Project Summary

The archaeology of early food production has become a topic of global interest for those seeking to trace long term human impacts on the environment. Thus far, however, research in Southwest Asia has focused primarily on the origins and evolution of plant cultivation, rather than specialized pastoralism — the other major component of this early food producing system. Although mobile pastoralism is frequently invoked to explain changes in the density and spatial distribution of agricultural sites through time, and its consequences cited as important in the abandonment of the large PPNB (10,500 – 8,250 cal B.P.) villages, it has been little studied in its own right.

Intellectual Merit

The research proposed here will examine the origins, nature, and evolution of mobile pastoralism in the Late Neolithic (8,250 – 7,800 cal B.P.) through the Chalcolithic (7,800 – 5,500 cal B.P.) and Early Bronze age I (5,500 – 5,050 cal B.P.) periods in the Wadi al-Hasa region of west-central Jordan. The objectives of the research are to understand **1)** how early pastoral economies developed, **2)** how early pastoralists interacted with farmers (and possibly foragers) in the region, and **3)** the changing impacts of pastoralism on Southwest Asian landscapes. The study will conduct low-impact surface recording of potential pastoral sites in west-central Jordan as well as limited new survey in the region. The investigated sites will be drawn from both the extant site database as well as from the pool of sites that will be discovered during the survey portion of the proposed field work. Types of analysis include in-situ lithic photography of artifacts, computerized analysis of artifact morphology, artifact density mapping, architectural mapping, and geomorphologic mapping. Sites will be dated through a combination of typological analyses, presence/absence of diagnostic artifacts, and whole assemblage analysis; calendar date age-range estimates will be assigned to site-types through correlation of the locations of the different site-types with landforms of known age. Landforms will be dated through Optically Stimulated Luminescence dating of sediments. New geomorphologic maps will be created to facilitate this correlation. All portions of field work will utilize GPS and remotely sensed data to ensure highest possible spatial accuracy. The data recovered from field work will be used as input for Geographic Information Science-based modeling of different pastoral economic strategies and the effects these had on landcover and erosion. These data will also be used to evaluate three previously proposed models for the origins and development of mobile pastoralism in the desert areas of the southern Levant—the Agropastoral Split, the Shifting Strategies, and the Mobile Forager Transition models.

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Broader Impacts

An important goal of the research is to illuminate the long-term impacts of mobile pastoralism under different social, political, economic, and environmental conditions. The work will improve our understanding of the pastoral component of the regional Late Prehistoric food production system, which should help further contextualize the known diachronic patterns of settlement and economy of nearby Late Prehistoric sedentary agriculturalists. The research should also provide a case study of the long term effects of mobile pastoralism, which may be of use to policy makers and aid organizations in developing nations with populations of traditional pastoralists.

Project Description

Introduction

In the story of the transition from a Mesolithic foraging system of food *procurement* to a Neolithic agropastoral system of food *production*, the development of agriculture in the Mediterranean phytogeographic zone of Southwest Asia has long taken center-stage. In the arid margins of this "Fertile Crescent", however, the environment has always been less friendly for agriculture. Consequently pastoralism emerged to become the dominant food production activity in these areas. To fully understand the early development of these desert pastoral economies we must move beyond models that combine archaeological data of domestic animals from sedentary agropastoral contexts with modern "Bedouin" analogs (Rosen 2008, Saidel 2008). Instead, we must study early pastoralism in the desert areas directly. To do so will require new research methods aligned under a theoretical approach designed to study mobile food production in arid lands.

The research proposed here aims to develop new theoretical approaches and methods formulated specifically for the archaeology of ancient mobile pastoralism. These techniques will be used to understand the early development of pastoral food production in the arid regions of southern Jordan, the nature of interaction between desert pastoralists and farmers on the highland plateaus, and the environmental impacts of early desert-adapted pastoralism. This project will focus field work in the Wadi al-Hasa region of west-central Jordan. Wadi al-Hasa is uniquely situated to study these phenomena because it is a natural corridor that connects the eastern and southern arid pastoral zones with the agricultural highland plateaus of the eastern escarpment of the Jordan Rift Valley.

Arid land pastoralism in the Late Prehistoric periods (Late Neolithic [LN: 8,250 – 7,800 cal B.P.], Chalcolithic [7,800 – 5,500 cal B.P.], and Early Bronze Age I [EBI: 5,500 – 5,050 cal B.P.]) is not well understood, but it is during these periods that the pivotal developments in pastoral economy, landuse, and society most likely occurred (Betts 2008, Rosen 2008). Limiting research to the more sedentary,

agricultural sites provides us with a picture of only one part of the Late Prehistoric subsistence economy, and current research recognizes this (e.g. Avner 2006, Henry 2006, Hill 2006, Quintero, Wilke, and Rollefson 2004). Recent work on the archaeology of mobile pastoralists east of the Jordan Rift Valley (Banning and Köhler-Rollefson 1992, Betts and Russell 2000, MacDonald in press) underscores the importance of these areas for pastoral production, but we still know little about the organization of Late Prehistoric pastoral economies, landuse, and society in these areas. Consequently, we do not yet fully understand how the trajectory of arid land pastoralism parallels or deviates from the patterns of change known from the archaeology of their contemporary agricultural neighbors. The proposed research directly addresses this issue.

There are practical difficulties to studying prehistoric pastoralism with the archaeological methods widely used in Southwest Asia; thus, the proposed research will require a data collection methodology that specifically targets pastoralist sites. Pastoralist sites in the desert regions are relatively ephemeral, especially compared to those of agriculturalists elsewhere in the Levant. Commonly used archaeological techniques such as wide coverage pedestrian or automotive survey with broadly spaced transects, large-scale, long-term excavation projects utilizing deep sondage units, or an emphasis on defining and documenting long occupational phases at individual sites are inappropriate for sites which are relatively numerous, small, shallow, and that have little or no stratigraphy. This project will therefore adopt recording techniques appropriate for use with these types of ephemeral sites, such as a focus on mapping exposed architecture and surface artifact density at many sites rather than excavating at only a few, *in situ* artifact photography and measurement rather than intensive artifact collection and curation, and landscape-scale rather than site-oriented analysis of mobility and economic patterns. High-resolution geospatial modeling techniques will be combined with ethnoarchaeological models of pastoral economy and society to analyze the collected data.

Chronological control is a major issue for any archaeological research. There is a long tradition of relative dating in Southwest Asian archaeology, but recent radiometric dating assays show that many desert sites are actually significantly older than what relative dating assessments would show, indicating that typological dating approaches designed for sites in the Mediterranean zone do not work well for sites in the arid regions to the south and east (Avner 2006). As discussed in detail below, I will seek to develop relative dating techniques that are more appropriate to the study of pastoralist sites by modifying existing typological systems so that they incorporate changes in the frequency of artifact types that are specific to the desert areas. I will also use a geoarchaeological approach to constrain these periods to a range of calendar dates by refining the regional terrace chronology using Optically Stimulated

Luminescence and Radiocarbon techniques, and then correlating sites with specific terrace formation periods.

The low number of artifacts at pastoral sites requires this project to produce as much information as possible from each artifact while minimizing measurement error. I will accomplish this by utilizing computerized morphometric techniques facilitated by high resolution artifact photography. Aspects of artifact morphology will be used to better understand ancient patterns of mobility, exchange, and economy. Stylistic study of artifacts and architecture will be used to decode ancient patterns of exchange and territory. Functional and use-life studies of chipped stone assemblages of sites will be used to better understand mobility, technological, economic, and social strategies. High spatial resolution site maps created by the project will allow fine scale analysis of surface artifact densities that will be used to better understand the suites of activities that were performed at sites across the study region.

Research Overview

The research will be framed in three phases. The initial phase is currently ongoing, and includes preliminary examinations of collections from the project areas and formulation of an appropriate suite of fieldwork and post-fieldwork analysis techniques. These goals have been facilitated by a two-week pilot study (already completed) in the Wadi al-Hasa project area in west-central Jordan, which focused on developing and testing appropriate field methods (Ullah, Schuldenrein, and Smith n.d.). Results from this initial phase will serve as a valuable guide for the next portions of the proposed research, for which funds are asked. The major research questions of this phase have been:

- How can we identify ancient pastoral campsites, and how can we distinguish them from those of horticulturalists or foragers?
- Which parts of the lithic technology of early mobile pastoralism can be used as identifying types?
- Can pastoral sites be identified in the existing survey data?
- Is the spatial record in these existing survey data accurate?

The second phase will consist of in-depth fieldwork to take place over 4-6 weeks during the fall/winter of 2010. Most of the funds requested here will be used to support this phase. Several sample survey blocks will be defined both within and outside of previously surveyed areas. These blocks will be surveyed at a finer scale (closer surveyor spacing) than has been done previously in the area. This will allow a better assessment of the density of pastoral sites and non-site material in the area. All potential Late Prehistoric pastoral sites identified in these survey blocks will be mapped and recorded as well as additional potential Late Prehistoric pastoral sites from outside the new survey blocks identified in the

extant survey database. I will also do geomorphic field mapping, create crossections of river terraces, and take OSL dating samples from terrace embankments. Major research questions in this phase are:

- What is the density and distribution of Neolithic/Chalcolithic pastoral sites in the area?
- What kinds of site formation processes affect pastoral sites, and how well do signatures of pastoralism preserve?
- How frequently were prehistoric pastoral sites reused?
- What types of activities took place at pastoral sites?
- What was the middle and late Holocene landscape in the region?
- On what types of landforms are pastoral sites located?

In the final research phase, I will explore the origins and early character of pastoralism in the project region. Data gathered during the proposed fieldwork will be incorporated into a relational database of information focused on early pastoralism that will include published data from other surveys and excavation in west-central Jordan. The data in the database will be tied to site location in a GIS, which will facilitate spatial analysis of stylistic and functional aspects of Late Prehistoric pastoral archaeology in the region. The differential environmental impacts of these landuse scenarios will also be assessed through coupled GIS-based landuse and landscape evolution modeling as in the Mediterranean Landscapes Dynamics Project (Barton 2004, Barton, Ullah, and Mitasova, in press). The results of these simulations can be compared with archaeological settlement patterns to interpret diachronic and synchronic variations in the expression of mobile pastoralism in relation to three models of the development of mobile pastoralism in the region. I will investigate the relationship between desert pastoralists and contemporaneous farmers by connecting the Late Prehistoric pastoralist record produced by the proposed research with the known patterns for the neighboring agricultural highland plateaus. Research questions for this phase include:

- How did mobile pastoralism arise as a unique production strategy?
- Did environmental differentiation affect the way pastoralism originated and developed?
- How do pastoral strategies impact the environment over long periods of time?
- Can mobile pastoralism be considered a viable response to localized environmental degradation?
- How were early agriculture and early pastoralism related?
- How do the patterns of change in settlement, economy, technology, and social organization of early pastoralists compare with those of the sedentary farmers?

- What was the nature of interaction between agriculturalists and pastoralists in different parts of the Levant? Was it amicable or competitive, mutualistic or parasitic, one-way or reciprocal?

Background

The current general understanding of prehistoric pastoralism in the southern Levant has been highly influenced by evidence recovered from a small number of major archaeological sites. Almost all of these sites are located within the Mediterranean climate area, and consequently had mixed agropastoral economies rather than primarily pastoral ones. The proposed research will provide an alternative dataset focused on early pastoralism from a region outside the agropastoral zone.

`Ain Ghazal, a Pre-Pottery Neolithic (PPNB-PPNC: 9,250 – 7,500 cal B.P.) "megasite" north of Amman that also extended into the Late Neolithic (Yarmoukian: 7,500-7,000 cal B.P.), is the most widely known Levantine case study on early pastoralism. Excavations at the site yielded a large quantity of faunal remains that spanned the origins of intensive pastoralism at the site (Köhler-Rollefson 1989a, Köhler-Rollefson 1989b, Köhler-Rollefson, Rollefson, and Quintero 1993, Rollefson 1997, Wasse 2002, Wiedemann et al. 1999). Analyses of these remains showed a change from a faunal assemblage dominated by wild ungulates in the early PPNB to one dominated by ovicaprines by the late PPNB. Additionally, herd compositions switched from goat-dominated to sheep-dominated by the PPNC. In conjunction with this, other evidence suggested increasing environmental degradation around the site before it was eventually abandoned, and only seasonally occupied by pastoralists in the subsequent Yarmoukian period (Rollefson and Köhler-Rollefson 1992).

The Wadi Ziqlab Project, an ongoing long-term study in northern Jordan, is another major source of information about ancient pastoralism in the Mediterranean zone (Banning 1985, Banning 1993, Banning 1995, Banning 2001). Data from Wadi Ziqlab suggests that the Late Neolithic people of the region dispersed from villages to small hamlets and focused on small scale horticulture mixed with pastoralism. These sites, usually found on small river terraces in the bottoms of valleys, were occupied over many years, but not necessarily on a year-round basis. This pattern generally fits with the model developed from the 'Ain Ghazal data, and it seems that the dispersal may have been a response to increased social pressures and environmental degradation associated with life in the PPN megasites.

Prehistoric pastoralism outside of the Mediterranean zone has been studied far less intensively. Data from arid-land pastoral sites have been largely left out of the general understanding of early

pastoralism even though they are potentially contemporaneous with the well known agricultural sites in the Mediterranean zone. This has been done for several reasons, including dating issues and problematic chronologies, a perceived difficulty in locating these sites, and a preference for excavation of larger more complex sites. Survey and excavations in the Black Desert in the eastern panhandle of Jordan provide the best known example of archaeological investigation into Neolithic pastoralism in the eastern desert areas (Betts 1982a, Betts 1982b, Betts 1987, Betts 1988a, Betts 1988b, Betts 1989, Betts 1992a, Betts 1992b, Betts 1993, Betts and Helms 1987, Betts and Russell 2000, Garrard, Byrd, and Betts 1986, Quintero, Wilke, and Rollefson 2004). Preliminary evidence from these sparse sites suggests that hunting and foraging were important early on but that pastoralism was introduced in the Neolithic. This change was originally assigned to the later part of the Late Neolithic on the basis of significant changes in settlement distributions, material culture, and faunal remains (Betts 1992a), but new excavations in the area have documented the presence of significant quantities of domestic ovicaprine remains dating to the late PPNB (Quintero, Wilke, and Rollefson 2004). Garrard et al. (1996) argue that continuity in dwelling form across the transition supports an indigenous adaptation of pastoralism by desert foragers, while Quintero et al. (2004) argue that similarities of certain tool types with highland PPN sites such as `Ain Ghazal points to an influx of pastoralists from the Mediterranean zone. Currently, there is insufficient evidence to confirm either hypothesis, and the research proposed here is designed to address this issue.

Recent archaeological work in south Jordan and Israel suggests that these areas had a substantial pastoral population in the prehistoric periods (Avner 2006, Henry 1992, Henry et al. 2001, Henry et al. 2003, MacDonald et al. 2004, Rosen et al. 2005). Diachronic patterns in material culture and settlement distributions in these areas differ greatly from those of the north and west (Avner 2006), although it is currently unclear whether these are the same patterns as those in the eastern deserts. Because the Wadi Hasa is a potential connecting corridor between the southern and eastern deserts, the proposed research has the potential to clarify these issues. Early surveyors' unfamiliarity with the unique desert typologies have resulted in misclassification of many small Neolithic and Chalcolithic sites. With the exception of a few well documented cases (e.g., for paleoenvironmental reasons [Henry 2006], or because of erosion [Hill 2006]), this has tended to give the impression of settlement gaps where none actually existed, leading to a widespread belief in apparently false hiatuses for these time periods in the southern desert areas (Avner 2006, Rosen 1992). Radiometric assays of excavated sites document a fairly substantial human presence during episodes previously thought to be periods of abandonment (Avner 2006, Rosen et al. 2005). The research proposed here will add to the small number of documented Late Prehistoric

desert sites, and it will do so in a geographically important location where sites of this time period have not yet been thoroughly studied.

Proposed Research

Funds are requested for 4-6 weeks of new field research in the project area, and for analysis of Optically Stimulated Luminescence and ^{14}C samples collected during the field work. Field work will take place in the Wadi al-Hasa region of west-central Jordan (Figure 1). This area is an appropriate location for the archaeological investigation of ancient pastoralism because the Hasa region **1)** has always been more arid than the Mediterranean phytogeographical zone (Figure 2), **2)** has been generally at the periphery of the agricultural core (Hill 2006), **3)** likely acted as a kind of corridor between the eastern pastoral areas (The Eastern Desert and its fringes) and the southwestern pastoral areas (the Wadi `Araba and the Negev Desert), **4)** the tributaries of the Wadi al-Hasa drain the fertile agricultural Kerak and Edomite plateaus to the north and south and connect these agricultural areas to the main east-west Hasa corridor(Figure ##), **5)** surveys conducted in the area have identified a substantial number of possible pastoral sites from early periods (Figure ##), and **6)** many of these sites have substantial surface and shallow sub-surface deposits that have been well preserved in the arid climate of the region.

The first portion of the field work will focus on intensive survey of small sample blocks, focusing on the upper (eastern) portion of the Hasa drainage because **1)** there are more sites preserved in the upper Hasa than in the heavily eroded western part of the drainage, **2)** the upper Hasa may have been a kind of "frontier" or locus of interaction between the pastoralists of the eastern deserts and the farmers of the arable areas to the north and south, and **3)** the upper Hasa is an entryway into the natural corridor between the eastern and western arid pastoral regions (Figure ##). One kilometer square survey blocks will be placed both in the previously surveyed region west of the Desert Highway, as well as in previously unsurveyed areas to the east of the Desert Highway. Because the spacing of survey lines will be closer than those of prior surveys (30 versus 90-150 meter intervals), resurveying previously surveyed areas will provide a quantitative assessment of the reliability of the old survey data with regard to small site densities and settlement patterns, and will allow statistical estimates of site densities and distributions from the old survey data in areas not resurveyed during this project. The new survey blocks in the regions east of the Desert Highway will allow a comparison of pastoral activity, architecture, and artifact types with the other regions of the Hasa drainage proper. During the survey, potential pastoralist

sites will be recorded in detail as they are encountered; other sites will also be recorded summarily and added to the overall site database.

The second portion of the field season will be devoted to re-locating and re-recording additional potential pastoral sites from the original survey database (Clark et al. 1994, Coinman 1998, MacDonald, Banning, and Pavlish 1988) and to additional geoarchaeological field work. Sites will be chosen for relocation based on the presence of any pastoral markers in the primary survey records, and ranked on ease of access and site visibility on high resolution imagery. As sites are re-recorded, I will conduct geomorphologic mapping, stratigraphic analysis of terrace and other sediment outcrops, and will collect sedimentological sampled for texture analysis and OSL and ^{14}C dating in adjacent locales. This geoarchaeological work will be used to create a finer division of the current regional terrace chronology developed by Schuldenrein (2007), and will help build an environmental context for site location decisions that may include evidence for human-induced landscape change in site vicinities.

Because there is little precedent for this type of research, I will combine field and laboratory methods from other regional archaeological traditions and from other disciplines with new protocols specifically targeted at archaeological evidence of pastoralism. For example, this project will **1)** adapt site recording techniques developed for mobile foragers to the archaeology of mobile pastoralists, **2)** borrow techniques from geomorphology to map and date terrace sequences that will help contextualize and date archaeological sites by situating them on plaleolandscapes, **3)** deploy computerized morphometric techniques used in anatomy and paleontology to better understand artifact form and function, and **4)** use GIS and computer modeling techniques to help analyze ancient human impacts on the landscape. The background work needed to properly integrate these techniques to the interdisciplinary research proposed here is ongoing, and includes analysis of extant artifact collections from the project area, digitization of extant archaeological data, preparation of digital spatial data, preliminary mapping, and a pilot field study. I already have access to a substantial amount of these data from to the study area. ASU has collections, primary survey records, scanned survey maps, site records, and databases of information from surveys done in the Wadi al-Hasa in the 1980s and 1990s by B. MacDonald and G.A. Clark (Clark et al. 1992, Coinman 1998, MacDonald 1982, MacDonald 1992, MacDonald, Banning, and Pavlish 1998, MacDonald, Clark, and Neeley 1988). A member of the original survey team (Banning) and a Principle Investigator of the second survey team (Clark) are members of my committee, and I am in contact with other researchers who currently work in the region. Additionally, I have access to records from more recent surveys conducted in the adjacent regions in the northern Wadi Arabah, upland plateaus, and

adjacent wadis (MacDonald and Corbett 2006, MacDonald et al. 2004, MacDonald et al. 2001, Smith 2007) and from several older surveys in the Wadi Arabah catalogued in a large GIS database by the Wadi Arabah Project (Bienkowski and Galor 2005) .

My affiliation with the Mediterranean Landscape Dynamics Project (MLDP, NSF Award **BCS-0410269**) also allows me access to recent high resolution Digital Elevation Models (DEMs) for the region, high resolution aerial photography, remotely sensed images, temporally and spatially fine-grained Archaeoclimatological Macrophysical Climate Models (using the method described by Bryson and McEnaney-DeWall [2007], see Figure 2), and fine grained paleo-vegetation models, all in georeferenced GIS format. One of the main goals of the MLDP has been to establish a modeling laboratory for research into ancient human landuse. As a member of the project, I have created GIS-based models of landscape evolution (erosion and deposition) for pastoral and agricultural landuse, which can be iterated over significant time depth to uncover the relationship between landuse and landscape degradation. These already complete models are currently being applied to archaeological data from northern Jordan (Barton, Ullah, and Mitasova, in press), and can be easily modified for use with the field data collected during the proposed research. The MLDP has developed a collaborative relationship with the new OSL dating laboratory at Utah State University. As a member of the project, I benefit from these collaborations, and will be using this laboratory to process OSL dating samples collected during the proposed fieldwork at a discounted rate.

Comment [IITU2]: Create a figure showing these digital data?

Fieldwork Methods

The field methods that this project will use were developed and tested during a two-week pilot study during the summer field season of 2008, where I relocated and re-recorded seven Late Prehistoric pastoral sites in the project area. This fieldwork allowed for on-the-ground assessment of site accessibility, preservation, and quality, provided an invaluable reference from which to plan future fieldwork, and enabled me to establish a professional relationship with the Jordanian Department of Antiquities and a rapport with local authorities needed for continued research in this region. Details of this pilot study are soon to be published (Ullah, Schuldenrein, and Smith n.d.).

Site selection: The first step has been to develop methods to identify potential pastoral sites from the kinds of data typically recorded by traditional surveys. Currently accepted indicators of ancient pastoral activity—mainly the presence of circular stone enclosures (insert ref to Betts article), but also the presence of concave truncation burins or tabular fan scrapers (Quintero, Wilke, and Rollefson 2004)—were used to select a sample of Late Prehistoric pastoralist sites from the WHS and WHNBS site

databases (Figure ##). These sites will be ranked for potential reinvestigation during the proposed research by prioritizing access, preservation, and amount of pastoral features recorded in the site description.

Correcting the site database: An important goal of the pilot study fieldwork was to evaluate the spatial accuracy of the older survey data. The new GPS-gathered coordinates of the seven relocated sites were used to test the accuracy of the coordinates as recorded in the existing site database and with coordinates estimated by triangulating site locations on Google Earth (GE) imagery from landmarks recorded in the original site descriptions (Figure ###). Neither sets of site coordinates were accurate enough for use in the kind of high spatial-resolution GIS modeling that this project proposes to do. To better understand the nature of the coordinate inaccuracies, I examined the original 1:50,000 and 1:250,000 scale survey maps. Site locations were originally plotted on these maps in the field via triangulation from sometimes very distant landmarks in a featureless landscape, and the coordinates were then estimated to the closest grid square (100 meter interval) of the map (MacDonald, Banning, and Pavlish 1998). I georectified a scanned copy of one of these maps, and then digitized site locations directly in a GIS. The newly digitized points were generally more accurate than those in the database or those estimated from GE imagery, although some coordinates were still highly inaccurate (Figure ###). Comparison of these digitized points to the points gathered by GPS indicated that sites located on or near distinct landforms, such as wadi confluences or river bends, were consistently accurately plotted, while sites located on less distinct landforms, such as long linear terraces or ridges, were often misplotted. Updating the site database with these newly digitized coordinates has greatly increase its utility for this and future projects, but to be sure that the site coordinates used in the modeling portion of this project are of the highest spatial accuracy, sites must be relocated in the field and their coordinates recorded with a GPS.

Artifact Sampling: I have developed three sampling strategies that emphasize *in situ* recording of artifact attributes and distributions. The first is an encounter-based strategy that will rely on close field walking of the site to discover and mark all visible artifacts and to approximate site boundaries based on surface artifact density fall-off. These will be drawn on the site map along with the location of all diagnostic artifacts (e.g., formal tools, rim sherds, etc.). The second sampling strategy is a grid-based approach that will utilize systematically placed 1 by 1 meter Surface Transect Units (STU's) to probabilistically sample the artifact density and assemblage characteristics across each site. Finally, discretionary Purpose-Oriented Units (POU's) of varying size may also be employed to sample special areas of sites (e.g., near surface architecture). All surface artifacts within both STU's and POU's will be

counted, described, and measured with the aid of customized field forms. Description of lithic materials will follow methods outlined by Andrefsky (1998), and will include raw material characterization, color, flake or tool type, maximum length along the line perpendicular to the striking platform, maximum width parallel to the striking platform, maximum thickness, and percentage cortical area. Pottery fragments will be described in terms of Munsell color, temper, quality, and decoration, maximum length, maximum width, and maximum thickness. All diagnostic artifacts from each site—as well as all retouched lithics from STUs and POUs—will be photographed at very high resolution on a scaled whiteboard which will allow additional quantitative measurements to be taken in the lab using software such as ImageJ (Abramoff, Magalhaes, and Ram 2004).

Not only do these sampling methods facilitate understanding of emerging patterns in the field, but, because no artifacts will be collected, they also greatly simplify the process of obtaining permits from the Jordanian Department of Antiquities. Moreover, they will reduce the overall cost of the proposed fieldwork by eliminating fees associated with curation and shipping of collected artifacts, leaving more funds available for crucial but expensive post fieldwork analyses such as OSL dating. In addition, because some of these sites may be very shallow and thus easily disturbed, leaving artifacts *in situ* will preserve the integrity of site contexts for future archaeological work.

Field Mapping: Older surveys in the area only provide schematic sketches of architecture at recorded sites, and little or no information regarding artifact distributions or geomorphologic contexts. Therefore, a major part of the proposed research will be to create detailed and spatially accurate site plan maps. These maps will be drawn in reference to a centrally located site datum using a tape and compass, and will include the site boundaries, surface architecture, artifact densities, the locations of diagnostic artifacts, the location of the SGUs and STUs, and basic topographic information. They will serve as the primary spatial record for each site. I will also create detailed geomorphologic maps of landforms in site vicinities from which sediment samples are taken. These maps will help to identify the extent and shape of surviving early Holocene landforms as well as any subsequent landscape changes in site vicinities. All maps created by the project will be digitized in a GIS, and used as a basis for analyses of site structure , intra-site spatial analyses, and, when used in conjunction with existing topographic data (DEM's), will help aid interpretations of site formation processes.

Landscape Formation History: A new Department of Antiquity policy forbids subsurface archaeological testing under a survey permit, and restricts investigations to only one site under an excavation permit. Thus, excavation or coring to recover sediment or dating samples from multiple sites

is no longer possible in Jordan. However, a survey permit does allow for offsite geologic samples to be collected, including OSL and ^{14}C samples obtained from natural cutbanks into landforms on which sites are located. Therefore, this project will devote significant effort to creating a landscape formation history of the Wadi tied to calendar dates by OSL and ^{14}C age estimates of alluvial terrace sets. Terraces sets will initially be correlated at a large scale using stereo imagery and digital elevation models following the chronology proposed by Schuldenrien (2007). This rough terrace sequence will be field checked in the upper, middle, and lower reaches of the Wadi Hasa drainage, where detailed geomorphic maps will be made in the field, and specific terraces will be sampled for age estimation. Once the terrace sequences is well established, sites located on landforms of known age will be used to create a correlation matrix of sites to landscape formation intervals. While this method cannot be used to definitively date specific sites, it will provided a series of maximum and minimum age range estimates for sites that share particular geomorphologic attributes. In fact OSL and ^{14}C age estimates usually come from materials stratigraphically associated with prehistoric structures and artifacts—not these materials themselves. Here, such a landscape history is needed in any case.

Post-Fieldwork Analysis

Chronological framework: Chronological control is a major issue for archaeological survey research. Most surveys in the region have been done by researchers interested in either Bronze Age, Iron Age, and Classical sites (e.g., MacDonald 2007, MacDonald, Banning, and Pavlish 1998, Smith 2007), or Paleolithic and Epi-Paleolithic sites (e.g., Clark, Majchrowicz, and Coinman 1998, Clark et al. 1992). Sites lacking significant architecture or large amounts of artifacts that did not fall clearly into these time ranges were assigned dates on the basis of the presence of a few lithic and/or pottery "type fossils", and were only dated to very broad time ranges. Lithic typologies for the Early Prehistoric periods of the southern Levant are better developed than those for the Late Prehistoric periods. This is because Late Prehistoric chronologies are more reliant on pottery than on stone tools, and those stone tool types that are typical of specific Late Prehistoric periods (Late Neolithic, Chalcolithic, and Early Bronze I) are also found in the other Late Prehistoric periods (i.e., certain types of sickle blades, tabular scrapers). This is problematic for Late Prehistoric archaeology in the desert regions, as many of the Late Prehistoric assemblages from sites in the region contain little or no pottery. Consequently, these sites have been either dated only loosely, or have been left un-dated.

I will re-assess the dates for these sites with a three-pronged approach. First, in order to match the new findings with older survey data, I will attempt to refine the lithic chronology using the

traditional "type fossil" approach. I will examine collections from excavated sites in the region that have been radiometrically dated to the time periods in question to determine a suite of chronologically sensitive artifact forms that are specific to desert assemblages. Second, I will apply an alternative "whole assemblage" approach, which will use frequencies of artifact types and aggregate analysis of chipped stone rather than simple presence or absence of certain types. This approach may allow finer temporal divisions as there may be changes in the proportion of certain indicator types that are very long-lived (e.g., tabular scrapers). Any fluctuations in type proportions in assemblages may actually represent functional shifts in economic activities, rather than (or in addition to) stylistic changes, so this approach will be used with caution. Finally, in order to securely tie the relative dating framework to calendar years, funding will be requested to process OSL and ^{14}C dates on river terrace sediments associated with Late Prehistoric sites. OSL, which dates the last time quartz or feldspar crystals were exposed to light, is appropriate to this project because it dates the sediments directly, and thus does not require preserved organic materials. OSL dating is complimentary to ^{14}C methods as OSL needs no calibration, and thus may be more reliable for material that was deposited during time periods where the ^{14}C calibration curve for the region is extremely complex, and radiocarbon dates have large uncertainties.

Comment [IITU3]: citation? eg. so and so

Lithic Analyses: In addition to chronological data, Lithic analyses will provide information about economic and mobility strategies at each site. I will use a combination of traditional analytical procedures as well as some new techniques. Specifically, I will reconstruct Late Prehistoric economies in the region by examining proportions of tools strongly correlated with pastoralism, foraging, or farming. This study provides a unique opportunity to delineate more clearly the characteristics of artifact assemblages of ancient pastoralists, facilitating future archaeological research on ancient pastoralism. For example, recent research indicates that burin spalls from concave truncation burins and certain types of tabular scrapers are potential indicator tool types associated with prehistoric pastoralism (Betts 2008, Quintero, Wilke, and Rollefson 2004), and the proposed research should add to this list.

In situ photography of lithic material will facilitate advanced computer analysis of artifact form while leaving sites intact for future research. Robust open-source software such as ImageJ (Abramoff, Magalhaes, and Ram 2004) and GRASS GIS (GRASS Development Team 2009) will be used to convert scaled photographs of tools into measurable vector outlines (Figure 3). Once vectorized, artifact shapes will be studied using PAST (Hammer and Harper 2004), an open source statistical software package that implements a combination of image analysis and morphometric techniques collectively referred to as Landmark Analysis (LA [Rohr 2001]). In LA, tool shapes are entered as a series of X/Y coordinate pairs

(vector format), and are then simplified and standardized with techniques such as Elliptical Fourier Transformation (Ferson, Rohlf, and Koehn 1985), Eigenshape Transformation (MacLeod 1999), or Procrustes Transformation (Dryden and Mardia 1998) which redefine the shapes as a series of scale-independent landmarks. These landmarks are then input into automated clustering techniques such as K-means Cluster Analysis (Duta, Sonka, and Jain 1999) and Shape Principle Components Analysis (Dryden and Mardia 1998). This procedure allows artifacts to be clustered into types based on shape alone. Variations of tool shape within types will then be analyzed with Thin Plate Spline techniques (MacLeod 1999), which identify, quantify, and compare divergences in the shape of each artifact from the average shape of the entire type. LA will not only allow for a more detailed and nuanced understanding of lithic assemblages than do other types of metric analyses, but should also help to reduce errors due to observer bias, analyst fatigue, and measurement mistakes by replacing traditional measurement and classification techniques with automated alternatives.

Mobility patterns will be studied by comparing the frequency of retouched pieces to the total surface density of all lithic artifacts. Originally developed for Paleolithic cave deposits (Riel-Salvatore and Barton 2004), and later adapted for surface scatters (Barton 1998, Miller and Barton 2007) this method assumes that the frequency of retouched tools in lithic assemblages is proportional to the length of time over which individual tools are curated. Highly mobile foragers are less likely to stockpile raw material than logistically organized ones, and therefore are more likely to curate tools for longer periods of time before discarding them. This logic applies equally well to mobile pastoralists, making this an appropriate technique for this project (but see Close [1996]). Finally, retouched pieces can be easily detected through visual inspection of artifact photographs, and it may even be possible to automate detection using the Thin Plate Spline techniques described above.

Past economic and mobility patterns will be further investigated using the ratio of extant to original cortex area in lithic assemblages. First proposed by Dibble et al. (2005), and modified by Douglas et al. (2008), this method compares the combined cortical surface area present in a lithic assemblage to the total original surface area of the toolstone nodules required to produce the assemblage, as estimated by the total volume of lithic materials in the assemblage divided by the number of cores. If the ratio of extant to original cortex area is less than one, then some material has left the system (i.e., has been curated and transported away, traded out, or lost off-site), whereas if the cortex ratio is greater than one, then lithic material has been imported into the system (i.e., has been brought or traded in, and then discarded on-site). A ratio of one indicates that no material has entered or left the system. Here again, the assumption is

that highly mobile societies will tend to curate items longer, and so the sites of mobile pastoralists should exhibit cortex ratios lower than one. While there are some important methodological issues to be resolved with this method (e.g., controlling for effects of natural site formation processes on surface assemblages), it provides an independent investigatory avenue into ancient mobility and economy that should complement the information gained by retouch frequency analysis. This method will work well with the LA techniques described above to measure the amount of cortex on individual lithics and to estimate the volume of artifacts by multiplying the surface area derived from the vector outline with the maximum artifact thickness measurement taken in the field.

Architectural Analysis: There are many sources of ethnoarchaeological information related to pastoral architecture (e.g., Banning and Köhler-Rollefson 1992, Bienkowski and Chlebik 1991, Cribb 1991b, Eldar, Nir, and Nahlieli 1992, Johnson 1983, Lancaster and Lancaster 1991, Simms 1988); I will draw on these to create ethnoarchaeological models to help interpret the visible extant architecture at these sites. The major hypotheses of such models relate to mobility and economy, and it is important to combine these two variables when attempting to distinguish the architectural remains of pastoralists from those of mobile foragers or the temporary structures of seasonal horticulturalists. Specific architectural evidence related to pastoralism includes temporary or removable constructions related to animal penning and/or processing of pastoral products (Hole 1979). Animal pens may be identified by shape, as they tend to be circular. They can be larger than a normal dwelling size, but some can be rather small (for separating lambs and kids) (Cribb 1991a). There may be isolated rock platforms associated with storing of milk or yogurt in skin bags (Simms 1988) or "cairns" used as territory markers and storage structures (Simms and Russell 1996). The large rock alignments known as "Desert Kites" and "Jellyfish" have also been associated with gazelle hunting by ancient hunter/herders (Betts 2008). Although rock art dating is particularly problematic, some images have been associated with prehistoric pastoralism (Betts 2001), and may provide useful contextual data if they can be shown to be associated with a site.

Computing and GIS: I will utilize a variety of data management and analysis techniques in this endeavor. Once data are processed for the sites recorded during the new field work, they will be incorporated into a larger database of archaeological data from all known Late Prehistoric sites in the region. This informational database will be linked to spatial information in a GIS to create a geodatabase that will allow multidimensional cross tabulation of social, economic, spatial, and environmental variables. In this way, the research will utilize the computational advantage of current GIS software programs, such as GRASS (GRASS Development Team 2009), to analyze the large quantity of data

pertaining to the origins and early development of pastoralism in way that was not heretofore possible. Coupled human landuse and surface process models created by the MLDP in GRASS GIS (Barton, Ullah, and Mitasova n.d.) will also be used to assess the impact of ancient pastoralist landuse patterns on the Middle Holocene environment of Wadi Hasa.

Model Testing

This phase of the project will analyze the data produced in the preliminary and field work phases to explore the origin of mobile pastoralism in the arid regions of southern Jordan. Currently, there are three loosely organized schools of thought regarding this question. I have organized these ideas into three scenarios—the Agropastal Split Model (ASM), Shifting Strategies Model (SSM), and Mobile Forager Transition Model (MFTM). I use ethnoarchaeological data from extant pastoral peoples (Table 1, Appendix A, [Ullah n.d.]) to derive test implications for each scenario. La Bianca (1990) presented a similar tripartite division with his idea of high, medium, and low intensity food systems, but his models were designed specifically to examine changing pastoral strategies in the Late Bronze and Iron Ages, focused exclusively on the hinterlands surrounding Tell Hesban on the Madaba plains, and were not concerned with the origins and early development of arid-land pastoralism.

The scenarios presented in the three models are not mutually exclusive, and it is probable that processes described in each occurred in different places and moments in time across West Asia. As Dever (1995: 295) points out, there has probably always been a "*continuum*—an almost infinite variety of interrelated adaptive responses on a theoretical scale from 'urban' to 'nomadic'". Constraining such variety into three discrete models creates a clear-cut heuristic framework that will help to focus the research.

The Agropastoral Split Model (ASM): Based on the pattern of faunal remains at 'Ain Ghazal, Köhler-Rollefson (1992) proposed a model for the origin of mobile pastoralism in the area. In this scenario, the distance from agricultural fields in which sheep and goat herds were pastured increased as degradation of the landscape near the site increased. Eventually, the distance of the annual movement of the herds became so great that a specialized component of the 'Ain Ghazal community became full-time pastoralists. Quintero et al. (2004) expand this scenario with evidence from Neolithic pastoral sites near the Azraq oasis in eastern Jordan to suggest a material connection between these desert pastoral sites and highland towns such as 'Ain Ghazal. This scenario is similar to aspects 1 and 2 of Lees and Bates' (1974: 189) analysis of the origins of specialized pastoralism, models proposed by Garrard et al. (1996) and Levy

(1983, 1992) for different parts of the Levant, and the model proposed by Hole et al. (1969) for the Deh Luran region of Iran. All basically follow the same logic: mobile pastoralism co-evolved with farming, and pastoralists—initially ethnically and socially identical with the farmers from whom they fissioned—would likely remain culturally similar as long as the two groups continued to interact.

The main components of the ASM scenario are:

1. Interaction and exchange between the agricultural heartland and the pastoral margins is frequent and regular, resulting in many shared aspects of material culture in the two areas.
2. Pastoral peoples rely on exchange of pastoral products for agricultural products from farmers for a significant portion of their subsistence base.
3. Pastoralists most likely spend hot summer months amongst the agriculturalists of the highland plateaus, moving to desert areas in the fall and winter to take advantage of ephemeral pastures.
4. Pastoralists will be semi-sedentary/logistically-mobile in summers but will have high residential mobility in the winters.

The test implications of the ASM are:

1. Similar stone tool types and pottery styles between desert and highland sites.
2. Retouch frequencies and cortex ratios at sites will indicate high curation rates for campsites in the desert, but will indicate low curation rates for campsites in the agricultural areas.
3. Desert sites should have some stone tools made on raw material that sources to the agricultural areas.
4. Settlement pattern will be "tethered" to the agricultural core, and sites should radiate from there out into the desert with evidence of increasing residentially mobility in arid areas (Figure 4).
5. There will be site furniture related to grain storage and processing (e.g., bins, pits, storage vessels, granaries, small rock platforms, or grinding implements).
6. Architecture at all sites will be related mainly to dwelling and herding, but the architecture at sites in or near the agricultural areas should be more robust than that of desert sites and show evidence for repeated seasonal occupation over long periods of time.

The Shifting Strategy Model (SSM): Another hypothesis, first proposed by Barth (1961), and derived from his work with the Baseri of Iran, suggests that mobile pastoralism is one phase of a subsistence strategy where people shift their subsistence emphasis toward or away from agriculture as

conditions for farming improve or decline (Barth 1961, Barth 1973). The SSM corresponds with aspect 3 of the Lees and Bates (1974: 189) model. La Bianca (1990) and Hill (2006) respectively develop similar scenarios for the Transjordan Plateau and Wadi Hasa, suggesting that people in the region have always oscillated between agriculture and pastoralism depending upon prevailing conditions. Dever (1995) notes that the high degree of environmental variability in the Judean Hills predisposed Early Bronze Age pastoralism in the area to function this way, and this may have also been true in the Late Neolithic and Chalcolithic. In all of these scenarios mobile pastoralists and sedentary farmers in a given area are the same people, and are therefore ethnically and socially identical.

A similar approach was also applied to the case of San foragers in south east Africa, who also shift to and from cattle pastoralism (Solway and Lee 1990). A more complete model was developed by Layton et al. (1991), in which groups often switch between hunting, herding, or farming as a response to changing environmental, economic, and social conditions. More important for the case of the origins of mobile pastoralism in the Levant, both Solway and Lee (1990) and Layton et al. (1991) point to case studies where the combination of decreased productivity of high-ranked hunted-and-gathered resources and increasing contact with neighboring agropastoralists induced foragers to become mobile pastoralists. Byrd (1992), Martin (1999), and Betts (2008) apply a variant of this scenario to the development of pastoralism in the North Arabian deserts, where they believe that once domestic sheep (and eventually goats) were introduced into the region, local populations of gazelle hunters adopted sheep and goat herding into their seasonal movements to become herder-hunters. In these cases, the mobile pastoralists and the hunter-gatherers are ethnically and socially the same.

The main components for the SSM are as follows:

1. Pastoralists, farmers, and/or foragers are part of the same cultural or social group.
2. Subsistence strategies are constantly adjusted through time.
3. Sites will be in locations that are good for both agriculture and pastoralism or both foraging and pastoralism.
4. Mobility patterns change through time and vary with economic strategy.

Test implications for the SSM are as follows:

1. Stylistic aspects of the material culture of contemporary pastoralists, farmers, and/or foragers should be basically identical.

2. Alternating frequencies in technology related to pastoralism, horticulture, and foraging at different sites that otherwise share similar material culture.
3. Retouched tool frequencies and cortex ratios will indicate minimal curation of lithic tools at all sites.
4. Most stone tools will be made on local raw material.
5. Variation in settlement patterns over time and space from fairly sedentary to logistically mobile (Figure 4)
6. Architectural analyses will show evidence of multiple occupational phases at sites, and changing frequencies of architecture related to pastoralism between adjacent sites and over time.

The Mobile Forager Transition Model (MFTM): Using a strictly ecological approach, Alvard and Kuznar (2001) argue that mobile pastoralism was taken up by mobile foragers who were already intimately dependent on the seasonal movement of the wild herds. These foragers managed risk by deferring the harvest of some of the herd animals by husbanding them until needed. Alvard and Kuznar's calculations are for meat-consumption only, although this need not be a necessary condition. This view is complementary to those of Zeder and Hesse (2000) and Ingold (1980, 2000). The MFTM offers an alternative to the dual evolution of agriculture and pastoralism embodied in the ASM, but implies a more linear transition between hunting and herding than does the SSM. Instead it implies that early desert pastoralism was a local invention of a previous population of desert hunter-gatherers who were ethnically and socially distinct from the farmers of the highland plateaus. This scenario differs from the hunter-herder SSM variant in that the MFTM stipulates that herding gradually but permanently supplants hunting and gathering as the main subsistence activity.

The main components of the MFTM are as follows:

1. Pastoralists and farmers are culturally and socially distinct, and interaction between pastoralists and farmers is sporadic and infrequent.
2. Although pastoral foods dominate, wild resources will be more important than agricultural ones as a source of supplemental food.
3. Desert pastoralists derive from an earlier group of desert-adapted hunter-gatherers.
4. Pastoralists will be residentially mobile year-round, and pastoral mobility patterns might resemble previous game-hunting mobility patterns.

Test implications for the MFTM are as follows:

1. Significant stylistic differences in material culture from contemporaneous farmers, but stylistic similarities with antecedent desert foragers.
2. Relatively high proportions of hunting and wild plant processing equipment will characterize the assemblages of these sites (e.g., projectile points, small grinding or pounding implements).
3. Cortical indices and retouch proportions will indicate a fairly high degree of mobility.
4. Most stone tools at sites will be made on raw material from desert areas.
5. Most sites should be located in the desert, away from agricultural areas, and the settlement pattern will indicate that migration tracks drifted randomly over time resulting in a more "nomadic" signature, and (Figure 4)
6. Campsite architecture will be both simple and ephemeral, and show signs of long abandonment periods between infrequent reuse.
7. Architecture related to hunting and gathering, such as game traps like the "desert kites" might be associated with these sites.

Broader Impacts and Intellectual Merit

The proposed research should provide a needed examination of the pastoral component of Late Prehistoric food systems in the southern Levant. This little-studied subject could add new lines of evidence in support of hypotheses of ancient environmental impacts, demographic events, and landuse practices created from other sources of archaeological data. I expect that the origins of mobile pastoralism in the area were multi-factorial, and occurred differently at different times and places. A variety of environmental, social, and economic factors would have influenced early pastoralism, and the proposed research is designed to detect them. I also expect that certain types of pastoralism will affect the environment more strongly than others, and that the intensity and strategy of pastoral production would vary with diachronic and synchronic changes in the environment. This study addresses questions concerning pastoral origins, development, and long-term impacts, but it should also open new avenues of research. The data produced by the proposed fieldwork will expand the context of early food production to include arid lands. Ultimately, the research should provide a better understanding of how and why people adopt pastoralism as an alternative to farming or foraging.

The persistence of pastoral adaptations in environments considered inhospitable to other food production systems underscores the importance of pastoralism as a traditional mode of production. "Pastoralism in the New Millennium" (FAO 2001) highlights the issues facing modern pastoral peoples, and tries to determine the fate of pastoralism in the years to come, reviewing the economic, social, political, and environmental problems faced by some 20 million pastoral households of the modern world. Controversial issues include the impacts of rangeland degradation, aridification, forced re-settlement, political pressure, economic oppression, movement restrictions, and disease on pastoralists, as well as the effects of different types of pastoralism on vegetation, erosion, agriculture, and economics. These same processes also operated in the past. By taking a long-term perspective, the research proposed here can help to contextualize modern pastoralism—its breadth and scope in many different environments, political systems, economic systems, societies, and technologies—and to provide information that could help guide public policy when creating laws and regulations to govern pastoralism in arid and marginal lands and, both in the West and in the developing world. Aid organizations such as OxFam and Heifer International offer aid to developing nations through gifts of domestic animals to individuals and families. These gifts come with stipulations, however, and the long-term effects of these are unknown. This study will assess the environmental impacts of pastoralismon a scale of centuries, and therefore could help clarify debates about the potential sustainability of pastoral production in different contexts in the modern world.

Tables and Figures

Production Activities	Consumption Profile	Material Culture	Amount of Mobility	Mobility Type	Distance of Yearly Movement	Permanence of Migration Routes
Heavily pastoral	Around half of all consumed foodstuffs obtained through exchange	Much of material culture obtained through exchange	High	Residential	Very far	Routes change frequently
Pastoralism and small scale horticulture	Produce almost all of what they consume	Manufacture most of their own material cultural items	Low	Logistic	Not far	Well defined permanent routes
Pastoralism and foraging	Produce or gather much of what is actually consumed	Manufacture much of their own material cultural items	Moderate	Residential	Moderate	Routes change frequently

Table 1: Relationships between aspects of economy, mobility, and material culture determined from a cross-cultural ethnographic investigation of recent pastoralists. Groups included in the study are detailed in Appendix A.

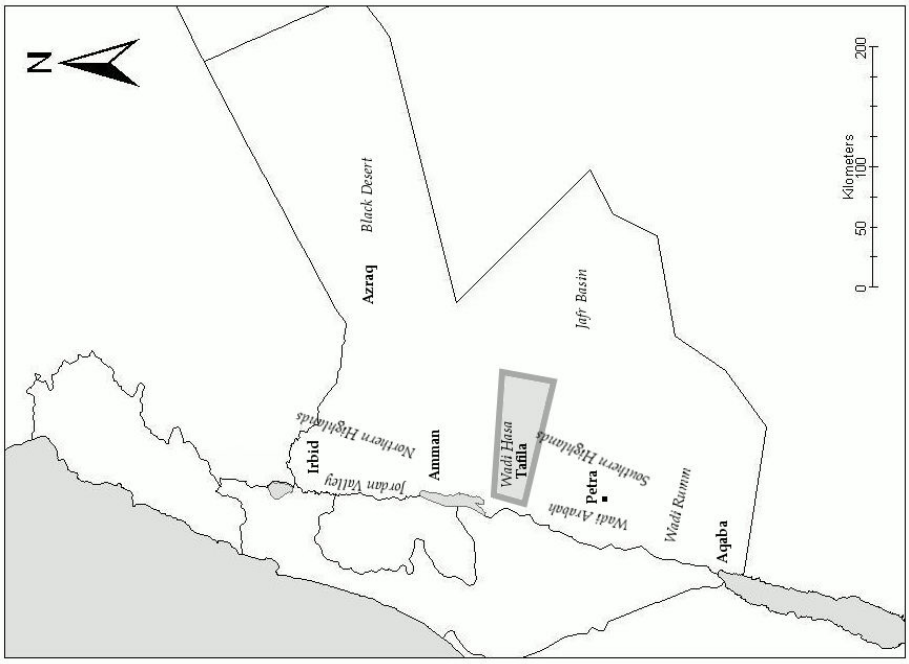

Figure 1: Map of the project area in southern Jordan.

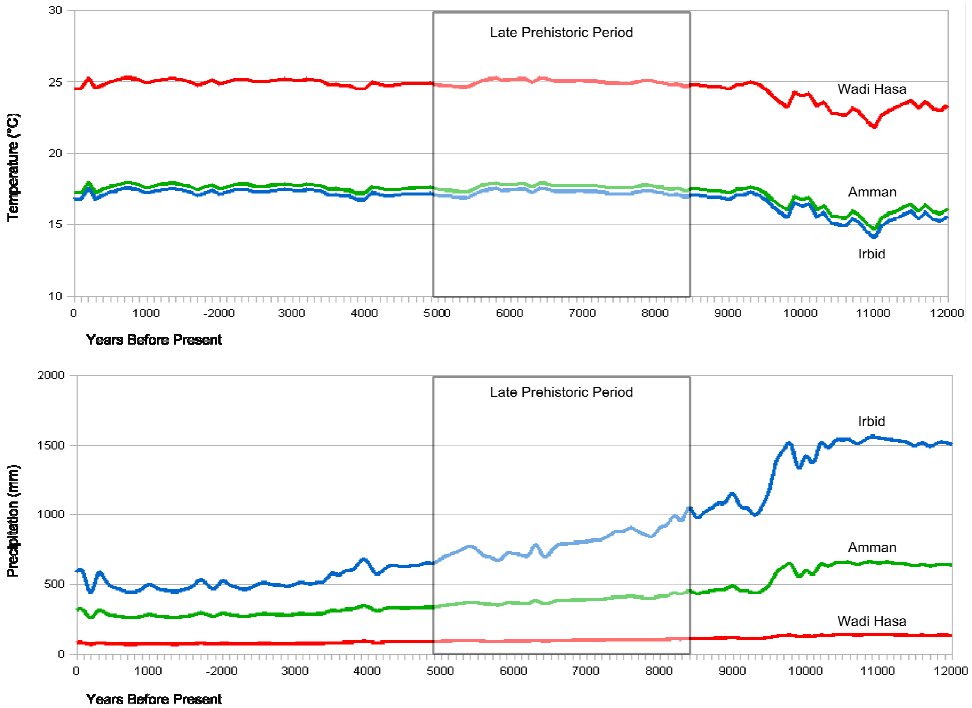

Figure 2: Holocene climate curves for three Jordanian locations based on results of the Archaeoclimatology Macrophysical Climate Model (Bryson and McEnaney-DeWall 2007).

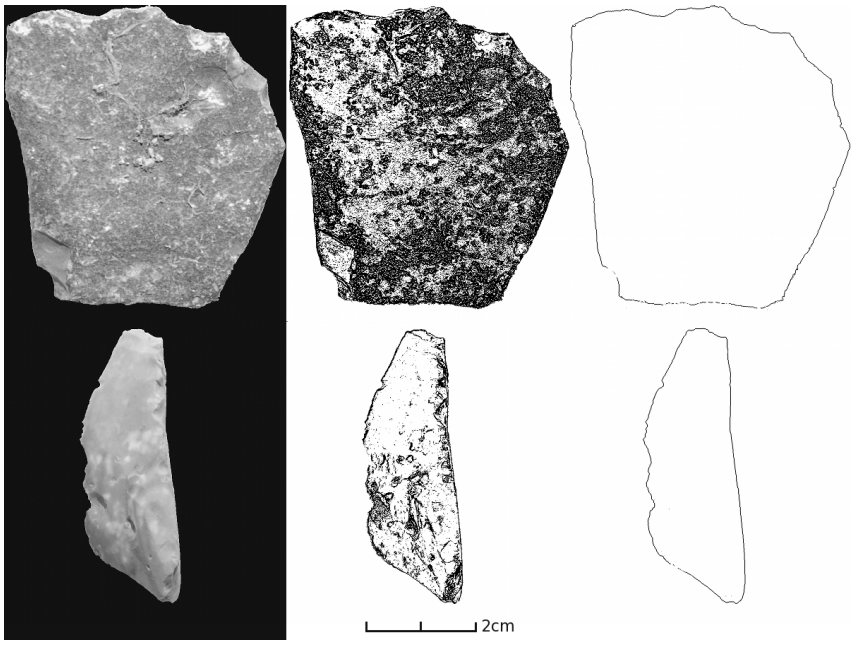

Figure 3: Process of deriving vector outlines of stone tools from high resolution photographs using multi-thresholding in ImageJ.

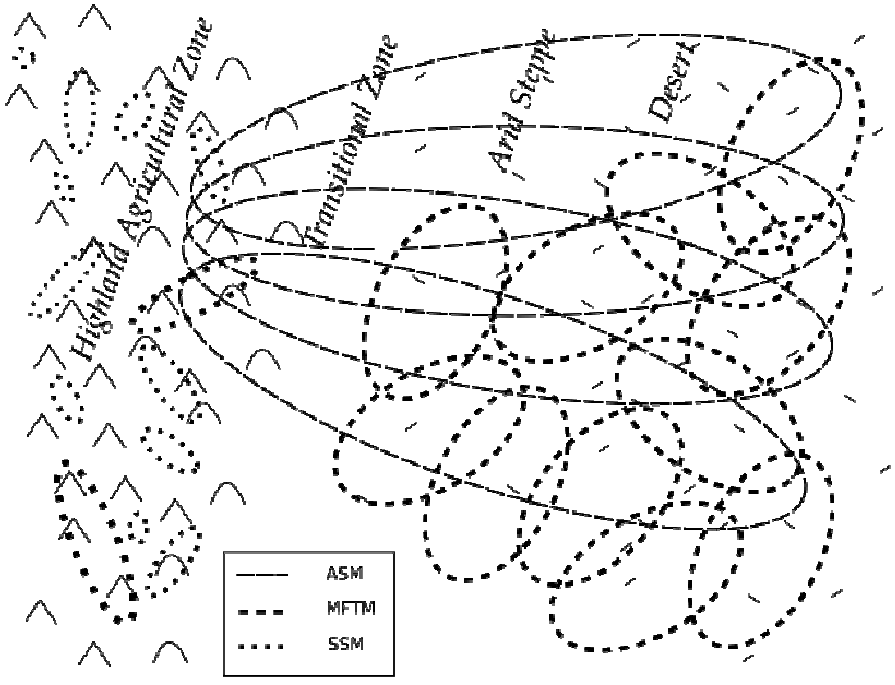

Figure 4: Schematic drawing of pastoral seasonal rounds associated with the three interpretive models of early pastoralism (the Agropastal Split Model (ASM), Shifting Strategies Model (SSM), and Mobile Forager Transition Model (MFTM)), indicating how these seasonal rounds would have interacted with geography.

Appendices

Appendix A: *Table of landuse data for the ethnographic and historic pastoral groups used in this study. Note that figures with question marks indicate that these data had to be approximated indirectly. The abbreviations listed in this table are the same abbreviations used in the figures.*

Group Name	Desert Al Murrah	Ruwalla	Rashayda 'Amarin	Kushman Mi'aza	Bedul 'Amarin	Lurs	Qashqa'i
Abreviation	DAM	RW	RA	KM	BA	L	Q
Production							
% Agriculture	0	0	28	10	45	60	35
% Pastoralism	90	90	65	70	55	35	60
% Hunting and Gathering	10	10	7	20	5	5	5
Consumption							
% Agricultural foods	40	40	50	45	60	70	60
% Pastoral foods	50	50	45	40	38	28	38
% Hunted and Gathered foods	10	10	5	15	2	2	2
% Food derived from trade/raids	45	45	35	40	20	10	20
% Material culture obtained by trade	90	90	70?	30?	30	20?	20?
Animals							
% Camels/Donkeys/ Horses	100	100	80	20	10	4	5
% Sheep/Goats	0	0	20	80	90	90	90
% Cattle/Oxen	0	0	0	0	0	6	5
Mobility							
% Sedentary	0	10	45	10	40	50	40
% Logistically Mobile	30	30	25	70	60	45	55
% Residentially Mobile	70	60	30	20	0	5	5
% Movements are tied year to year	50	50	70	70	95	90	90
Max km traveled one way in seasonal round	600	300	100?	100?	15	50?	150
General Climate	Hyperarid	Hyperarid	Arid	Arid	Arid	Temperate High Elevation	Temperate High Elevation

Group Name	Cyrenaicans	Tuareg	Turkana	Pastoral Fulani	Historic Xhosa	Historic Khoikohi
Abreviation	C	TG	TK	PF	HX	HK
Production						
% Agriculture	50	0	0	0	60	0
% Pastoralism	45	90	90	92	40	70?
% Hunting and Gathering	5	10	10	8	10	30?
Consumption						
% Agricultural foods	55	45	12	20	60	0
% Pastoral foods	43	45	78	75	40	70
% Hunted and Gathered foods	2	10	10	5	10	30
% Food derived from trade/raids	10	40	20	40?	0	20?
% Material culture obtained by trade	30?	80?	50?	50?	5?	5?
Animals						
% Camels/Donkeys/ Horses	10	85	10	5	0	0
% Sheep/Goats	85	10	75	15	10	50?
% Cattle/Oxen	5	5	15	80	90	50?
Mobility						
% Sedentary	50	0	0	0	80?	0
% Logistically Mobile	45	30	30	50	20?	40
% Residentially Mobile	5	70	70	50	0	60
% Movements are tied year to year	95	50	70	70	95?	50?
Max km traveled one way in seasonal round	200	200	200	200?	20?	200
General Climate	Mediterranean / Mediterranean Steppe	Hyperarid	Semiarid	Semiarid	Mediteranean	Mediterranean Steppe

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