely a preferred habitat for both foragers and herders. This finding is not surprising given the concentration of important resources found in this zone including a wide range of plants and animals for subsistence, numerous springs and deeply cut stream drainages, and rocky outcrops that provide shade in the summer and protection from the wind in winter months. While this area was an important draw for both hunters and herders, its importance increased during the Bronze Age/Oasis 3 (ca. 4500-3000 BP) as people presumably began to incorporate herding practices. During the Neolithic-Bronze Age transition, the area saw not only an increase in utilization (larger proportion of overall population), but also an increase in the intensity of use (larger median area-density indices), reflecting larger group size or increased duration of occupation episodes. Broadly, this pattern appears to align with expectations for continued prioritization of forager strategies as herding practice developed, signaling a gradual transformation to food production.

Looking more closely, however, a few factors belie this interpretation and signal that a more abrupt reorganization of priorities was underway. Most notable is the lack of evidence for population growth over time; increased use of upland habitats was not accompanied by an increase in overall population size (i.e., estimated total period area-density index), suggesting a shift in habitat preference (Table 8.1). During the Neolithic, people certainly prioritized upland zones, however other areas made up about 40% of all occupations (Table 8.1).

Table 8.1 Estimated Total Period Area-Density Index by Environmental Zone*.

	Neolithic (Oasis 2)	**Bronze Age (Oasis 3)**
Lakebed	3.02 (21.84%)	1.23 (9.38%)
Upland	8.31 (59.80%)	11.25 (85.90%)
Lowland	2.55 (18.36%)	0.62 (4.72%)
Estimated Period Area-Density Index (All Zones)	13.88 (100%)	13.10 (100%)

***Data summary from Table 6.2**

The shift away from adjacent wetland/dune field habitats in the north also signals a change in habitat preference, an interpretation that is supported by the catchment analysis that demonstrates a significant decline in proximity to wetland areas within lowland and lakebed zones (Section 6.3, Table 6.5). Associated with the shift away from wetland/dune field contexts is an increased focus on areas with relatively high winter productivity (high winter NDVI), further signaling a shift in priorities of early herding populations, specifically, a need for reliably productive pasture for herd animals. The strengthening of the relationship between population and high winter NDVI during the Iron Age (3000-2300 BP) and Xiongnu eras (2300-1600 BP) strongly supports this interpretation. This post-Bronze Age patterning likely reflects a growing emphasis on a herding economy, one that may have included the adoption of ruminant dairying and the expanded use of horses for transport and riding. If so, it is likely that these innovations would have improved herd yields and allowed for more far-ranging movements (Taylor et al. 2020). In the absence of evidence for significant population growth over time, the study data indicate a distinct narrowing of preferred habitats by herder populations over time.

This trend is reversed by the Kitan Period (10^{th}-12th c. AD) when an increase in overall population size across all environmental zones is accompanied by a distinct increase in use of areas with lower winter NDVI; this suggests that people *were* moving into secondary, or less desirable areas. However, a lack of correspondence between median area-density index and NDVI rank suggests that people were moving to these areas not as a result of infilling of preferred areas, but possibly to target new resources (e.g., other types of vegetation to meet the needs of changing herd composition). Pattens could also signal that movements were based on considerations beyond pasture access, perhaps reflecting changing socio-political conditions, territoriality, access to trade-networks or ritual features.

The land use patterns observed in the present study generally support those proposed for the region (e.g., Janz 2012 for the broader Gobi and and Wright et al. 2019 for Dornod Gobi) including the primacy of wetland bearing habitats during the Neolithic, continued (albeit lessened) use of these environs during the Bronze Age, and a shift to dryer grassland habitats by the Iron Age as herding economies were established (ca. 3000 BP) (Wright et al. 2019:12). The current study strongly indicates that preferences of committed herder societies (Iron Age and beyond) were firmly established during the Bronze Age as people began to prioritize upland grasslands over wetland areas, particularity areas with high wintertime productivity. Put another way, land use and population patterning indicate a rather abrupt change in habitat preference across the Neolithic-Bronze Age transition, possibly signaling the earliest stages of food production.

8.2 Mobility Strategies

In addition to questions about habitat preferences and priorities of hunters and herders, the current research seeks to understand if there were distinct differences in how these areas were exploited over time (i.e., different mobility strategies) (Research Question 2). For the current study, mobility strategies were assessed primarily through flaked stone tool analyses, specifically, a comparison of tool and waste profiles to identify shifts in manufacture, use, and discard patterns that may signify changes in settlement mobility likely associated with the transition from foraging to herding. For example, groups that move often (e.g., foragers living in a marginal environment) are expected to produce lithic artifact assemblages that have different manufacture and use profiles (tools are not made and used in the same place), while people who stay in one place for longer periods (e.g., herders tethered to a specific resource area who employ logistical movement) should produce a more even profile, reflecting a continuum of manufacture, use, and discard.

The lithic analyses also included an assessment of assemblage and tool diversity, formality, and material conservation to characterize patterns of movement (e.g., degree/duration of mobility). Recalling from the discussions in Chapters 2 and 4, tool assemblages from highly mobile populations are expected to be less diverse than those who employ more restricted movements (Oswalt 1976; Shott 1986). Assemblages reflecting high residential mobility are also expected to contain a relatively high ratio of formal to informal implements (Parry and Kelly 1987) and are likely to contain a higher proportion of multiple-use tools (Andrefsky 1991).

The following sections provide a recap of interpretations from surface and excavated contexts (Sections 8.2.1. and 8.2.2), and a discussion of mobility strategies employed in the upland zone across the Neolithic-Bronze Age transition (Section 8.2.3).

8.2.1 Recap of Surface Assemblage Patterns

Lithic assemblages from the survey's upland zone exhibit a high degree of technological continuity between the Neolithic/Oasis 2 (ca. 8000-5500 BP) and Bronze Age/Oasis 3 (ca. 4500-3000 BP); patterns suggest that both hunter and herder populations relied on tool kits composed of a range of core types and a suite of simple and formed flake tools (i.e., microblades). Together, assemblage traits suggest that during the Neolithic and Bronze Age, people we generally carrying out the same types of tasks, however, by the Bronze Age there was a shift in how they incorporated bifacial tools (a minor tool kit component), suggesting a change to "offsite" manufacture and increased investment in recycling and repair of broken implements. A growing (but still limited) concern for tool conservation is also evidence by increased intensity of core reduction, though retouch on formed flake tools (the most common tool type) decreased over time. Overall, the upland assemblages present contradictory or equivocal evidence for tool stone conservation.

It is unclear if patterns reflect a high degree of residential mobility or an overall shift in manufacturing away from residential sites, perhaps embedded in logistical movements associated with other resource procurement activities. The latter interpretation is in alignment with the reported increased median area-density index during the Bronze Age, implying an intensive focus on upland resources by groups who were larger in size, staying for longer periods, or returning to the same local more frequently (Table 6.2i).

As for lakebed contexts to the north, the survey data presented in Section 6.2 reveal a significant shift away from these areas during the Bronze Age, though intensity of use (larger group size or length of duration) increased to match that observed in the upland zone. Lithic assemblages reflect adjustments in tool manufacture and use that mirror those of the upland, including an increase in reliance on formed flake tools and investment in microblade retouch, though tool conservation is not as prevalent (Table 7.16).

As described in Sections 6.1. and 7.1, lowland habitats were of low importance for all periods, though the area was targeted differently over time, including an overall decline in use (proportion of period area-density index) from the Neolithic to Bronze Age, accompanied by a significant increase in reliance on bifacial tools (Table 7.4) at the expense of microblade technology, and a high degree of recycling/conservation. Coupled with low assemblage diversity (and a scarcity of ground stone tools), patterns suggest these areas were targeted for a special purpose, conceivably for hunting pursuits.

8.2.2 Recap of Excavated Contexts

As presented in Section 7.2.1, period components from upland excavated contexts are notably different from surficial settings containing mostly microblades (95-98%) mixed with a few cores, flake tools, and bifacial implements (Table 7.19); no other tool types, such as ground or polished stone tools were present.

Several other lines of evidence point to continuity in upland period assemblages including ratios of expedient to formal tools, overall tool density, and low degree of microblade retouch suggesting only limited investment in tool conservation. Debitage profiles across period components further demonstrate stability in how uplands were used, with ample evidence for tool shaping and finishing activities, and little evidence for the earliest phases of tool manufacture (i.e., decortication). The only noteworthy change over time is an increase in biface manufacturing during the Bronze Age and later, and a substantial increase in the density of lithic debitage and the ratio of debitage to tools between the Neolithic and Bronze Age (Table 7.20). In combination with the observed technological stability, increased evidence for tool manufacture/maintenance during the Bronze Age suggests that while on-site activities were unchanged over time, there was a notable increase in the intensity of site use. Overall, evidence from excavated contexts suggests that hunters and early herders likely focused on short-term occupations with a high degree of residential mobility, though intensity of use increased during the early to mid-Bronze Age. The intensity of site use appears to have dropped by the Late Bronze Age as indicated by declines in tool and debitage density, as well as the ratio of debitage to tools.

8.2.3 Discussion: Upland Mobility Strategies

With datasets from both surface and excavated contexts, the upland region of the study area affords the best opportunity to determine if there were distinct changes in how hunters and herders exploited areas over time. As addressed in Chapter 7, direct comparison of upland assemblages (excavated materials from IKH-09 and survey surface collections) is extremely challenging, made difficult by differences in collection methods, types of disturbances, and analytical scale (e.g., IKH-09 represents the activities at one specific location over time, whereas the survey data reflect an aggregate of behavior across the upland landscape). As discussed previously, we can overcome these issues by comparing interpretations derived from analyses, not the assemblages themselves. For example, the strong evidence for continuity in technological organization across the Neolithic-Bronze Age transition at IKH-09 is also expressed in surface collections spanning the same period, just in different ways. The actual tool profiles are vastly different (diverse with a mix of formal and expedient tools versus narrow with mostly formalized tools), but both signal technological continuity as foragers presumably took up herding.

Important but not so obvious similarities between the datasets deepen our understanding of this apparent continuity, providing insight to settlement decisions during this transformative period. For example, both excavated and surface collected contexts produced broadly similar debitage profiles reflecting activities centered on later stages of tool finishing and maintenance (biface thinning debris and pressure flaking), and a decided lack of early reduction (primary and interior flaking debris). These "truncated" debitage profiles indicate that the earliest stages of manufacture occurred elsewhere. As discussed in the previous section, contradictory evidence for conservation among the surface assemblages makes it unclear whether the shortened manufacturing trajectory was the result of high residential mobility or if tool manufacturing activities were simply embedded in other resource procurement activities, part of a logistical arrangement with people routinely returning to the same locale. Materials from the excavated site, though, strongly signal short-term occupations as opposed to more long-term, where activities associated with procurement, production, use, and discard were carried out in different locations.

Interestingly, the area-density indices from upland surface collections and debitage density at IKH-09 seem to signal increased intensity of use across the Neolithic-Bronze Age transition, the result of either longer periods of occupation, repeated short-term occupations, or larger sized groups. While it is indeed difficult to make an assessment based solely on the surface collected sites, the excavated assemblage from IKH-09 does not indicate long occupation periods, but more likely reflects reoccurring short-term site visits, with the rate of reuse increasing as people began to take up herding. Trends generally reflect those of adjacent regions where large scatters representing long-term occupations are rare, and a plethora of small, ephemeral scatters suggest locally constrained mobility (Honeychurch et al. 2007; Houle 2010; Seitsonen et al. 2018; Wright et al. 2019).

Together, the survey and excavation data from the upland regions of Ikh Nart reveal that both hunters and early herders employed short-term, high residential mobility to target resources, with either low or contradictory evidence for raw material conservation. That said, by the Bronze Age we do see an increase in intensity of use, likely the result of recurring occupation of upland habitats. In other words, mobility strategies of presumably Bronze Age herders were not that different from prior Neolithic Age foragers, however, increased recurrent use of upland habitats suggests that mobility may have not been as far ranging as before (i.e., more constrained). Survey data suggest that over time, movements became increasingly structured around relatively abundant upland grassland resources, particularly areas with productive winter vegetation.

8.3 Settlement Trends and Environmental Change

The last research question (Research Question 4) seeks to identify and understand how land use pattens articulate with environmental change, both natural and social. For the natural environment (Section 8.3.1), we consider published regional paleoenvironmental data alongside local trends based on geoarchaeological research at Ikh Nart to understand the context of demographic shifts across the Neolithic-Bronze Age transition (Sections 8.3.1.1 and 8.3.1.2). In Section 8.3.1.3 we consider what this context tells us about the nature of human decision-making processes and the role of climate adaptation in the transition to food production.

Finally, in Section 8.3.2 we briefly examine aspects of the social environment that can be gleaned from the data and draw connections to other regional observations. For the current study, changes in the social environment over time are evidenced by disparities in wealth or status as expressed by shifts in specialized technology, craft production, metal production, and presence of high quality or exotic goods.

8.3.1 Natural Environment

8.3.1.1 Regional Trends

As discussed in Chapter 3, a suite of regional environmental studies involving pollen, lake cores, sediments, hydrological systems attest to dynamic climate shifts across the region since the close of Pleistocene (ca. 11,700 years ago) (Rosen et al. 2019). Oxygen isotopes from speleothems from caves in China, for example, indicate cold and dry conditions across the region at the close of the Pleistocene, transitioning to a warmer and wetter setting by the middle Holocene about 8000 years ago (Zhang et al. 2011). According to Janz (2012) foragers occupying the region during this period are thought to have employed a somewhat constrained settlement strategy, with settlements tethered to wetland resources that thrived during this period.

A drying trend is proposed around 6000 years ago, intensifying between 4500 and 4000 BP (Cai et al. 2010; Feng et al. 2007; Rosen 2008), though frequent and wide-ranging shifts in $\delta 18O$ suggest patterns were highly variable. Regional mid to late Holocene aridification is further evidenced in oxygen isotope data obtained the Guliya ice caps on the Qinghai-Tibetan Plateau

(Thompson et al. 1997). Shifting δ18O values signal lower temperatures during the Younger Dryas period; a warming trend by the start of the Holocene; and a return to colder conditions by about 6000 years ago. Pervasive aridification (low precipitation) accompanied these temperature shifts (An et al. 2008) and may have led to the deterioration of steppe environments including the contraction of lakes and wetland habitats that characterize earlier periods (Janz 2012:288-293). Initially, these cool/dry conditions may have prompted forager populations to move to other regions (see Janz et al. 2021). By about 5000 BP, foragers appear to have reoccupied the East Gobi, intensifying use of remaining wetland environments and employing a settlement regime that included high residential mobility centered on oasis resources, alongside logistical mobility to target an array of non-wetland resources. It was during this period of heighted residential mobility that herd animals were first incorporated into the hunter-gatherer system (Janz 2012:288-293). Temperature trends appear to have reversed again by 3200 BP in the Gobi, accompanied by persistent low levels of precipitation.

8.3.1.2 Local Environmental Conditions

Preliminary results from geoarchaeological analyses of alluvial sections in the vicinity of Burgasny Enger (IKH-09) (Rosen et al. 2019) generally corroborate broader Gobi climate trends (e.g., Janz 2012; Janz et al. 2017, 2021). Table 8.2 presents a summary of environmental information derived from geoarchaeological work to date at Ikh Nart.

Table 8.2 Summary of Regional and Local Climate Data from Geoarchaeology Study at Burgasny Enger*.

	Early Holocene (ca. 11,600-8000 BP)	Middle Holocene (8000-4500 BP)	Late Holocene (4500 BP and later)
Cultural Chronology		Neolithic to Neolithic-Bronze Age transition (Oasis 2 to Oasis 2/3 transition).	Bronze Age (Oasis 3) and beyond.
Regional Climate	Transition from cool/dry to warm/wet conditions.	Increased aridity after 6000 BP with variable temperatures.	Warmer with increased aridity.
Local Hydrology*	Development of shallow saline ponds.	Wetland areas and saline ponds.	Infilling of wetlands/ponds with colluvial deposits from eroding hillslopes.
Local Vegetation*		High density of succulent phytoliths indicate aridity and saline soils.	Tree, shrub, rangeland grass phytoliths indicate more verdant vegetation present.

***=From Rosen et al. 2019 at IKH-09, upland zone of Ikh Nart Nature Reserve.**

Data derived from geoarchaeological research at Burgasny Enger point to important changes in hydrological regimes that signal significant environmental change across the Holocene including the development of shallow-water saline ponds sometime during the early Holocene (ca. 11,00-8000 BP); eventual replacement by wetland marshes during the mid-Holocene (ca. 8000-4500 BP); followed by a period of aridification, increased colluvial action (eroding of nearby hillslopes) and the establishment of steppe grasses by the late Holocene (after 4500 BP). Phytolith analyses contextualize the hydrological sequence, providing not only insight into local processes, but also a framework to interpret human demographic and technological trends. Importantly, the vertical distribution of phytolith forms from geo-sections described by Rosen et al. (2019) signal that mid-late Holocene shifts in vegetation were the result of not only changes in precipitation (moist to dry paleoclimatic conditions) but may be linked to human land use behavior. For example, high densities of succulent phytoliths in units dating to the mid-Holocene are explained by local hydrological conditions within these valleys which promoted the ponding of alkaline water. Succeeding this phase are periods of seasonal stream activity and slope wash action that transformed the prior alkaline conditions into a sediment rich environment that supported shrubs and rangeland grasses. Rosen et al. (2019) propose that the appearance of more verdant vegetation would be counter-intuitive if the vegetation change was only driven by Late Holocene aridification. Ongoing work by Rosen and colleagues is testing the hypothesis that early herders entered these valleys to target abundant water sources (e.g., springs and remaining ponds) at the end of the mid-Holocene Climatic Optimum (ca. 4300 cal. BP). A growing reliance on grazing herds may have contributed to the thinning of the hillslope vegetation, promoting erosion of the shallow hillslope soils. These colluvial sediments would eventually cover the older alkaline deposits, improving growing conditions for trees, shrubs, and *Stipa* grass, important resources for a growing herding economy (Rosen et al. 2019).

Researchers view this not so much as stewardship of the “natural” environment, but as a case of “landscape improvement” for economic sustainability (Rosen et al. 2019:305). The on-going study employs a multi-scalar adaptive cycle approach adopted from resilience theory that allows for examination of the interface between multiple independent and dependent systems of environmental change (i.e., atmospheric, biotic, lithologic) and human social change (i.e., technology, mobility, social structure, economy). Work is focusing on reconstructing small- and medium-scale climatic fluctuations through examination of existing paleoclimate data and collection of local geomorphological, hydrological, and vegetation data. The study endeavors to match these cycles of environmental change with cycles of human adaptations such as settlement patterns (high residential mobility, semi-sedentary), technological systems (possible cycles of highly formalized to more expedient tool production), changes in economic systems (cycles of exploitation wetland plants versus collection of plants growing in the uplands) and also cycles in the exploitation of wild versus domestic resources (i.e., sheep and goat).

Data from the current study, including area-density indices from upland sites and debitage density at IKH-09 at Burgasny Enger, support the above hypothesis and interpretative framework, demonstrating increased intensity of use across the Neolithic-Bronze Age transition as vegetation and hydrological regimes were transformed. Across all periods, people targeted upland areas (including areas with high winter productivity) by way of repeated short-term occupations, with the rate of site reuse increasing over time. It may be the case that as the subsistence economy shifted to include herding animals, the abundant and possibly enriched upland grassland resources became even more important, with groups of hunter-herders returning to the same locations more often than prior forager populations. Further, the apparent correlation between intensified upland use and shifting local hydrological and vegetation regimes as described by Rosen et al. (2019) strengthen the prior proposition that despite a continuation of some aspects of forager lifeways, a reorganization of priorities was underway by the Bronze Age. This shift in land use and potential economic reorganization coincided with the regional onset of dryer conditions (with widely varying temperatures), a reversal of wetter and cool conditions when foragers still prioritized uplands but exploited a broader range of habitats, especially wetlands to the north and south of the upland zone.

8.3.1.3 Discussion: Land Use, Mobility, and Adaptation

Taken together the archaeological and geoarchaeological data presented here suggest that the shift in habitat preference across the Neolithic-Bronze Age transition was a risk management response to increased variability in resource productivity due to shifts in the natural environment. In other words, increasing region-wide aridification and presumed decreases in productivity resulted in increased focus on the most productive resources (e.g., upland grasslands and associated wetland/riparian habitats). Employing the logic of foraging theory (Kelley 1995), in this context of local abundance and regional scarcity we should expect people to: 1) reside for longer periods in areas of high productivity (i.e., reduced residential mobility) and employ logistical mobility to exploit surrounding areas; and/or 2) intensify subsistence practices to increase food energy produced from same unit of land (i.e., increase diet breadth to include low ranked /high cost species; intensify processing of some resources; incorporate specialized food production technology) (Binford 1968; Flannery 1969; Keeley 1988; Stiner et al. 2000; Stiner and Munro 2002).

Regarding mobility, the survey and artifact analyses show that counter to the expectations of foraging theory, people continued to employ high residential mobility as aridity increased, however, movements were increasingly centered on habitats suitable to a wide range of economic pursuits (grasslands for herding, large game hunting, wetland/riparian resources, a variety of flowing plants). Put another way, high residential mobility was employed by both hunter and herder economies, with increased re-occupation of upland contexts as herding was introduced.

As for resource intensification, tool kits across the Neolithic-Bronze Age transition exhibited no evidence for intensified resource processing (e.g., high number of task specific tools, such as projectile points for hunting, ground stone tools for processing plans), though the study does make a case for diet diversification. For example, through the lens of IFD, the shift in habitat preference across the Neolithic-Bronze Age transition is interpreted as an abrupt change in priorities likely associated with the transition to food production (as opposed to infilling of previously preferred habitats). In this scenario, the introduction of domestic animals can be viewed as a form of diet diversification that served to minimize perceived risk. The introduction or "auditioning" (e.g., Zeder 2006, 2008) of domestic animals already adapted to long distance travel (such as sheep and goat) in the Gobi Steppe may have improved existing foraging economies by affording a buffer against presumably declining return rates of wild resources associated with regionwide aridification. Initially, the expanded resource base would not have required significant alteration of foraging lifeways (e.g., mobility strategies, subsistence, social organization), yet would have improved outcomes for people experiencing unpredictable conditions. Such a mixed strategy would likely continue until return rates of wild prey dropped below the opportunity costs of herding (e.g., defending, feeding resources that have delayed returns) (Alvard and Kuznar 2001; Zeder 1994), or when opportunity costs for herding were lowered (e.g., exploitation of secondary products, introduction of foddering).

Together, the study data link shifting mobility strategies to processes of diet diversification, giving us an understanding of the logic behind movement over time. Foragers employed wide ranging high residential mobility to target resources distributed across a range of habitats (with a focus on wetlands in both upland, lakebed, and lowland contexts); herders also moved frequently, however movements were constricted to areas of high resource diversity and productivity (i.e., uplands). Still at issue is the question of why or how diversification came about in the first place. Was proposed diet diversification (i.e., domestication) a response to environmental stress or population pressure along the lines of optimal foraging models? Or are patterns more in alignment with niche construction theory that reasons that diversification is likely to occur in resource rich environments that encourage investment in innovations that promote greater productivity (Zeder 2012, 2016)? Of course, full exploration of these alternatives requires archaeological data on the ubiquity and diversity of plant and animal taxa (both wild and domesticated), as well as information on the intensity of resources processing (Zeder 2016:). While the current study does not provide for these datasets, the present archaeological and geoarchaeological records (e.g., absence of evidence for population growth in concert with evidence for human induced grassland enhancement) do give some credence to the niche construction framework.

According Zeder (2016), niche construction theory "places initial domestication in the context of environments where diverse and abundant resources can be reliably found within defined catchments capable of fostering both co-evolutionary interactions leading to domestication and cooperative behaviors in humans and target species needed to sustain and further those interactions" (Zeder 2016:338).

Proponents of niche construction theory have long questioned the ability of simple optimal forging models to capture the variable ways in which food production came about (Hegmon 2003; Zeder 2012), thought others have advocated for optimization frameworks, citing their utility in assessing human decision-making processes in dynamic settings (Gremillion et al. 2014). A number of researchers have chosen to highlight the compatibility of the two approaches, citing their value in recognizing the active role of humans in forming their environments (Bliege Bird et al. 2008), and highlighting a systematic approach to the assessment the motivations for niche-construction activities (e.g., costs of land management investment and associated return rates). Gremillion et al. (2014:6176) posit that the two approaches "share a commitment to evolutionary explanation even though they emphasize different processes, questions, and types of causation".

Haas and Kuhn (2019) also illustrate the compatibility of these frameworks in their evolutionary model of forager mobility in constructed environments; here the authors examine how infrastructure/feature construction and discarded material deposits that promote reuse/recycling shape settlement decisions, specifically, the tendency for mobile people return to certain places. Based on concept of energy optimization, the authors propose that mobile tool-using people can be expected to reoccupy locations that have been previously modified or constructed. They posit that in cases where some degree of utility remains, foragers can be expected to reoccupy those locations to achieve cost savings in infrastructure construction and tool production, reserves that ultimately increase fitness (Haas and Kuhn 2019; Haas et al. 2019).

The data from Ikh Nart fit well with Hass and Kuhn’s model, allowing us to consider how distinct economic pursuits (forager versus herding) might have influenced the “relative pull” of natural or cultural resources (Hass et al. 2019:231), and how mobility articulated with economic decisions. At Burgasny Enger, the proposed human-induced enhancement of grassland habitat during the Bronze Age (Rosen et al. 2019) may have provided a “pull” that encouraged serial reuse of the upland zone. While this appears to have to have resulted in some degree of population consolidation, the continued use of high residential mobility may have discouraged the depletion of important pasture resources, supporting the sustainably of food production during times of environmental stress, but also setting the stage for the growth of mobile herding practices that ultimately took hold by the end of the Bronze Age (see next section). This patterning contrasts with earlier foragers who also employed high residential mobility, but for different reasons. For example, wetland resources appear to have been an important draw during the cooler, wetter Neolithic, however, mobility was structured to target resources across broadly distributed habitats, a pattern that fits well with central place modeling that links high residential mobility with more even resource distribution (Kelly 1995:151).

8.3.2 Social Environment

The current study clearly demonstrates that people living at Ikh Nart across the Neolithic-Bronze Age transition adjusted settlement and mobility strategies in response to growing resource uncertainty (i.e., fluctuating vegetation and hydrological conditions). The development of more constrained or bounded short-term residential movements during the Bronze Age resulted in population concentration over time, and no doubt impacted the ways in which people interacted. Similar trajectories across Eurasia highlight the importance of such local processes (namely short-range movements and interaction) as opposed to long-range mobility, migration, and exchange in the development of food production and complex polities (Wright 2021).

It is important to emphasize that shifting settlement priorities during the Neolithic-Bronze Age transition were not accompanied by a wholesale replacement or abandonment of forager lifeways. The tool assemblages from the current study tell us that people were generally carrying out the same types of tasks, with settlement organization structured around frequent residential moves. The continuity in mobility structure observed at Ikh Nart is in alignment with trends reported in other parts of the Gobi (Janz 2012; Odsuren et al. 2015; Wright et al. 2007; 2019), however in these places, the endurance of foraging lifeways coincided with shifting social practices including the development of mortuary practices that possibly reflect developing social complexity (e.g., memorializing individuals, creation of community spaces) (Bauer 2001; Wright 2021; Wright et al. 2019:9). According to Wright (2021), this duality signals the "place-based" resilience of hunter-gather lifeways in the face of developing social complexity, and together represent a "consolidation" of behaviors that set the stage for later dramatic changes in the social landscape that developed by the during the Iron Age (ca. 3000-2300 BP). These behaviors came to define highly mobile pastoralists across Eurasia and include high rates of residential mobility; long distance connections and trade networks; social differentiation and hierarchy; and broadly adopted mortuary and architectural traditions (Jeong et al. 2018; Makarewicz et al. 2018; Taylor et al. 2017; Wright 2021; Wright et al. 2019).

Diachronic trends observed in the current study generally support those noted across the Gobi and underscore the role of high residential mobility in the evolution of food production, though as demonstrated, the relationship is not straightforward. Frachetti's (2009) model of non-uniform socio-political complexity provides a useful framework for exploring the relationship between mobility and social change. In this model, variation among mobile pastoralists is attributed to local institutions influenced by and interacting with other communities in a variety of ways resulting in differing levels of socio-political organization, mobility patterns, and inter-group connections. In Bronze Age Eurasia, Frachetti includes trade networks and building conventions (e.g., mortuary and monumental architecture) as general institutions that are shared across a wide area; however, particular associated cultural practices are not. For example, while specific rules for trade may have varied across a network, people are thought to have adhered to generally accepted rules to achieve a desired outcome (general rules are broad but were reshaped in local contexts). The degree of consolidation and fragmentation among groups depends on interconnectedness of neighbors, not on the durability of an institution or a shared sense of society. (Frachetti 2009:22). Periods of consolidation are marked by larger aggregations of people, a high degree of material uniformity, stability in land use patterns, uniformity in burial practices. Consolidation could have promoted access to trade networks and materials for metal production, though without control of production, did not require high levels of political control. Frachetti speculates that over time, the growth of commodity-based trade may have promoted the development of specialized communities that relied on interactions with other communities. Smaller, non-centralize groups (fragmentation) would have been in a better position to respond to this need, making larger, consolidated communities unnecessary. Fragmentation is marked by smaller groups who moved more frequently for longer distances, with increased interactions with a broad range of communities as evidenced by a high degree of material diversity, variable burial and land use practices.

The evidence form Ikh Nart fits well with Frachetti's model in that presumed early herders of the Bronze Age appear to have developed the first recognizable forms of consolidation; people aggregated in upland contexts, with a decline in the range of movements compared to earlier pre-Bronze Age foragers. Not surprisingly, the slight shift in land use and mobility strategies are accompanied by a continuation of technological traditions; however, in the absence of evidence for population growth, shifts likely reflect changing priorities, specifically, the need for reliable and productive pasture as people presumably began to rely on domesticated animals. The question at hand is, what impact did this proposed consolidation have on the social lives of emerging herding communities?

Clearly, the current study does not lend itself to a robust or nuanced discussion of how social complexity developed along with the advancement of pastoralism, however, the survey data do reveal that counter to the proposed region-wide growth of monument and burial construction (Wright 2021), there is little evidence for specialized production such as disproportionally high concentrations of a single artifact class, specialized or highly standardized tools, or evidence of metal production. High concentrations of microblades from IKH-09 might suggest some form of specialization, however, there appears to be no change over time in their abundance, nor any shift in morphology that might suggest specialization (e.g., metric standardization) (see Table 1.2). While confirmation of this finding requires more robust datasets from excavated contexts, the interpretation fits well with the evidence for constrained the mobility during the Bronze Age which may have impeded wealth development in emerging herding communities. This interpretation is based on the idea that among herding societies, one's ability to move is intimately linked to wealth and well-being; access to pasture has a direct impact on the number of animals an individual or family can own. Given that herd size is an indicator of wealth among mobile pastoralists, restricted mobility may be linked to limitations on affluence.

While the current study found no obvious or clear evidence for social differentiation in the material record, we cannot ignore the evidence for monument building that appears to have flourished by the end of the Bronze Age both regionally (Wright 2021) and locally (Figure 1.4; see also Schneider et al. 2021). Researchers often associate monument construction with the appearance of elites competing to establish themselves in an unpredictable social landscape (e.g., Allard and Erdenebaatar 2005), or interpret monuments as manifestations of progressively integrated social hierarchies based on control of non-material resources (e.g., ritual activities) rather than economic variables (Houle 2010). While the relationship between the habitation sites from this study and the monument record of Ikh Nart has yet to be explored, their co-existence does not necessarily contradict the lack of evidence for social differentiation among Ikh Nart habitation sites. As Wright (2014) proposes, monuments were not necessarily an expression of an emerging elite but could have been a strategy enacted by early semi-egalitarian early pastoralists who sought to build a stable social landscape. In other words, monument construction may have served to encourage social cohesion and enhance survival in an environment marked by perpetually fissioning social units and uneven or unpredictable access to resources.

Relating this to the current study, the consolidation of populations in the upland zones as herding was introduced may well have introduced some level unpredictability as people vied for scarce resources and faced increasing rates of interaction (and potential for conflict) and potential resource depletion. In this context, monuments may have served to define re-use territories, promote cohesiveness for highly mobile groups, and signal to outsiders a sense of group solidarity and a claim to that region (Wright 2014:155-160). Future possible research avenues relating to social complexity and the material record of habitation sites are discussed further in Chapter 9.

9.0 Reflections on Research

9.1 Regional Connections

This study has documented subtle yet important shifts in land use and mobility strategies across the Neolithic-Bronze Age transition as people presumably began to take up herding practices. The shift to upland habitats with productive grasslands and winter vegetation broadly coincides with the regional onset of dry, cool conditions, a reversal of wetter and cool conditions where prior foragers exploited a range of habitats, especially wetlands to the north and south of the upland zone. Both Neolithic hunters and early herders of the Bronze Age employed short-term, high residential mobility to target resources, demonstrating that foraging lifeways were amenable to early mobile pastoralists. By the Bronze Age, mobility was more constrained resulting in increased recurrent site use and consolidation of populations, and possibly erosion induced enhancement of important grassland vegetation. Together, patterns signal an abrupt shift in priorities of highly mobile people, likely connected to the growing importance of herding animals among foraging populations. While this needs to be confirmed by direct evidence for the incorporation of domesticated animals, patterns fit well with the narrative provided by Janz et al. 2020 that contends that the southern and eastern portions of the eastern Eurasian steppe were only minimally impacted by neighboring herder populations until at least after 4500 BP (Janz et al. 2020). According to this model, Eneolithic and Early Bronze Age foragers (prior to 4500 BP) of the Gobi do not appear to have been influenced by Afanasievo hunter/herder populations who occupied the Altai region by about 5000 BP and who later transformed hunter-gatherer economies across Eurasian steppe (Honeychurch et al. 2021; Jeong et al. 2020; Kovalev and Erdenebaatar

2009; Taylor et al. 2019; Wilkin et al. 2020). Gobi Desert and desert-steppe patterns are somewhat analogous to those observed in the Lake Baikal region where forager lifeways persisted into the Late Holocene (Losey et al. 2017; Nomokonova et al. 2010, 2015; Weber and Bettinger 2010; Weber et al. 2013); together these forager-focused studies provide important comparative datasets to investigate the complex history of food production across Eurasia.

According to Janz et al. (2020) major economic transformations did not reach the Gobi subregions until after the 3rd millennium BCE (about 4500 BP) following a period of increased wide-ranging regional interaction and exchange with western groups such as the Chemurchek, connections that set the stage for widespread transformations across Mongolia and Northern China (i.e., investments in animal domestication and monument construction). By 3600 BP, intensification of herding practices (i.e., dairying) and monument construction are evidenced across the Gobi, developments that coincided with the growth of craft production and exchange that resulted in the circulation of wealth items (e.g., lapidary beads, fine-ware ceramics). Janz and colleagues (2020) hypothesize that it was wealth accumulation through exchange that stimulated investment and eventual adoption of domesticated animals and by foraging communities.

An alternate model by Honeychurch et al. (2021) proposes that domestication was introduced to eastern foraging populations earlier during the Eneolithic and Early Bronze Age, however the addition of herd animals did not constitute a meaningful transformation of subsistence economies linked to climate stress (i.e., aridification). Rather, activities likely reflected experimentation of a novel resource acquired through interactions with Afanasievo communities to the west. Accordingly, the incorporation of herding practices would not have required significant alteration of forager lifeways (i.e., habitat selection, mobility strategies). Honeychurch and colleagues (2021) suggest that this early but casual experience with domestic herds facilitated an understanding of animal needs and behaviors, enabling very early hunter herders of the Gobi to intensify use during the rapidly changing natural and social environment of the Bronze Age. They further speculate that knowledge of dairying practices intensified herding practices which fostered "new forms of social identities focused on pastoral resource territories as well as alliances with external communities", processes that likely involved increased commitment to monument building (Honeychurch et al. 2021:16). Of course, absent from this model is direct evidence for domesticated animals at this early date in Gobi steppe, as well as any genetic link between local pre-Bronze Age populations and those to the west. Moreover, a recent preliminary study involving a small number of burials across the Eastern Steppe identified genetic continuity between pre-Bronze Age (ca. 6600 BP) and later populations sampled across southern and eastern Mongolia (Jeong et al. 2020), suggesting "long-term" stability of the eastern Mongolia populations for over 4000 years (Jeong et al. 2020:909). Though the study requires confirmation from larger samples, differences in the genetic profile of pre-Bronze Age individuals of eastern Mongolia and those from central Mongolia further speak to the separation of these groups prior to the Bronze Age (Jeong et al. 2020:896). Results of this small but wide-ranging study support research from adjoining regions (Allentoft et al. 2015; de Barros Damgaard et al. 2018; Jeong et al. 2018), including cranial and dental nonmetric, cranio-morphometric, and DNA data which indicate preservation of indigenous traits in later pastoralist groups and restricted gene flow between groups prior to the Late Bronze Age (Janz et al. 2020).

The current study, focused largely on survey results and coarse-grained chronometric data, does not clarify these issues surrounding the timing or nature of early animal domestication nor the relationship to growing social complexity. On one hand, patterns may indicate support for Honeychurch et al. (2021) demonstrating that changes across the Neolithic-Bronze Age transition were subtle, reflecting conservation of knowledge and lifeways including technology and land use practices. That said, the current research does in fact speak to important distinctions between Neolithic and Bronze Age adaptions including an abrupt reordering of habitat preference and increased short-term residential mobility. Patterns broadly coincide with evidence for regional aridification and local improvements for pasturing, signaling that climate played a larger role than envisioned by Honeychurch et al. (2021).

The importance of these subtle shifts goes well beyond understanding local sequences and the role of climate; the study clearly demonstrates the importance of multi-scale approaches in deciphering variability within the highly fragmented, ephemeral, and seemingly continuous record of highly mobile people, perspectives that are not afforded by excavation-focused studies alone. Specifically, the ability to decipher subtle shifts in land use, mobility, and technology as hunter-gatherers began to incorporate domestic animals is key to understating the different ways that "pre-existing cultural fabrics" shaped the development of food production across Eurasia (Hermes et al. 2021:5), offering insight to how major transformations came about (e.g., the role of social interaction, migration, and climate change).

Indeed, the settlement data provided by the current study demonstrate an intentional shift in focus sometime after ca. 4500 BP to habitats well suited to both hunters and herders, with an increased focus over time on areas that would have supported a growing commitment to food production. This shift, as well as the amplification of Bronze Age trends in subsequent periods, seems to support Janz et al.'s (2020) proposition for a late and rather rapid development of pastoral lifeways, though many aspects of forager lifeways persisted until at least the close of the Bronze Age (Janz 2012). That said, the current study found no evidence to support Janz et al.'s (2020) contention that significant economic changes were linked to increased interest in wealth accumulation sometime after 4500 BP, though this was not a major focus of this research. The limited or constrained degree of mobility suggested by the current study may in fact reveal rather low levels of interaction with outside groups or could signal limitations on herd size due to pasture access; both situations could have restricted the value of herd animals and therefore the accumulation of wealth. While limited mobility during the Bronze Age may have hindered the growth of wealth, high degrees of local interaction may have illuminated or intensified the importance of shared traditions (Jaffe et al. 2018:153) including local versions of regionwide monument and burial traditions, such as Ulaanzuukh and Tevsh burials that emerged in southeastern Mongolia around 3500 BP (Honeychurch 2015; Kovalev and Erdenebaatar 2009). While it is possible that these features may signal a degree of status differentiation among early pastoral societies, it is also possible that they served as an expression of community identity among largely egalitarian hunter-herders in a time of economic and social transition (Wright et al. 2019).

9.2 Significance of Research

9.2.1 Method and Theory

This diachronic study of local processes across habitats within the Ikh Nart Nature Reserve offers an opportunity to examine how patterns of continuity and change among forager and herder populations in Mongolia's desert-steppe articulate with regional trends to better understand the nature of broader social change. Compared to other regional studies focused in part on the Neolithic-Bronze Age transition (Schneider et al. 2021; Janz 2012; Wright et al. 2007, 2019), the current study is unique in both its methodological approach and theoretical perspective.

Methodologically, the study demonstrates the importance of statistically sound survey methods to facilitate meaningful comparison of datasets across time and space. Previous small scale random sample surveys carried out at Ikh Nart were designed to assist park managers in identifying and protecting heritage resources, with efforts focused on recording site boundaries, mapping features, and describing site constituents (e.g., Schneider et al. 2021). Similar surveys conducted outside the park (e.g., Wright et al. 2007, 2019) have provide a broad understanding of land use choice over time, and have contributed to our understanding of the development of pastoralism (e.g., seasonal use patterns, range of movements), though have offered little insight into local or household scale patterns to compliment large scale trends (resource selection, spatial organization, division of labor, duration of occupation) (Killion 1992; Peterson and Drennan 2011). Lacking precise measurements of artifact density and site spatial dimensions, these types of surveys do not provide the kinds of data needed to fully characterize human land use across the region. This study demonstrates the importance of distributional or "non-site" survey approaches to identify variable and overlapping artifact patterning that characterize these large, open, contiguous landscapes (Drennan et al. 2015; Drennan and Peterson 2012; Dunnell and Dancey 1983; Thomas 1975), and importantly, the value of adequate sampling strategies to assess population trends over time and across broad areas (Drennan et al. 2015:155-159).

The study also demonstrates the value of both informal and formal theoretical models to link archaeological data to big questions about the evolution of pastoralism and social change, and more broadly, the nature of human decision making in changing environments. For example, interpretation of the material record was centered in informal models of technological organization (Kelly 1988; Nelson 1991; Torrence 1983) to examine linkages between lithic technology and settlement strategies of foragers and herders. Such an approach allows us to reach well beyond lithic analyses that typically focus on functional, morphological, and stylistic attributes to address issues of chronology, site function, and cultural taxonomy. Within an organizational framework, we can visualize the manufacture, use, and discard of stone tools as a dynamic aspect of cultural systems, tied to other aspects of society such as mobility strategies, subsistence pursuits, economic structure, and exchange (Andrefsky 1998). From this perspective, we can use changes in tool kit structure to better understand similarities and differences in forager and herder lifeways. Such changes may include the introduction of new technology to facilitate shifts in subsistence strategies, adjustments in artifact production to accommodate changing situational needs, and changes in levels of tool curation and discard patterning signaling shifts in access to raw materials.

More broadly, the use formal theoretical models like the IFD (Bird and O'Connell 2006; O'Brian and Lyman 2002; Smith and Winterhalder 1992a) focus our attention on the logic of individual decision making to allow us to formulate testable hypotheses about past processes; these approaches are integral to understanding variability in human behavior. In fact, they provide systematic and testable avenues to understand broad patterns of social development. IFD and other optimality models are designed to make predictions about behavior; they specify a decision necessary to a specific context relative to a particular goal and currency. These approaches necessarily reduce behavior to simple components for study, allowing one to look more carefully at the nature of specific interactions (Borgerhoff Mulder and Schacht 2012). These models have been successful in building bridges to the social sciences through a shared interested in understanding how people make decisions about existing conditions. Regarding questions posted by the current study, they are particularly useful in helping to distinguish settlement decisions based on subsistence and/or changes in the natural environment from those shaped by social or institutional constraints that may have been imposed by more complex sociopolitical organization.

9.2.2 Focus on Mobility

This dissertation study has attempted to understand the nature of human behavior change through the lens of mobility. As discussed in the introduction to this work, research on mobility has a long history within hunter-gatherer studies (e.g., Binford 1980; Kelly 1995), thought more recent trends have focused on relationships between foragers and mobile pastoralists and the variable ways people employ movement across production modes (Aldenderfer 2002; Barnard and Wendrich 2008). Efforts to frame mobility in terms of moment (length of time), motion (patterned movement), motivation (e.g., resource access, social or economic circumscription), and segment (who moves) has helped to dispose of static classifications of production modes, emphasizing the flexible nature of mobility and the role of social organization and agency in settlement (Barnard and Wendrich 2008:8). As demonstrated in the present study, the comparison of mobility trends across the forager-herder transition facilitates an understanding of variation in the logic behind mobility, and further, allows us to examine the implications for the evolution of pastoralism in this part of Eurasia. When approached from this perspective, it is clear that the study of mobility across the forager-herder transition is not only essential for understanding how human behavior changed with the addition of domestic animals, but it also contextualizes other patterns of cultural change like the emergence of novel forms of social integration/interaction, and differential access to material wealth, prestige, production, and ritual.

Ultimately, these research threads, supported by sound methods and a unifying theoretical perspective, allow us to understand the development mobile pastoralism and provide a systematic way to distinguish between decisions based on foraging needs and those based on social constraints, helping us to explain broad patterns of social development, including complexity and inequality.

9.3 Future Directions

In order to better understand the relationship between mobility and social development it is critical to expand our knowledge on the timing of climate shifts, domestication, and the development of social complexity/differentiation. These research avenues require more robust datasets than offered by the current study, but together provide the foundation for a fuller understanding of local processes. At the heart of this endeavor is the development of better regional chronologies, specifically, a refinement of Janz's (2012) baseline chronology for technology, economy, and land use for prehistoric Gobi Desert groups (e.g., Oasis 1,2, and 3). Refinement of this regional typology, including the identification of local variations, is a critical research avenue requiring incorporation of materials from in-situ site contexts from across the area. The refinement of ceramic typologies, of course, is key to this goal, and requires a robust program of radiocarbon dating (e.g., dating carbon isotopes, trapped charged analyses) alongside typological analyses focused on manufacture, form, decoration, and function.

9.3.1 Working with Surface Collections

Beyond providing a better understanding of local sequences (including improved cross-dating of lithic artifacts), these accessible but underused datasets open up opportunities for other material studies focused on identifying differences between foragers and mobile herders including resource procurement and levels of interaction (e.g., compositional studies of ceramics, lithic material provenance), technological organization, and subsistence (residues on ceramics and lithics). While skepticism about the integrity of surface assemblages is deeply entrenched among some archaeologists, others have demonstrated the potential for surface assemblages to provide vital information about the nature of associated buried contexts (Downum and Brown 1998), regional and local demography (Peterson and Drennan 2011), and site structure (Hawkins 1998). Further, efforts to date surface assemblages (namely luminescence dating of ceramics) have been demonstrated in several cases (Dunnell and Feathers 1994; Feathers 2003; Janz 2012; Sampson 2010).

To date, virtually no studies carried out in Mongolia have fully tapped into the data potential held by surface collections, datasets that are relatively ubiquitous and accessible when compared to excavated counterparts (though see Janz et al. 2021). In most cases, surface scatters are typically used to define "site" boundaries or serve as indicators for the location of buried deposits, overlooking the potential for durable lithic and ceramic materials to provide insight into past lifeways. Owing to their association with specific time periods, ceramics from hunter-gatherer and herder contexts in the desert-steppe provide an opportunity to better understand the nature of forager and pastoral households (i.e., subsistence pursuits, specialized activities, spatial organization), and how lifeways changed as people transitioned between production strategies. Several aspects of ceramic assemblages including physical characteristics (manufacture, form, and function) and their distribution within an archaeological deposit can inform us about basic lifeways, but further, provide insight to aspects of social life that link to broader characteristics of social complexity such as organization of labor, resource intensification, and production specialization.

That said, the ability to use ceramic assemblages from surface contexts to interpret past lifeways is often stymied by sparsely distributed, highly fragmented, and sometimes temporally mixed artifact assemblages that are indicative of highly mobile people. Recent advances in ceramic analysis (i.e., trapped charge dating methods, organic residues) have helped researchers to overcome some of these issues, providing powerful methods for understanding the role of ceramics among highly mobile populations, including the development and spread of dairying, an important component of burgeoning pastoral economies across Eurasia. For the current study area, larger scale analytical programs focused on organic residues from ceramics will no doubt provide an important line of evidence for the timing and development of pastoralism, contributing to recent research from adjoining regions that strive to identify and understand the variable ways in which food producing economies developed across Eurasia.

9.3.2 Geoarchaeology

In excavated contexts, future research will benefit from the incorporation and expansion of geoarchaeological programs already ongoing in the region (e.g., Janz et al. 2021; Rosen et al. 2019; Wright et al. 2019). On-going research in the region has clearly demonstrated the importance of this line of inquiry in documenting local environmental conditions but also in providing insight to the scope of human impact on the environment. The integration of sediment analyses (e.g., grain-size, magnetic susceptibility, pH, calcium carbonate abundance) alongside macrobotanical studies and phytolith analysis will no doubt help to reconstruct landscape changes related to climate, hydrogeology, vegetation, and land use, and will clarify other aspects of forager and herder lifeways provided by faunal and botanical analyses such as seasonality, subsistence, and resource intensification (e.g., foddering, penning, dairying) (Rosen 1999; Shahack-Gross et al. 2004).

9.3.3 Exploring Social Complexity

The role of social interaction and social differentiation during Neolithic-Bronze Age transition has yet to be explored in the current study area. Past research on the evolution of social complexity and pastoralism in Mongolia has focused on the role of monumental stone constructions of Late Bronze Age and Early Iron Age pastoralists, with little focus on behaviors expressed in the more ephemeral remains of residential occupations. For example, some researchers associate monument construction with the emergence of elites competing to establish themselves in an unpredictable social landscape; here monuments are viewed as visual cues or reminders to highly mobile people of the ancestral links that connect them to the land in which they travel (Allard and Erdenebaatar 2005). This perspective is echoed by Houle (2010) who envisions monuments as manifestations of progressively integrated social hierarchies based on control of non-material resources (e.g., ritual activities) rather than economic variables. Others link distinct built environment traditions to increased interregional wealth exchange (Janz et al. 2020), with monuments and burials serving as status indictors (Wright et al. 2019). Still, others argue that monuments were not an expression of an emerging elite but were “part of a broad strategy enacted by early semi-egalitarian early pastoralists who sought to build a stable social landscape” (Wright 2014) who memorialized individuals or groups to express social identity and to ensure land use rights (Honeychurch et al. 2021). Along these lines, monuments were not vehicles for aggrandizing elites to establish themselves in an unstable natural and social landscape, but reflected a more “egalitarian experience” designed to build social cohesion and enhance survival in an environment marked by perpetually fissioning social units and uneven or unpredictable access to resources. According to Wright, these circumstances did not require chiefs, but necessitated situational leadership to facilitate systems of support. The purpose of monument construction, according to Wright, was to define re-use territories, to provide a sense of belonging or cohesiveness to highly mobile groups, and to signal to outsiders a sense of group solidarity and a claim to that region (Wright 2014:155). Despite these efforts to understanding the underlying forces of social change that accompanied mobile pastoralism, we still know little about the ways that complexity evolved; we know even less about forager and early hunter-herder populations that pre-dated pastoralism in this part the eastern steppe.

Understanding the development of social differentiation from the ephemeral remains of habitation sites requires a robust program rooted in household archaeology (e.g., fine grained data on spatial organization, waste disposal patterns, organization of labor, interaction between household/camp members), research avenues that are well beyond the scope of the current project.

Conventional wisdom in the field of archaeology dictates that excavated contexts provide the most reliable datasets from which to interpret household activities, however, numerous researchers continue to push the boundaries of the interpretative power of surface assemblages like those amassed during this study, tremendously expanding opportunities to link local and regional scale analyses to understand the dynamics of social change. The interpretation of surface collections, of course, is improved through comparison with excavated materials to understand patterns of association, however, other approaches such as ethnographic and ethnoarchaeological studies provide a vehicle for identifying behavioral aspects of the archaeological record and making inferences about social constructs. For example, Wright‘s (2016) examination of ethnographic and archaeological studies from steppe and desert step regions of Mongolia affords important insight to the physical structure, social order, and ethos of herder households, providing an elegant and flexible framework for identifying and interpreting household spaces in the archaeological record of mobile pastoralists. As discussed in Section 9.3.1, operationalizing these models is made difficult by the diffused, fragmented, and sometimes mixed archaeological record of mobile pastoralists; however, the interpretive power of these problematic assemblages will no doubt be enhanced by future material studies focused on improving chronological assessments (e.g., trapped charged analyses of ceramics), understanding procurement strategies (e.g., compositional studies of ceramics, lithic material provenance), and identifying subsistence pursuits (residues on ceramics and lithics). Together, these studies capitalize on easily accessible datasets to operationalize highly conceptual models of spatial and social organization (e.g., Wright 2016).

On a theoretical level, the examination of local or household level patterns over time will inform broader research on how household level economic and subsistence practices articulate with regional land use patterns to understand how mobility strategies may have supported or suppressed the development of social complexity, including diverse forms of differentiation (e.g., wealth, status, prestige) (Borgerhoff Mulder et al. 2009; Drennan, Peterson, and Fox 2010). Together, these local and regional datasets will expand on recent advances in Eurasian studies regarding the development of social complexity and fill in the gaps regarding the role of forager adaptations in the evolution of pastoralism and the development of complex socio-political structures.

In closing, the research themes identified in this chapter (e.g., land use, technology, domestication, resource intensification, social complexity, climate) supported by rigorous methods and a uniting theoretical perspective will enable researchers to make use of the ubiquitous ephemeral habitation sites of mobile people to investigate how residential movements changed with the addition of domestic plants and animals. Such an approach will expand our understanding of how mobility developed from a strategy for household subsistence (by earlier foragers) to an expanded venue for social and political communication. Comparison with adjacent regions where foraging was followed by herding and areas where herding was never adopted will go a long way in in understanding the variable ways in which food production and more complex social strategies came about, enriching our ability to test theories about the drivers of human behavior change including models that relate changes in population and behavior complexity to resource abundance (mediated by climate) and those that consider the influence of social, demographic, and historical contingencies on behavior change.

Appendix A Environmental Multivariate Dataset.

Table A 1 Environmental Multivariate Datasets for Period Components.

Site No.	ADI	Elev. (m asl)	Landform Classification	NDVI (Ranked 5-7)	Pasture Prod. (Ranked 2-4)	Site Type	Activity
NEOLITHIC (0.408351 ADI)							
A006	0.004043	1,140.62	6 (upland)	7	3	R	ML
A024	0.015831	1,114.55	6 (upland)	6	3	R	MLXHC
A040	0.001777	1,141.26	3 (n. facing hill)	7	3	R	MLXC
A049	0.000601	1,114.52	7 (low/flat)	6	3	R	MLX
A050	0.000245	1,067.39	8 (minor drainage/depression)	6	2	R	SMLX
A059	0.006999	1,123.81	8 (minor drainage/depression)	7	3	R	MLXC
A066	0.007384	1,100.91	6 (upland)	6	3	R	MLXHCF
A077	0.03657	1,109.94	4 (s. facing hill)	6	2	R	MLX
A078	0.000075	1,101.48	6 (upland)	6	2	T	MLH
A099	0.000142	1,078.99	7 (low/flat)	6	2	R	MLXCF
A100	0.000392	1,081.33	7 (low/flat)	7	2	R	C*
A101	0.000323	1,085.67	6 (upland)	5	2	R	MLX
A158	0.001379	1,099.48	7 (low/flat)	7	3	R	MLX
A168	0.000051	1,120.69	6 (upland)	6	3	T	L
A175	0.002587	1,103.50	6 (upland)	6	3	R	MLX
A177	0.000248	1,052.28	6 (upland)	6	2	R	MLXC
A178	0.000131	1,049.91	8 (minor drainage/depression)	6	2	T	ML
A179	0.000069	1,065.36	6 (upland)	5	2	T	L
A184	0.0002	1,118.07	3 (n. facing hill)	6	3	R	MLX
A189	0.000492	1,078.07	6 (upland)	7	2	R	MLX
A193	0.000113	1,048.54	6 (upland)	6	2	R	MLX
A194	0.000537	1,052.62	6 (upland)	5	2	T	LX
A197	0.000032	1,080.97	6 (upland)	6	3	R	MLX
A198	0.000379	1,095.67	78 (low/flat, minor drainage)	7	3	R	LXC
A200	0.000716	1,110.89	67 (upland, low/flat contact)	6	3	R	MLXCF
A203	0.101035	1,062.59	6 (upland)	6	3	R	MLX
A209	0.000116	1,073.67	6 (upland)	5	3	R	MLX
A214	0.000016	1,069.94	6 (upland)	6	3	T	L
A220	0.000016	1,069.69	6 (upland)	5	3	T	ML
A232	0.000016	1,085.85	6 (upland)	6	3	T	L
A242	0.00054	1,078.35	9 (major drainage)	7	3	R	MLX
B002	0.003065	1,179.81	6 (upland)	7	3	R	MLXC
B012	0.000236	1,189.46	8 (minor drainage/depression)	7	3	R	MLX
B014	0.034071	1,180.07	4 (s. facing hill)	7	3	R	MLX

Site No.	ADI	Elev. (m asl)	Landform Classification	NDVI (Ranked 5-7)	Pasture Pro. (Ranked 2-4)	Site Type	Activity
B018	0.000012	1,175.71	6 (upland)	7	1	T	L
B027	0.001106	1,160.03	467 (s. hill, low/flat, upland contact)	7	1	R	C*
B028	0.000216	1,211.53	6 (upland)	7	3	R	MLC
B033	0.000012	1,179.77	6 (upland)	7	3	R	CF
B034	0.000229	1,185.04	6 (upland)	6	3	R	C*
B038	0.000087	1,204.38	6 (upland)	7	3	T	L
B041	0.000394	1,181.01	789 (low/flat at major/minor drainage confluence)	7	3	R	C*
B043	0.000313	1,163.73	67 (upland, low/flat contact)	7	3	T	LX
B046	0.002405	1,217.77	6 (upland)	7	3	R	MLX
B049	0.000882	1,228.47	6 (upland)	7	3	R	C*
B050	0.000207	1,192.36	6 (upland)	7	3	R	C*
B054	0.001799	1,176.88	78 (low/flat, minor drainage)	7	1	R	MLX
B056	0.000315	1,232.50	7 (low/flat)	6	3	R	ML
B058	0.000025	1,225.23	6 (upland)	6	3	T	L
B064	0.000086	1,186.04	8 (minor drainage/depression)	6	1	T	L
B066	0.003611	1,239.73	8 (minor drainage/depression)	7	3	R	MLX
B070	0.000146	1,199.94	8 (minor drainage/depression)	7	3	T	L
B071	0.001708	1,189.68	6 (upland)	7	3	R	MLX
B072	0.005329	1,211.07	67 (upland, low/flat contact)	7	3	R	MLXC
B073	0.006886	1,212.66	6 (upland)	7	1	R	ML
B074	0.000311	1,194.22	64 (upland, s. facing hill contact)	7	1	T	LX
B080	0.038993	1,241.88	67 (upland, low/flat contact)	7	3	R	MLXC
B090	0.000334	1,245.60	6 (upland)	7	3	R	LC
B094	0.000217	1,202.02	8 (minor drainage/depression)	7	1	R	ML
B110	0.000596	1,239.75	6 (upland)	6	3	T	ML
B113	0.000907	1,265.63	67 (upland, low/flat contact)	7	3	R	ML
B128	0.001233	1,210.42	3 (n. facing hill)	6	3	R	LX
B130	0.005627	1,212.94	6 (upland)	7	3	R	MLX
B132	0.002232	1,243.87	7 (low/flat)	6	3	T	LX
B159	0.009855	1,238.26	67 (upland, low/flat contact)	7	3	R	MLXF
B161	0.001587	1,243.11	67 (upland, low/flat contact)	7	3	T	L
B166	0.002239	1,209.65	67 (upland, low/flat contact)	7	3	R	MLX
B167	0.000127	1,212.00	678 (upland, low/flat, minor drainage contact)	7	3	R	C*
B176	0.000739	1,235.69	7 (low/flat)	7	3	T	L
B177	0.000815	1,246.83	67 (upland, low/flat contact)	7	3	R	LX
B185	0.00036	1,235.41	8 (minor drainage/depression)	7	3	R	ML
B187	0.000863	1,275.36	64 (upland, s. facing hill contact)	7	3	R	MLX
B191	0.000372	1,259.94	6 (upland)	7	3	R	C*
B192	0.000154	1,264.84	6 (upland)	7	3	R	MLX
B193	0.000292	1,270.71	6 (upland)	6	3	T	L

Site No.	ADI	Elev. (m asl)	Landform Classification	NDVI (Ranked 5-7)	Pasture Prod. (Ranked 2-4)	Site Type	Activity
B204	0.000012	1,238.81	6 (upland)	6	3	T	L
B206	0.002439	1,268.17	6 (upland)	7	3	R	C*
B216	0.001648	1,239.72	678 (upland, low/flat, minor drainage contact)	7	3	R	C*
B227	0.001172	1,191.86	89 (minor, major drainage confluence)	7	3	R	MLX
B231	0.000012	1,245.61	67 (upland, low/flat contact)	7	3	T	L
B234	0.000107	1,197.65	7 (low/flat)	7	3	R	ML
B240	0.000068	1,168.27	7 (low/flat)	7	3	T	L
B244	0.000259	1,209.51	68 (upland, minor drainage contact)	7	3	T	ML
B249	0.000692	1,177.91	6 (upland)	7	3	T	ML
B250	0.00014	1,188.18	8 (minor drainage/depression)	7	3	T	ML
B258	0.001069	1,152.78	3 (n. facing hill)	6	3	R	ML
B261	0.001921	1,154.60	78 (low/flat, minor drainage)	7	4	R	MLX
C110	0.000941	1,132.83	7 (low/flat)	5	1	R	MLX
C126	0.000117	1,161.25	4 (s. facing hill)	7	1	R	MLX
C128	0.006427	1,166.50	64 (upland, s. facing hill contact)	6	1	R	MLX
C150	0.000495	1,146.20	64 (upland, s. facing hill contact)	5	1	T	ML
C190	0.001953	1,187.18	6 (upland)	5	1	R	MLX
C192	0.050333	1,188.12	6 (upland)	6	1	R	MLX
C199	0.000111	1,153.92	6 (upland)	7	1	R	MLX
C203	0.000394	1,204.84	6 (upland)	5	1	R	MLX
C213	0.001008	1,179.52	6 (upland)	5	1	R	MLX
C222	0.001475	1,151.24	7 (low/flat)	5	1	R	MLX
C227	0.000615	1,199.52	78 (low/flat, minor drainage)	5	1	R	C*
C233	0.000054	1,184.87	6 (upland)	5	1	R	MLC
C245	0.000382	1,189.60	3 (n. facing hill)	5	1	T	L
C248	0.020459	1,181.04	3 (n. facing hill)	5	1	R	MLXH
BRONZE AGE (.285011 ADI)							
A003	.008809	1152.32	3 (n. facing hill)	7	3	R	MLXC
A009	0.002524	1,117.32	7 (low/flat)	7	3	R	MLXCF
A032	0.019277	1,132.65	8 (minor drainage/depression)	6	3	R	MLC
A037	0.001395	1,104.35	7 (low/flat)	7	3	R	MLXC
A055	0.000197	1,088.78	7 (low/flat)	7	2	R	LC
A100	0.003073	1,081.54	7 (low/flat)	7	2	R	C*
A117	0.023255	1,113.25	6 (upland)	7	3	R	MLXH
A150	0.00042	1042.62	8 (minor drainage/depression)	5	2	R	C*
A166	0.00002	1,077.81	8 (minor drainage/depression)	6	2	R	LC
A177	0.000047	1,049.18	6 (upland)	6	2	R	LC
A199	0.0151214	1,108.88	8 (minor drainage/depression)	6	3	R	MLXC
B017	0.003507	1,178.08	89 (minor, major drainage confluence)	7	1	R	MLXC

Site No.	ADI	Elev. (m asl)	Landform Classification	NDVI (Ranked 5-7)	Pasture Prod. (Ranked 2-4)	Site Type	Activity
B018	0.000242	1,169.95	6 (upland)	7	1	R	MLC
B027	0.002076	1,152.97	67 (upland, low/flat contact)	7	1	R	C*
B028	0.005556	1,209.84	6 (upland)	7	3	R	MLC
B034	0.000382	1,185.04	6 (upland)	6	3	R	C
B036	0.003585	1,160.12	68 (upland, minor drainage contact)	7	1	R	LXC
B041	0.000753	1,180.47	89 (minor, major drainage confluence)	7	3	R	C*
B044	0.001727	1,171.81	7 (low/flat)	7	1	R	MLC
B046	0.001844	1,215.63	6 (upland)	7	3	R	MLXC
B048	0.000022	1,215.50	6 (upland)	7	3	R	C*
B049	0.007369	1,220.88	6 (upland)	7	3	R	C*
B050	0.010801	1,188.61	67 (upland, low/flat contact)	7	3	R	C*
B052	0.00636	1,175.95	6 (upland)	7	3	R	MLXC
B053	0.006086	1,168.52	67 (upland, low/flat contact)	7	1	R	MLXC
B054	0.004292	1,175.44	7 (low/flat)	7	1	R	MLXC
B062	0.001134	1,188.79	9 (major drainage)	7	3	R	MLXC
B072	0.081959	1,209.61	67 (upland, low/flat contact)	7	3	R	MLXHCW
B073	0.004893	1,207.22	6 (upland)	7	1	R	MLC
B080	0.00179	1,241.02	67 (upland, low/flat contact)	6	3	R	MLC
B084(cu1)	0.000441	1,193.27	9 (major drainage)	7	1	R	MLC
B084 (cu3)	0.00058	1194.05	79 (low/flat, major drainage)	7	1	R	MLC
B084 (cu5)	0.00244	1194.58	79(low/flat/major drainage	7	1	R	MLC
B085	0.000604	1,268.38	67 (upland, low/flat contact)	6	3	R	C*
B109	0.00203	1,228.92	78 (low/flat, minor drainage)	7	3	R	LXC
B115	0.000369	1,207.28	8 (minor drainage/depression)	7	1	R	MLXH
B126 (cu1)	0.000235	1212.07	7 (low/flat)	6	1	R	MLXC
B126(cu2)	0.001107	1,219.85	67 (upland, low/flat contact)	6	1	R	MLXC
B130	0.001698	1,208.51	6 (upland)	7	3	R	MLC
B158	0.015579	1,225.55	7 (low/flat)	7	3	R	MLXCF
B167(cu 2,5, 15)	0.001941	1,206.42	6 (upland)	7	3	R	C*
B169	0.001122	1,248.84	6 (upland)	7	3	R	MLC
B171	0.002618	1,234.28	6 (upland)	7	3	R	MLXC
B180	0.001764	1,228.32	7 (low/flat)	7	3	R	MLC
B191	0.000079	1,259.66	6 (upland)	7	3	R	C*
B194	0.000698	1,254.39	68 (upland, minor drainage contact)	7	3	R	LC
B206	0.00216	1,269.07	6 (upland)	7	3	R	C*
B208	0.001356	1,251.18	6 (upland)	6	3	R	C*
B216	0.004453	1,232.72	678 (upland, low/flat, minor drainage contact)	7	3	R	C*
B235(cu1)	0.000231	1,205.36	78 (low/flat, minor drainage)	7	3	R	MLHC
B235(cu2)	0.000033	1205.30	67(upland, low/flat contact)	7	3	R	MLHC

Site No.	ADI	Elev. (m asl)	Landform Classification	NDVI (Ranked 5-7)	Pasture Prod (Ranked 2-4)	Site Type	Activity
B244	0.003323	1,209.67	68 (upland, minor drainage contact)	7	3	R	MLCF
B252	0.001073	1,185.19	6 (upland)	7	3	R	LC
C113	0.000007	1,133.89	8 (minor drainage/depression)	6	1	R	C*
C154	0.000806	1,152.76	6 (upland)	6	1	R	C*
C204	.000108	1181.51	6 (upland)	5	1	R	MXC
C162	0.002243	1,172.81	6 (upland)	5	1	R	MLX
C226	0.003722	1,185.33	6 (upland)	5	1	R	MLXC
C227	0.003823	1,200.59	78 (low/flat, minor drainage)	5	1	R	C*
C229	0.000266	1,179.49	6 (upland)	5	1	R	LC
C237	0.000174	1,185.07	8 (minor drainage/depression)	6	1	R	SMLXCD
C250	0.009413	1,199.19	4 (s. facing hill)	5	1	R	MLHC
IRON AGE (0.302064 ADI)							
A032	0.0002314	1,136.17	8 (minor drainage/depression)	7	3	R	C
A055	0.0012686	1,088.78	7 (low/flat)	7	2	R	C
A100	0.0076871	1,081.54	7 (low/flat)	7	2	R	C
A117	0.0022586	1,110.39	6 (upland)	7	3	R	C
A146	0.00021	1,081.28	8 (minor drainage/depression)	6	2	R	C
A150	0.0050929	1,042.71	78 (low/flat, minor drainage)	5	2	R	C
A198	0.0005629	1,092.24	7 (low/flat)	6	3	R	C
A200	0.0013114	1,110.89	6 (upland)	6	3	R	C
B012	0.0002814	1,189.46	8 (minor drainage/depression)	7	3	R	C
B017	0.0002914	1,178.08	89 (minor, major drainage confluence)	7	1	R	C
B018	0.000014	1,170.74	6 (upland)	7	1	R	C
B027	0.0590414	1,160.03	467 (s. hill, low/flat, upland contact)	7	1	R	C
B028	0.0007714	1,211.53	6 (upland)	7	3	R	C
B034	0.0008171	1,185.04	6 (upland)	6	3	R	C
B036	0.00673	1,160.12	68 (upland, minor drainage contact)	7	1	R	C
B041	0.0014071	1,176.30	89 (minor, major drainage confluence)	7	3	R	C
B043	0.0011157	1,163.73	67 (upland, low/flat contact)	7	3	R	C
B044	0.0030857	1,173.95	7 (low/flat)	7	1	R	C
B049	0.00802	1,227.91	6 (upland)	7	3	R	C
B050	0.0525457	1,192.36	6 (upland)	7	3	R	C
B052	0.0227929	1,175.95	6 (upland)	7	3	R	C
B053	0.0190214	1,169.71	679 (upland, low/flat, major drainage contact)	7	1	R	C
B066	0.0013357	1,239.73	8 (minor drainage/depression)	7	3	R	C
B070	0.0005229	1,199.94	8 (minor drainage/depression)	7	3	R	C
B072	0.0123786	1,211.03	7 (low/flat)	7	3	R	C
B080	0.0010471	1,236.51	67 (upland, low/flat contact)	7	3	R	C
B084	0.0017429	1,194.58	79 (low/flat at major drainage)	7	1	R	C

Site No.	ADI	Elev. (m asl)	Landform Classification	NDVI (Ranked 5-7)	Pasture Prod. (Ranked 2-4)	Site Type	Activity
B109	0.00055	1,232.00	78 (low/flat, minor drainage)	7	3	R	C
B130	0.0022057	1,209.13	6 (upland)	7	3	R	C
B132	0.0004386	1,243.87	7 (low/flat)	6	3	R	C
B159	0.0008771	1,238.22	67 (upland, low/flat contact)	7	3	R	C
B166	0.0101243	1,208.52	67 (upland, low/flat contact)	7	3	R	C
B167	0.0247771	1,212.00	678 (upland, low/flat, minor drainage contact)	7	3	R	C
B171	0.00268	1,231.80	6 (upland)	7	3	R	C
B176	0.0026386	1,235.69	7 (low/flat)	7	3	R	C
B177	0.00873	1,246.83	67 (upland, low/flat contact)	7	3	R	C
B193	0.0010443	1,270.71	6 (upland)	6	3	R	C
B194	0.00484	1,256.88	678 (upland, low/flat, minor drainage contact)	7	3	R	C
B206	0.0030543	1,266.74	6 (upland)	7	3	R	C
B216	0.0133143	1,239.72	678 (upland, low/flat, minor drainage contact)	7	3	R	C
B244	0.0038657	1,209.67	68 (upland, minor drainage contact)	7	3	R	C
B247	0.0000142	1,161.79	6 (upland)	7	3	R	C
B252	0.0016229	1,185.19	6 (upland)	7	3	R	C
B255	0.0014643	1,174.33	3 (n. facing hill)	5	3	R	C
B261	0.00188	1,155.64	8 (minor drainage/depression)	7	4	R	C
C190	0.0017443	1,187.18	6 (upland)	5	1	R	C
C192	0.0015871	1,183.22	6 (upland)	6	1	R	C
C209	0.000042	1,167.15	7 (low/flat)	7	1	R	C
C226	0.0016171	1,185.20	6 (upland)	5	1	R	C
C245	0.0013657	1,189.60	3 (n. facing hill)	5	1	R	C
XIONGNU (0.11956 ADI)							
A024	0.0002	1,114.55	6 (upland)	6	3	R	C
A059	0.00038	1,123.81	8 (minor drainage/depression)	7	3	R	C
A100	0.00076	1,080.40	7 (low/flat)	7	2	R	C
B017	0.00046	1,177.54	89 (minor, major drainage confluence)	7	1	R	C
B018	0.00028	1,175.71	6 (upland)	7	1	R	C
B027	0.00422	1,155.18	67 (upland, low/flat contact)	7	1	R	C
B041	0.00164	1,176.45	89 (minor, major drainage confluence)	7	3	R	C
B044	0.00204	1,173.95	7 (low/flat)	7	1	R	C
B049	0.00742	1,215.03	6 (upland)	7	3	R	C
B050	0.00312	1,190.63	6 (upland)	7	3	R	C
B052	0.00326	1,174.82	6 (upland)	7	3	R	C
B053	0.00662	1,168.52	679 (upland, low/flat, major drainage contact)	7	1	R	C
B054	0.00018	1,170.80	78 (low/flat, minor drainage)	6	1	R	C
B058	0.00008	1,225.23	6 (upland)	6	3	R	C

Site No.	ADI	Elev. (m asl)	Landform Classification	NDVI (Ranked 5-7)	Pasture Prod. (Ranked 2-4)	Site Type	Activity
B070	0.00052	1,199.94	8 (minor drainage/depression)	7	3	R	C
B072	0.01154	1,211.07	7 (low/flat)	7	3	R	C
B073	0.0019	1,205.06	6 (upland)	7	1	R	C
B074	0.00164	1,192.60	4 (s. facing hill)	7	1	R	C
B084(CU2)	0.00002	1,197.89	9 (Major drainage)	7	1	R	C
B084(CU3)	0.00124	1,194.05	79 (low/flat at major drainage)	7	1	R	C
B085	0.00648	1,268.39	67 (upland, low/flat contact)	6	3	R	C
B130	0.00336	1,212.53	6 (upland)	7	3	R	C
B158	0.00308	1,222.17	7 (low/flat)	7	3	R	C
B166	0.0019	1,209.65	67 (upland, low/flat contact)	7	3	R	C
B167	0.00352	1,206.11	67 (upland, low/flat contact)	7	3	R	C
B171	0.00244	1,234.28	6 (upland)	7	3	R	C
B177	0.00026	1,248.69	6 (upland)	7	3	R	C
B191	0.00398	1,259.94	6 (upland)	7	3	R	C
B194	0.00334	1,256.88	67 (upland, low/flat contact)	7	3	R	C
B206	0.00354	1,268.17	6 (upland)	7	3	R	C
B208	0.00186	1,250.76	6 (upland)	6	3	R	C
B216	0.03	1,239.72	678 (upland, low/flat, minor drainage contact)	7	3	R	C
B227	0.00048	1,185.83	89 (minor, major drainage confluence)	7	3	R	C
B240	0.00024	1,168.27	7 (low/flat)	7	3	R	C
B244	0.00294	1,209.67	68 (upland, minor drainage contact)	7	3	R	C
B252	0.00068	1,182.51	6 (upland)	7	3	R	C
B261	0.00192	1,153.37	78 (low/flat, minor drainage)	7	4	R	C
C113	0.00008	1,133.89	8 (minor drainage/depression)	6	1	R	C
C192	0.00088	1,184.40	6 (upland)	6	1	R	CO
C224	0.00048	1,175.43	8 (minor drainage/depression)	5	1	R	C
C229	0.00058	1,179.49	6 (upland)	5	1	R	C
KITAN (0.289436 ADI)							
A100	0.0022185	1,081.33	7 (low/flat)	7	2	R	C
A177	0.0002505	1,049.18	6 (upland)	6	2	R	C
B017	0.0059535	1,177.54	89 (minor, major drainage confluence)	7	1	R	C
B027	0.029064	1,157.46	467 (s. hill, low/flat, upland contact)	7	1	R	C
B036	0.0033375	1,160.12	68 (upland, minor drainage contact)	7	1	R	C
B044	0.001809	1,171.98	7 (low/flat)	7	1	R	C
B049	0.023367	1,220.65	6 (upland)	7	3	R	C
B050	0.013392	1,192.36	6 (upland)	7	3	R	C
B052 (CU 1,2)	0.009474	1,173.56	6 (upland)	7	3	R	C
B052(CU7)	0.004845	1,173.54	6 (upland)	7	3	R	C
B062	0.002529	1,186.08	9 (major drainage)	7	3	R	C

Site No.	ADI	Elev. (m asl)	Landform Classification	NDVI (Ranked 5-7)	Pasture Prod. (Ranked 2-4)	Site Type	Activity
B072	0.0096045	1,209.61	7 (low/flat)	7	3	R	C
B073	0.00465	1,212.66	6 (upland)	7	1	R	C
B084	0.0000495	1,197.89	9 (major drainage)	7	1	R	C
B090	0.0041685	1,245.60	6 (upland)	7	3	R	C
B107	0.0017925	1,242.37	6 (upland)	7	3	R	C
B167	0.012027	1,207.38	6 (upland)	7	3	R	C
B171	0.0064035	1,235.59	6 (upland)	7	3	R	C
B191	0.0150375	1,259.94	6 (upland)	7	3	R	C
B194	0.0169335	1,256.88	678 (upland, low/flat, minor drainage contact)	7	3	R	C
B208	0.03504	1,251.18	6 (upland)	6	3	R	
B216	0.036213	1,239.72	678 (upland, low/flat, minor drainage contact)	7	3	R	
B244	0.0135315	1,209.51	68 (upland, minor drainage contact)	7	3	R	
B247	0.0000495	1,161.79	6 (upland)	7	3	R	
B261	0.0196905	1,154.60	8 (minor drainage/depression)	7	4	R	
C190	0.0122055	1,187.18	6 (upland)	5	1	R	
C227	0.005799	1,197.02	78 (low/flat, minor drainage)	5	1	R	

Site Types: R=Residential; T=Temporary Encampments or task specific site.

For the purposes of this study, residential bases are distinguished from non-residential sites based on two lines of evidence: 1) artifacts associated with residential activities including cooking or food preparation (ceramics, ground stone, fire-affected rock, hearths); and/or 2) artifacts indicating a range of on-site tasks such as manufacturing (e.g., flake tools, drills, knives, slag), lithic reduction (e.g., non-microblade cores, hammerstones, waste flakes), and hunting (e.g., projectile points).

Activities: M=generalized manufacturing (e.g., flake tools); S=specialized manufacturing (e.g., punch, awl, adz, spindle whorl); L= lithic reduction (debitage and cores); X=multi task tools (e.g., bifaces, microblade); H= hunting (projectile point); C=ceramic; F=food production/processing (e.g., ground stone, fire affected rock); O=metal production (e.g., oar, slag); W=weaponry (e.g., metal projectile point); D=decorative metal.

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