Pastoralists and GIS in Beidha, Southern Jordan:

An Exploration in Methods and Applications for Predictive Modeling

Isaac I. T. Ullah

Submitted in partial fulfillment of the Masters of Arts Degree

University of Toronto

November 10, 2005September 1st, 2003

Abstract

This paper explores the methods and applications of predictive modeling of nomadic pastoral sites in Beidha, southern Jordan, within a GIS system. Specific model-building and testing techniques are discussed; and special consideration is given to the development of practical locational parameters for nomadic sites in southern Jordan. The process of building small-scale, highly detailed, 3-D spatial models within a GIS system from scanned topographic maps, satellite data, and survey reports is described. Model testing and refining procedures are discussed, and the final model is presented, and tested against other data with satisfactory results.

Table of Contents

Maps and Tables

"Years afterwards it is still possible to recognize an old camping place, *marh al-'arab*. The fireplace hollowed out in the men's compartment; the small piles of clay and ashes; the three scorched stones by the fireplace of the women's compartment; the piles of stones or fuel, upon which the beds were laid; …all this awakens memories in the mind of the solitary traveler."

—Alois Musil, 1928, p. 78

"I had been told that Diana Kirkbride, a noted English archaeologist, had established a "dig" on the far side of Petra, and I was anxious to visit her excavations. The approach to the cleft in the mountains led through a deep, pleasant *wádi* with a sprinkling of Bedouin tents on the slopes of the hills and flocks of goats grazing in the green pastures."

"Early the next day I set out with Mifleh. The narrow trail leading up from Petra to Beida can be negotiated only on foot, since horses and camels cannot pass through some of the narrow slits in the rock. It is about 5 kilometers to the top. There the remains of a stone-age village, probably of Neolithic time, led into deeper caves. There were marks of Bedouin fires along the walls, which might have been even later than the Nabateans."

—Edward Nevins and Theon Wright, 1969, p.287 and 295

Introduction

This study was developed as a response to some of the perceived gaps in the application of theory to data in the study of the archaeological remains of nomadic pastoral groups in the Near East. Middle-range theory in the last few decades has made great strides in connecting High Theory with lowly archaeological data. However, many of these middle-range theories were pursued no further after their initial introduction, and consequentially the archaeological community has both ignored many middle-range theories and simply repeated over and over many others as "good things to do", without necessarily understanding why they were such good things. The result is that many very useful middle-range theories have stagnated and have not taken advantages of the phenomenal advances in technology or the increases in the corpus of archaeological data that have occurred since their inception. With the exception of a few dedicated researchers, most of the Near Eastern archaeological community has ignored this growing gap, and it has become painfully obvious that something needs to be done.

The archaeology of nomadic pastoralists is one of the research areas of Near Eastern archaeology that is most critically affected by these problems. As a consequence of the marginality of their work to mainstream Near Eastern archaeology, many of the researchers who were doing the best work in the area have moved on to other research topics. This paper is an attempt to carry the flame that they ignited into the new millennium.

This paper has a two-fold purpose: to build an empirically-based site-location model for Near Eastern nomadic pastoralists that does not ignore the cultural data gained from the few ethnoarchaeological studies that have been conducted with these groups, and to explore the process of implementing this type of model through the construction and interrogation of small-scale, highly detailed spatial models developed from maps and satellite data with advanced GIS systems. The data set used in this study comes from a highly detailed ethnoarchaeological and archaeological survey that Banning and Köhler-Rollefson conducted in the Beidha region of southern Jordan in 1982. This survey was the source of two important papers (Banning and Köhler-Rollefson 1986, 1992) and is especially suited to the development of this type of predictive modeling because of the tightness of the survey methodology and the varied terrain of the survey area. ESRI's ArcGIS 8.3 program suite provides the robust computing power and the high-precision tools needed for the development and analysis of the 3-D spatial model of the Beidha region and survey data.

Nomadic pastoralism defined

The concept of nomadism is one of the most oft-confused ideas used by archaeologists, especially in relation to pastoralism. The lack of a concise definition of nomadic pastoralism leads to many inconsistencies in the description of past and present pastoral groups. For example, why is one group classified as nomadic while another as sedentary, even though the former may move only in easily predictable seasonal rounds, while the latter may move once in a generation, but in a completely unpredictable manner? Other terms, such as transhumant, semi-nomadic, and semi-sedentary, coupled with the broad range of economies and social structures that can be associated with nomadism, confuse the issue even more. Khazanov (1994) writes that the term 'nomads' has historically been applied both to hunter-gatherers and to pastoralists. He believes that this has caused confusion because, while both are highly mobile, hunter-gatherers are governed by different conditions (i.e., not having to look after the needs of domesticated animals) and implement their "nomadism" in a very different way than do nomadic pastoralists. His definition of pastoral nomadism describes an economy of extensively mobile pastoralism in which the majority of the population follows the pastoral migrations. While this definition has the virtue of brevity, it needs some clarification. I define nomadic pastoralism as follows: 1) it is a generalized food-producing strategy withits main base relying on the intensive management of herd animals for their primary products of meat and skin, and for their secondary products such as wool or hair, milk, blood, dung, traction, and transport; 2) because of the different climates and environments of the areas where nomadic pastoralism is practiced and because of the ecology of their herd animals, this management includes daily movement and seasonal migration of herds; 3) because a majority of the members of the group are in some way directly involved with herd management, the household moves with these seasonal migrations; and 4) while the products of the herd animals are the most important resources, use of other resources, such as domesticated and wild plants, hunted animals, goods available in a market economy, is not excluded. Barfield's (1993) definition of nomadic pastoralism agrees with this, and its stipulations effectively exclude other intensive pastoralists, such as large-scale dairy farmers, who are not nomadic, and other nomadic groups, such as hunter-gatherers and gypsies, who are not pastoralists.

The significance of nomadic studies

Nomadic pastoralism is a unique subsistence pattern practiced by a significant number of people in the Near East, and has been important in the course of Near Eastern history. In spite of this, archaeological research on pastoralism is very scant when compared with the archaeological study of other subsistence patterns, especially that of hunter-gatherers, and it is therefore of the utmost necessity to bring pastoral archaeology up to speed. Also, the difficulties of pastoral archaeology are by themselves reasons for further study: *because* pastoralism is different from other subsistence patterns, and *because* it has unique characteristics and problems, new theories and models can be developed from its study. Finally, pastoralism's long history in the Near East makes the study of pastoral archaeology important to broader questions in Middle Eastern archaeology.

Since the advent of the New Achaeology in the 1960's, hunter-gathers have become a major focus of the archaeological and anthropological community (Bettinger 1991). Many major theoretical breakthroughs in archaeology and anthropology since then (e.g., cultural ecology, optimal foraging theory, sociobiology, culture-transmission theory) have been intimately tied to the study of hunter-gathers either because they were created using hunter-gather data or because they have been used effectively in hunter-gatherer research (Bettinger 1991). While research in pastoral archaeology and anthropology has also increased since the 1960's, it has not been as important to mainstream researchers, and therefore lacks a large body of collected knowledge like that belonging to hunter-gatherer archaeology. This is a great disadvantage for prehistorians interested in finding and understanding the archaeological remains of pastoralists.

Although there are many models for the location and interpretation of hunter-gatherer sites (c.f. Bettinger 1991), the basic difference in the subsistence patterns of hunter-gathers and pastoralists makes using models defined for hunter-gathers precarious for pastoralists. The location and interpretation of pastoral sites are necessarily different than those of hunter-gatherer sites, and must be based on entirely different data and models.

Pastoral sites do, however, share one trait with hunter gather sites: sites produced by both systems of adaptation can be relatively ephemeral, and therefore are often hard to see and identify in the archaeological record. This does not mean, however, that it is impossible to find pastoral sites. Hunter-gatherer sites are equally hard to find, yet literally thousands have been identified by archaeologists because there is a large body of knowledge about hunter gatherers that anticipates the location of their sites. This only underscores the importance of defining traits that can identify pastoral sites.

Recently, ethnoarchaeology has been used to address the lack of general knowledge about pastoral people (e.g., Chang and Koster 1986, Cribb 1991, Goldberg and Whitbread 1993, Köhler-Rollefson 1992, Simms 1988, Simms and Russell 1996). These studies use ethnographic data and scientific analysis of the remains of modern and recent pastoralists to create generalized models for interpretation of pastoralist archaeology. Studies like these are beginning to show that pastoral archaeology can be done, and that even though it shares some characteristics with the archaeology of sedentary peoples and hunter-gatherers, it is distinct from both (Rosen 1992).

Animal domestication in the Near East is about 10,000 years old, and nomadic pastoralism is about 6000 years old (Alvard and Kuznar 2001, Bar-Yosef 1996, Clutton-Brock

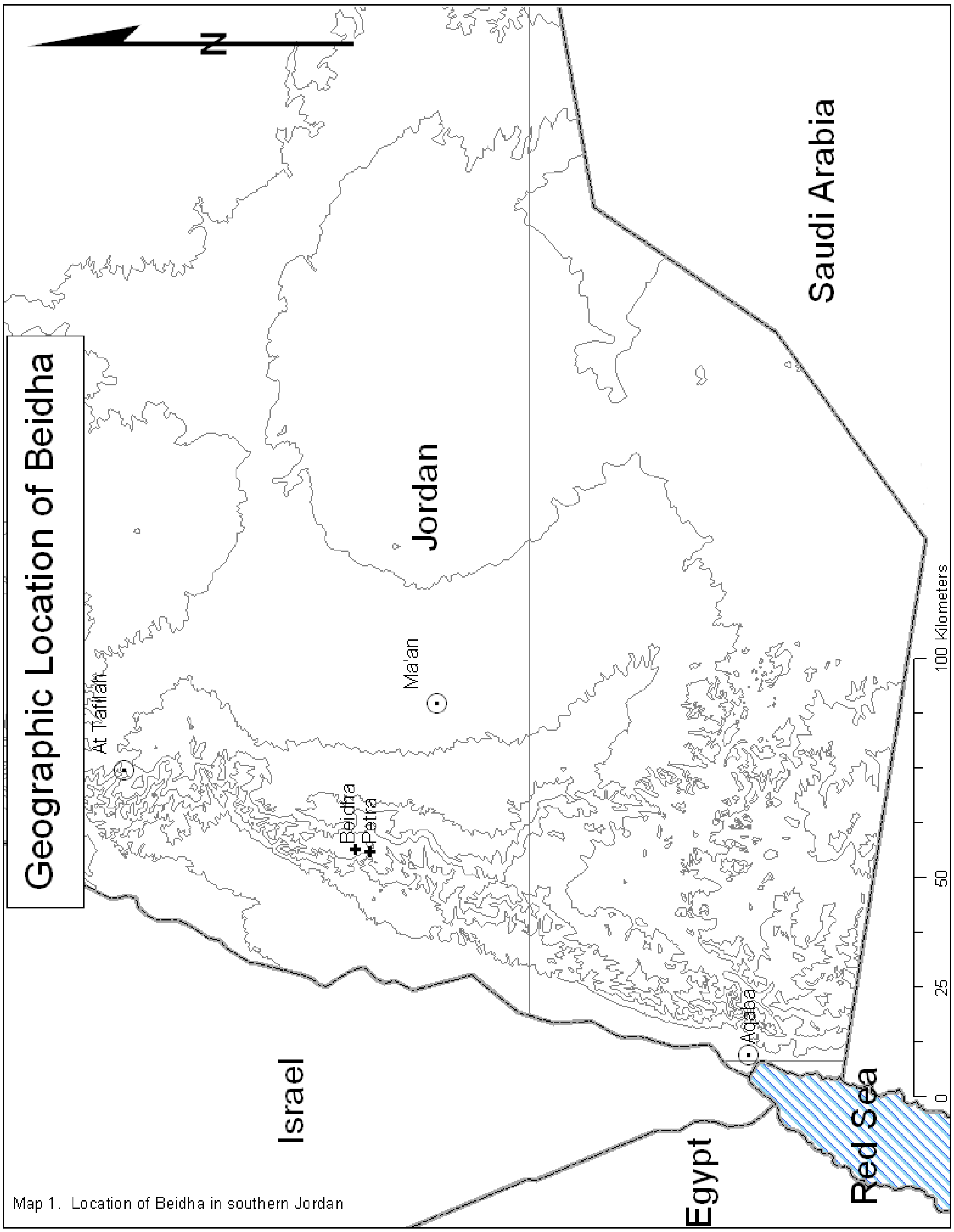
1999, Hole 1979, Hole 1989, Legge 1996, Levy 1983, Sherratt 1983, Simms and Russell 1996, Uerpmann 1989, Uerpmann 1996).This predates the first states and is concurrent with the beginning of agriculture in the area. Based on expectations discussed above, nomadic pastoralism cannot survive in a vacuum, and therefore must have been involved with the rise of agriculture and the first states. To fully understand the history and prehistory of the area, mainstream Near Eastern archaeologists need to study the archaeology of pastoralists in addition to the more traditional questions of Near Eastern archaeology.

The Study Area

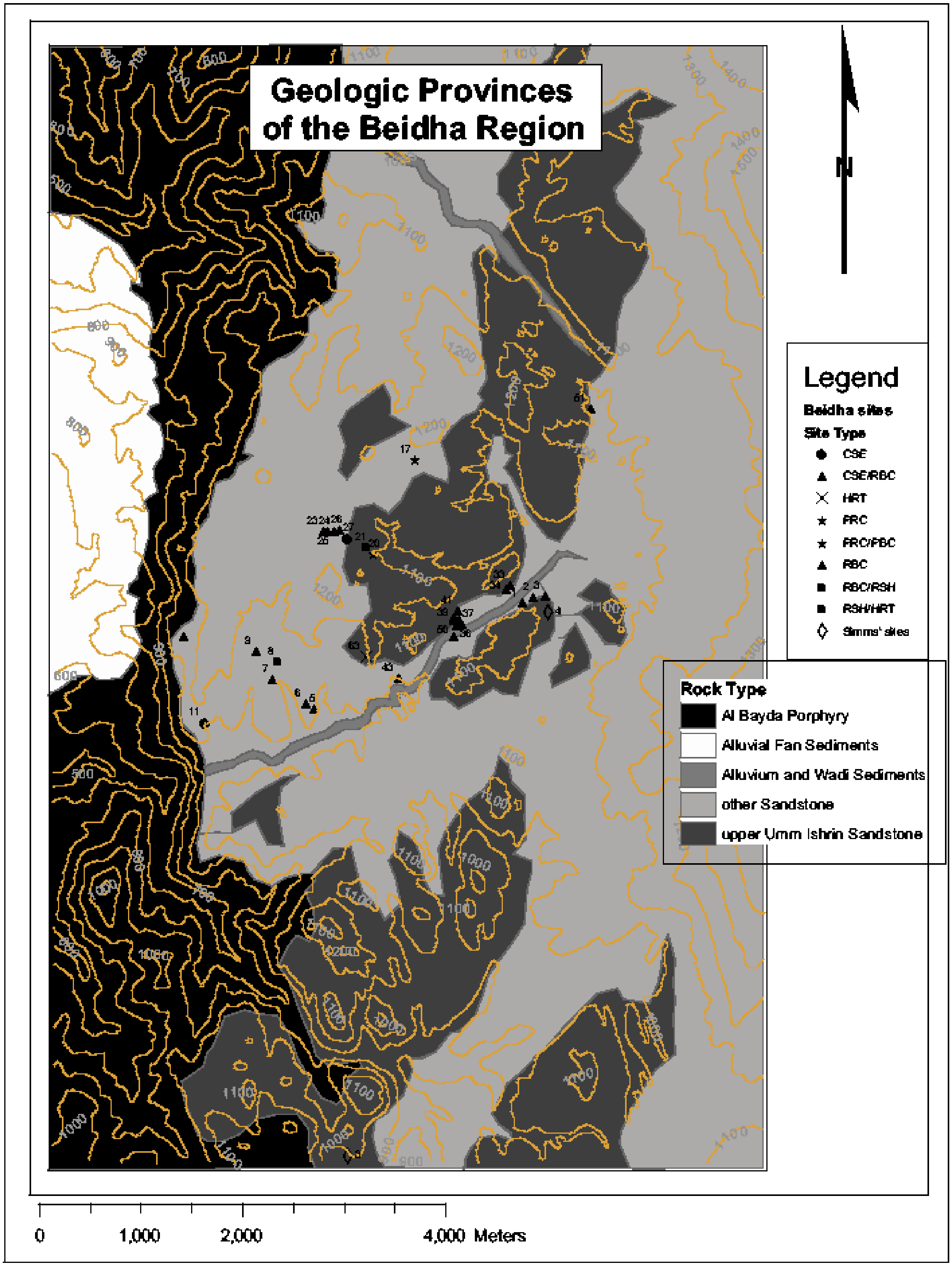
The geographic and environmental setting

Beidha is in southern Jordan about 4 km north of the famous rock-cut tombs and monuments of the ancient Nabatean city of Petra (Map 1.), and many Nabatean caves and features can be found throughout the Beidha region. Also, in the heart of the Beidha region where the Wadi Beidha meets the Wadi El Ghurab lies the Natufian/Neolithic site of Beidha, which was excavated by Kirkbride (1960, 1966, 1968) (See also, Byrd 1989).

The Beidha region lies on a narrow, Cambrian sandstone shelf that interrupts the generally steep decline from the limestone hills of the Jebel Shera'a and the Jordanian plateau in the east to the Wadi Araba basin in the west (Byrd 1989). Geologically, most of the Beidha region consists of this Cambrian, continentally formed, massive, brownish, weathered sandstone. The harder upper Umm Ishrin sandstone, the famous rose-red sandstone of Petra, however, is less friable than the surrounding sandstone and therefore weathers more slowly than the softer surrounding sandstone. This upper Cambrian sandstone trends generally north-south along the central axis of the shelf (Map 2) and forms rocky mesas with steep cliffs and deep, narrow canyons (German Geological Mission in Jordan 1968). The Bayda Porphyry, a granite massif that trends north-south, forms steep slopes that drop off drastically at the western edge of the sandstone, and numerous alluvial fans spread from its base into Wadi Araba (Royal Jordanian Geographic Centre 2000). The Wadi Beidha/Wadi El Ghurab drainage, which crosses the heart of the region, and the Siq Umm al-Hiran/Wadi Badj drainage, which crosses the northern extremity of the area, are the two largest drainages in the area, both channeling runoff from many smaller tributary wadis to drain into Wadi Araba to the west. Both have relatively large valleys lined with sandy accumulations of alluvium and wadi sediments.



Map 1. Location of Beidha in southern Jordan


Geologic Provinces
of the Beidha Region
Legend
Beidha sites
Site Type
CSE
CSE/RBC
HRT
FRC
FRC/FBC
RBC
RBC/RSH
RSH/HRT
Simms' sites
Rock Type
Al Bayda Porphyry
Alluvial Fan Sediments
Alluvium and Wadi Sediments
other Sandstone
upper Umm Ishrin Sandstone
N
0
1,000
2,000
4,000 Meters

Map 2. The major geologic provinces of Beidha

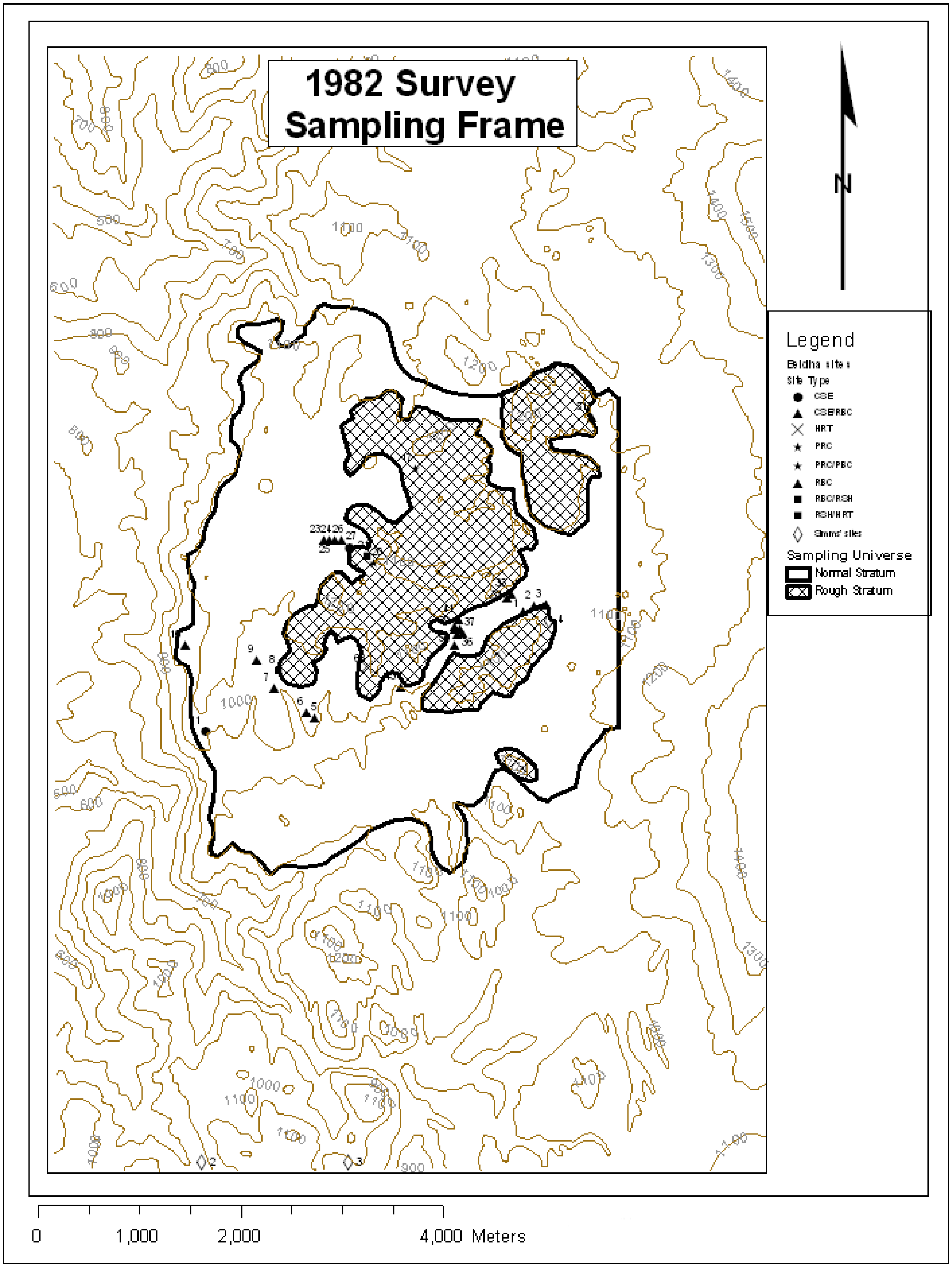
Rainfall varies substantially, but averages around 200 mm annually, and falls almost exclusively between the months of December and March (Banning and Köhler-Rollefson 1992). Banning and Köhler-Rollefson also report that just a few kilometers to the west, the average annual precipitation is only 50 mm, and that just to the east, the average is about 300 mm. In addition, they identify the prevalent wind as being from the West.

The vegetative communities

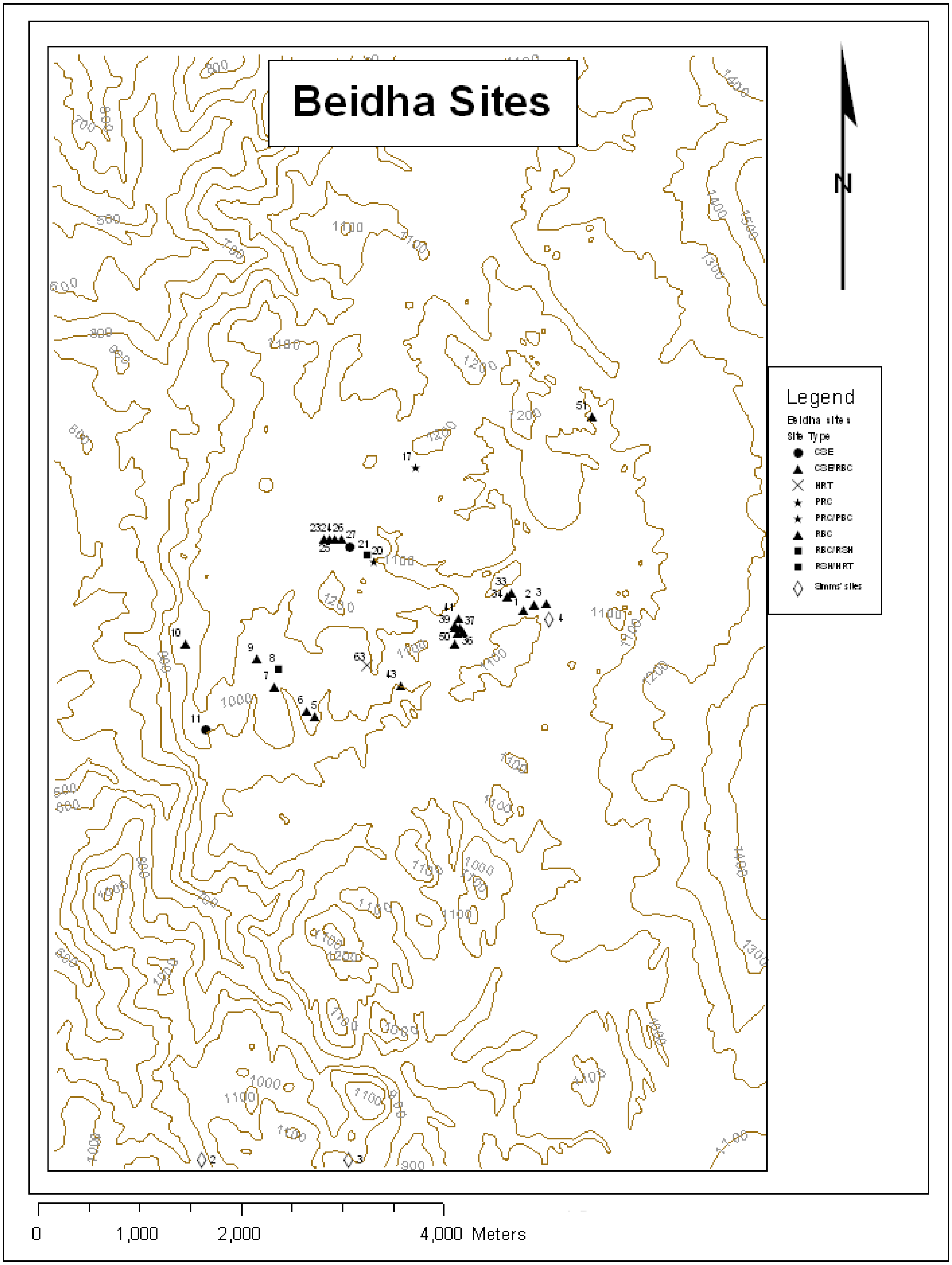
Although the modern vegetative communities have been drastically degraded (Byrd 1989), Zohary (1962, 1973) describes the flora and its geological affiliations. Zohary writes that the Beidha region falls mainly within the Mediterranean vegetative zone, characterized by evergreen maquis and forest, but also includes some Irano-Turanian vegetation, characterized by dwarf steppic shrubs, mainly wormwoods (*Artimesitalia herbae-albae*) and other sages, especially in the granite slopes to the west and the large alluvial valleys. Oak (*Quercus calliprinos*) and Juniper (*Juniperus Phoenicia*) occur in low densities on the mesa tops and in the small wadis that drain them. Pistachios (*Piatacia palaestina*) and Acacias (*Acacia sp.*) also occur in these smaller wadis. Banning and Köhler-Rollefson (1992) also identified white broom (*Retama raetum*), *Achillea fragrantissima, Urginea maritime,* and *Lonicera etrusca* in the lower sandstone areas. Carob trees also occur sparsely in the canyons.

The pastoral groups and the 1982 survey

The Beidha region is home to two groups of modern pastoral people. The ‘Ammarin are an ‘ashirah (tribal subsection) of the Huwaytât Bedouin tribe and occupy Beidha and the Faynan to the north (Banning and Köhler-Rollefson 1992). The Bedul are a very small tribe whose origins and affiliations are


1982 Survey
Sampling Frame
N
Legend
Sampling Universe
Normal Stratum
Rough Stratum
0
1,000
2,000
4,000 Meters

Map 3. The 1982 survey sampling frame.



Map 4. The nomadic sites in Beidha.

somewhat of a mystery, and who occupy mainly the Petra region but also overlap slightly with the ‘Ammarin territory in Beidha (Simms and Russell 1996). Some of the ‘Ammarin and Bedul practice traditional, Bedouin-style “Black Tent” nomadism, albeit with rather constricted migrations, but most practice a peculiar type of transhumance, spending the winter in modified ancient Nabetean caves and rock-cut rooms of the narrow canyons, and sometimes practicing limited dry-land horticulture (Banning and Köhler-Rollefson 1992, Bienkowski 1985, Simms and Russell 1996). In the summer, they abandon these protected caves for more breezy higher ground. Together, these two groups practice an amazing variety of pastoral strategies and everything from fully sedentary agriculture to highly mobile pastoralism can be witnessed in the area. Consequentially, Beidha is extremely rich in abandoned campsites.

Banning and Köhler-Rollefson (1986) cite this attribute, coupled with Beidha’s accessibility and its easily delimited boundaries, for what made the area ideal for their ethnoarchaeological survey. Map 3 shows their sampling frame for the 1982 survey. The Beidha region was split into “lowland” and “rough” strata loosely based on the limits of the upper Umm Ishrin sandstone. A series of six randomly sampled points in the lowland stratum and four in the rough stratum were generated, and every visible archaeological site within 100 meters of each sampling point was recorded (Banning and Köhler-Rollefson 1986, 1992). These sites were described, sketched, and plotted on the 1:50,000 scale map (Army Mapping Service 1962) of the Petra region. Various measurements, including soil samples, gradient, distance to nearest permanent water, and distances to nearest hilltops were also recorded and later analyzed as possible factors for site-location choice. The analysis of these measurements is presented in Banning and Köhler-Rollefson’s 1992 paper, and they are not included in this study. Banning and Köhler-Rollefson conclude, however, that because these data were collected from cluster samples, they suffer from the effects of spatial autocorrelation, and their conclusions may not show actual affiliations of the site locations to the variables. Presumably, this effect may also color the results of this study.

Banning and Köhler-Rollefson recorded many Nabatean and Roman/Byzantine sites as well as pastoral sites, but only the pastoral sites were entered into the spatial model. These sites (Map 4) were divided into five types: Recent Bedouin Camps (RBC), Circular Stone Enclosures (CSE), Probable Roman/Byzantine Camps (PRC/PRB), Hearths (HRT), and Rockshelters (RSH). In addition, Map 4 shows the location of three of the RBC's recorded from1986-1988 by Simms and Russell (1996) that overlap into Beidha. Only the 1982 RBC's are used in the development of the main model, and the Simms RBC's, the CSE's and the PRC/PBC's are used as independent test samples. The HRT's and RSH's are not included in the study, but appear on the map.

Methods

Introduction to predictive modeling

Predictive modeling is an important archaeological tool that allows archaeologists to make survey and research decisions before heading into the field. It has been used to reduce overhead by various state agencies, private CRM firms, and by scholarly archaeologists for several decades. Predictive modeling does more than just reduce the cost, time, and effort of fieldwork, however. Because predictive modeling is rooted in the idea that humans understand and interact with their surroundings, it can also inform the archaeologist about how the inhabitants of the sites they are studying might have regarded their environment.

Kohler and Parker (1986) define predictive modeling as a way of anticipating "at a minimum, the location of archaeological sites or materials in a region, based either on a sample of that region or on fundamental notions concerning human behavior". This definition distinguishes two types of predictive models, which Kohler and Parker (1986) term empiric correlative modeling and deductive modeling. These are referred to elsewhere as the "Inductive" and the "Deductive" approaches respectively (Kvamme 1990). Banning (2002) points out, however, that both methods are actually inductive in nature, the only difference being that the "Inductive" method derives the conditions of the model directly from archaeological patterns, while the "Deductive" constructs the model conditions based theoretical ideas or educated guesses about ecology the human nature. To avoid any more unnecessary confusion, I will use the terms "data-driven" and "theory-driven" for each of the methods respectively.

Many authors distinguish between the two methods and even extol the virtues of one over the other (e.g., Kohler and Parker 1986). Kohler and Parker believe that of the two methods, only the theory-driven approach can both predict site location and help archaeologists discover why people located activities and sites where they did. They believe the data-driven model can only locate sites, and only those types of sites included in the known sample; furthermore, they believe it can only be used effectively if there is already a sufficient sample size of known sites of the same type. Moreover, they say that only the theory-driven model can include social factors, which may play a large part in site-location (Rosen 1992), but which archaeologists rarely can identify (e.g., asthetics, religious/ceremonial customs, etc.).

In practice, however, there is no real reason for the separation of the two methods. It is virtually impossible to let a predictive model be entirely data-driven as the modeler would not know which archaeological patterns to look for, and these patterns could not be deciphered with out some middle-range theory to explain them. Likewise, all model assumptions in a theory-driven model must have been based on some real archaeological data with which the modeler had prior experience. This paper combines the most appropriate steps from both methods in order to account for the problems pointed out above.

Choosing site-location attributes

Because sheep and goats are the main herd animals of the Bedul and ‘Ammarin bedouin in the Beidha region (Banning and Köhler-Rollefson 1992, Simms and Russell 1996), many of the site-location factors included their choices of campsites are presumably derived from knowledge and assumptions of the ecological characteristics of a mixed sheep and goat herd. These ecological facts originate in the biological abilities of the animals but are product of those abilities and the physical qualities of the environment. Ethnographic data is also very important in the choice of model parameters as many pastoral groups have found various cultural methods of dealing with these constraints.

Water is an important parameter for any predictive model, but many of these cultural adaptations have to do with water management and consequently change the modeling conditions. An extreme example of such a cultural response are the water tankers that various modern Bedouin groups use (Kay 1978), but a similar adaptation is also apparent in the simple skin water bags and donkeys that many Bedouin groups use to haul water (Keohane 1994, Musil 1928). Also, point sources of water are extremely variable from season to season and year to year. Levy (1983) writes that most wadi beds contain shallow aquifers trapped in the gravel layers. He writes that modern Bedouin frequently dig shallow wells to exploit these water resources. Banning (1985) also describes this practice as do de Villiers and Hirtle (2002). Because of the extremely expedient nature of these wells, and their wide distribution over the landscape, it becomes functionally impossible to model radii around them as the zones of possible site-location, and, as Table1 illustrates, even if this were possible, these radii would demark areas too large to be of practical value. In illustration of this point, de Villiers and Hirtle describe their encounter with a young shepherdess at a well in Saharan Niger: “The young woman belonged to a family of nomads camping a mile or so away… When asked why they hadn’t camped closer to

Table 1. Ethnographic herding data for sheep and goat herds.

Author	Maximum distance covered while pasturing	Pasturing Schedule	Maximum camping distance from water	Days between watering
(Behnke 1980)	15 km	Pasture 2 days, return for water on 3rd	--	3 to 5
(Khazanov 1994)	--	--	--	4
(Janzen 1986)	--	--	--	2 to 4

(Dickson 1951)	--	--	.5 mi. in Winter, 30 mi. in Summer	--
(Swetnam 1999)	10 km	Pasture during the day, back at night	Over and hour's walk, uphill	1 to 2

the well, she shrugged. To walk a mile or two to the well with the goats helped fill the day" (de Villiers and Hirtle 2002, p. 92). Because of these problems, the distance to point sources of water is in fact the most imprecise factor to use in such a model, a fact that would not be readily apparent without ethnoarchaeological research.

Table 1 also shows that the distance to pasture is not an extremely limiting factor either. If, as the data show, distance to water and pasture are not suitable modeling parameters for nomadic pastoral site-location, what *can* we model? The reason that these two measures are always at the top of the list for use in predictive models is that they are both measurable and ecologically based. These qualities are especially attractive to processual archaeologists because they are based outside culture, and may thus be thought "universal". Predictive modeling does not have to be based on ecological data alone, however, and many cultural variables for site-location have durable physical referents that we can measure and model in exactly the same fashion as ecological ones.

A survey of the ethnographic, and, especially, of the ethnoarchaeological literature returns many possible cultural and ecological variables for site-location. Swetnam (1999) writes that his reconnaissance of Bedouin pastoral activities in Wadi Feinan just to the north of the Beidha region discovered that the herders place their sites with more respect for shelter from the wind than proximity to water or ease of access to pasture. This can be modeled by measuring the aspect of the hillside nearest each site to determine if the site is on the lee of the prevailing wind. He also writes that proximity to tents of neighboring relatives was also a significant factor in site-location decisions, with the distance between tents being not so great as to make visiting cumbersome, but not so close as to compromise each family's privacy. While some form of nearest-neighbor analysis seems the best way to model this condition, it would actually be misleading as the distance to the nearest tent is not as important as the line of sight between tents; and, because the 1982 survey utilized a cluster sampling technique, some of the nearest neighbors might be excluded from the sample. Counting the number of other tent sites within each site's viewshed, if the number of sampling points within the viewshed of each site is taken into account and corrected for, is a better way to model this condition.

Banning and Köhler-Rollefson (1992) take advantage of data gained from ethnoarchaeological surveys in both the Beidha region and in Wadi Ziqlab in northern Jordan to determine some of the other important site-location criteria of the modern Bedouin groups of these areas. These criteria are cover by shrubs or trees, gradient of the ground, drainage, cleanliness, and distance or cover from "prying eyes" (Measured by the area of the viewshed and what features are visible from the site), as well as availability of water and proximity to pasture. According to Banning and Köhler-Rollefson, a combination of all the criteria that apply to a particular environment usually decides site-location.

Western and Dunne's (1979) ethnoarchaeological study of Masaai pastoralists in southern Africa also identified many factors for site-location. The one site-location factor that Western and Dunne describe for the Masaai that is the most practical for applying to the Beidha pastoralists is the distance from the top of the ridge to the sites. This measure reflects Masaai decisions meant to keep their camps out of the swampy ground at the base of slopes and to minimize damage to habitation structures due to runoff water. Other obvious candidates for possible locational factors in Beidha are availability of afternoon shade in the summer and morning sunlight in the winter, the nature of the substrate (which can be approximated by identifying the geologic province of the substrate), distance to the nearest wadi channel (as wadis frequently offer the easiest routes of travel), and the distance to major access points, such as roads.

Although distance to point sources of water or pasture are not viable model parameters, water and pasture availability do play a role in pastoral movements, and should not be entirely discounted. While the area described by these variables may be so large as to encompass the totality of a survey area, they should be modeled beforehand in order to make sure of this. These resources should also be modeled as zones rather than as point sources. As previously noted, Wadi channels can be seen as zones of water availability, and the distance to the nearest wadi channel may be used as a substitute model parameter for distance to nearest point source of water. As discussed above, Zohary (1962, 1973) describes the affiliation of vegetative matter with geologic strata in the Near East. This makes it possible to approximate the zones of possible occurrence for specific plant communities by modeling the distance from the site to each geologic province in the survey area. This method is important because it can also be used for ancient pastoral sites, as it accounts for modern changes in vegetation density and location caused by overgrazing, deforestation, agriculture, and urbanization.

Specific vegetative zones hold different meanings to pastoralists, however, and should be treated as separate decision factors by the modeler. For instance, zones that are known for their quality pasture will have different distance relationships than zones that are known for the quality of their firewood or for their abundance of aromatic herbs. The qualities of different vegetative zones can be discovered through botanical research, but their actual use can only be discovered through ethnoarchaeological research. For example, Behnke (1980) writes that, while Cyrenaican goats browse the various trees and perennial shrubs of the region, especially juniper, the Cyrenaican sheep can only graze grasses, and so are limited to certain areas of pasture. He also says that both prefer fresh grass when available and that in late summer, as tree browse becomes scarce, goats will eat clumps of dried grass. This might not have been apparent had he not observed the behavior of the flocks. In another example, Katakura (1977) reports that, in western Saudi Arabia both goats and sheep will browse *Acacia* leaves if the branches come close to the ground, and that goats often climb *Acacia* to get at the leaves. Janzen (1986) describes goats in Oman that can scale the embankments of wadis to exploit areas of vegetation that sheep and camels cannot. He also says that these goats also scale trees to eat foliage that would normally be out of their reach. These observed behaviors add significance to the distance relationships between sites and the various geobotanical zones in the region.

Creating model parameters from site-location attributes

A good model parameter is one that is both accurate and precise. By accurate, I mean that the model parameter has a high level of success at predicting the locations of sites. By precise, I mean that the model parameter does not describe a large portion of the survey area. The optimum balance of accuracy to precision of model parameters used in this study is set so that only model parameters that successfully predict at least 80% of the sites while covering the smallest possible area of the sampling universe were kept in the final model. In practice, the balance of accuracy to precision should be determined on a case-by-case basis according to the modeling goals and nature of the data in the sampling universe. The specific ratio of accuracy to precision is calculated in the first part of the model-testing phase, and is described below. The precision can also be improved by combining two or more model conditions. For example, a site-prediction parameter that uses both distance to ridge tops and distance to wadi channels will denote a smaller area of potential sites than either of the two variables independently. This technique is used in this model when two or more testing parameters should logically be associated.

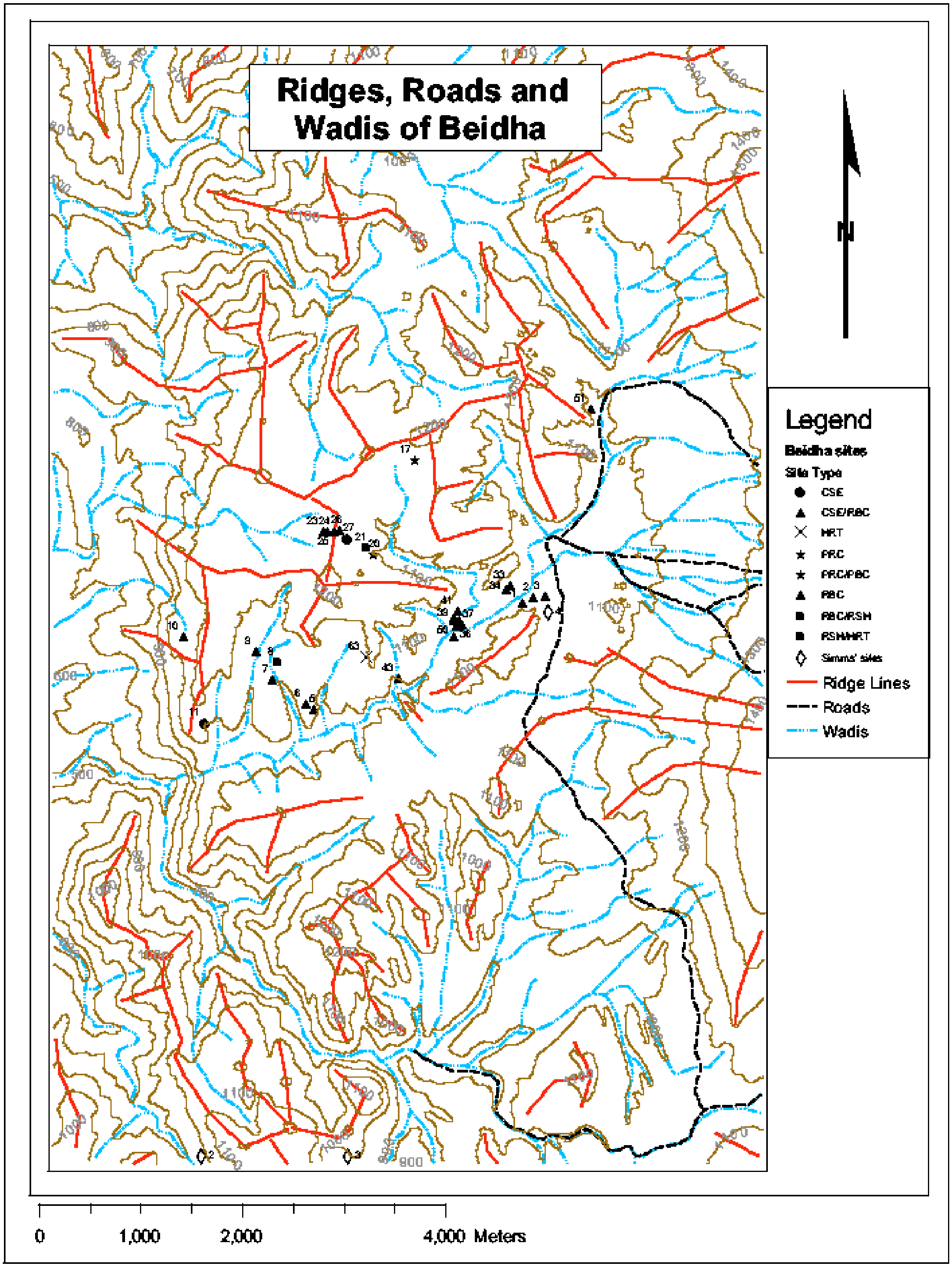
All of the site-location factors discussed above were considered when developing the predictive model for the Beidha survey area. The distance to wadi beds was calculated as an approximation of both distance to water and ease of access to the site. The distance to ridge tops was measured as an estimate of the degree of avoidance of runoff and swampy ground and approximate amount of wind exposure. The distance to the nearest segment of road was defined as a way to assess the relationship of sites to major travel routes. The distance to each of the major geologic provinces of the Beidha region was calculated to approximate the distance to the major geobotanical vegetative communities and the geologic province of each of the sites was recorded as an approximate description of substrate type. The slope was calculated as measure of both runoff avoidance and ease of camp setup. The aspect was calculated as a measure of wind avoidance and seasonality of campsites. The distance to shade was calculated for sunrise, midmorning, noon, mid afternoon, and sunset for both the winter and summer solstice as a measure of site-location as a means of regulation of the sun's energy. Finally, the area of viewshed, number of sites within the viewshed, general direction of viewshed, and the presence of wadi beds or roads within the viewshed were used to determine to what degree site-locations are chosen to be private or public. The distances and other measurements were all taken within the 3-D GIS spatial model, and the techniques used to accomplish this are described below.

The technical methodology for choosing and classifying predictive model parameters is discussed at length and in great detail by Kvamme and by Kohler and Parker (Kohler and Parker 1986, Kvamme 1990), and the possible applications of GIS to predictive modeling are discussed by several authors (e.g. Hansen 2000, Kohler et al. 1996, Kuiper and Wescott 1999, Stancic and Kvamme 1999) so these issues will not be discussed in any great detail here.

From contour map to DEM

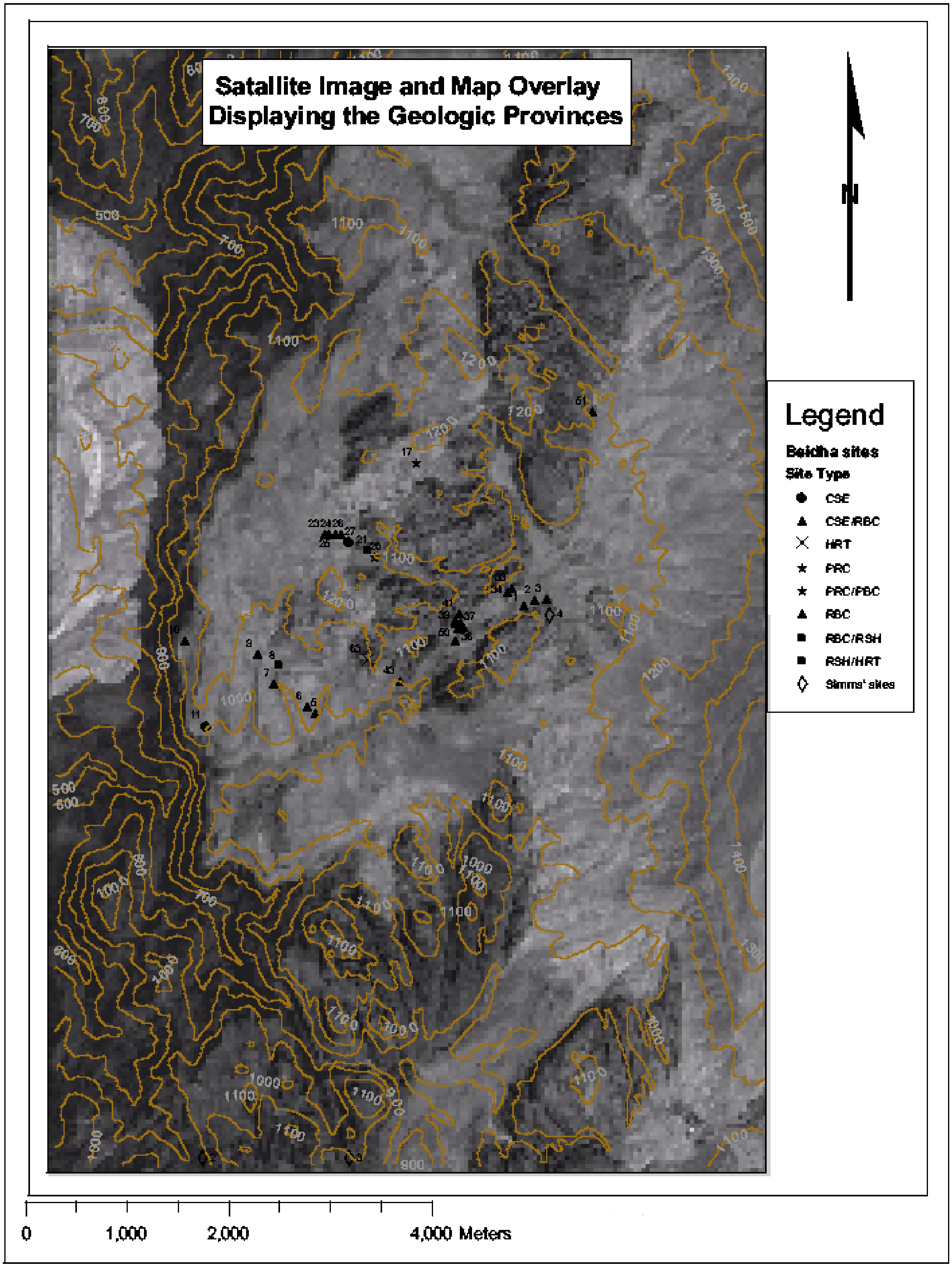
The first step in building the Beidha 3-D terrain model began with the Petra quadrat of the 1963 US AMS 1:50,000 scale UTM (1950 European datum) map which was the same map that Banning and Köhler-Rollefson used in their field survey. To save disk space and reduce processing time while still retaining high resolution, only the section directly encompassing the 1982 survey area was scanned and digitized. That area included northern Petra and Beidha, but excluded Wadi Araba to the west and most of the limestone hills to the east. After the map portion was scanned, it was saved as a multiband bitmap, and imported into ArcCatalog in ESRI's ArcGIS 8.3 program suite. In ArcCatalog, the bitmap was assigned its correct projection and datum, and then was added to the ArcMap section of ArcGIS 8.3 where it was rectified in the ArcScan extension by digitizing the coordinates of the vertices of its UTM grid. After rectification it was converted to a single band (two color) ESRI GRID raster file, and then cleaned and clarified using a combination of the raster cleanup tools in the ArcScan extension and the Raster Calculator tool of the Spatial Analyst extension of ArcMap.

Only the 100 m contour intervals were traced in order to save time and undue effort. These contour lines were vectorized using a combination of the batch vectorization and raster tracing tools in the ArcScan extension and freehand tracing in the Edit mode of ArcMap. The resulting polyline shapefile's database was then updated with an elevation field, and the relevant elevation data was encoded for each contour line. In order to preserve smaller-scale relief that was lost at the 100 m contour interval, more than 300 spot elevations were digitized into a point



Ridges, Roads and Wadis of Beidha
N
Legend
Beidha sites
Site Type
CSE
CSE/RBC
HRT
PRC
PRC/PBC
RBC
RBC/RSH
RSH/HRT
Simms' sites
Ridge Lines
Roads
Wadis
0
1,000
2,000
4,000 Meters

Map 5. Wadis, roads, and ridges.

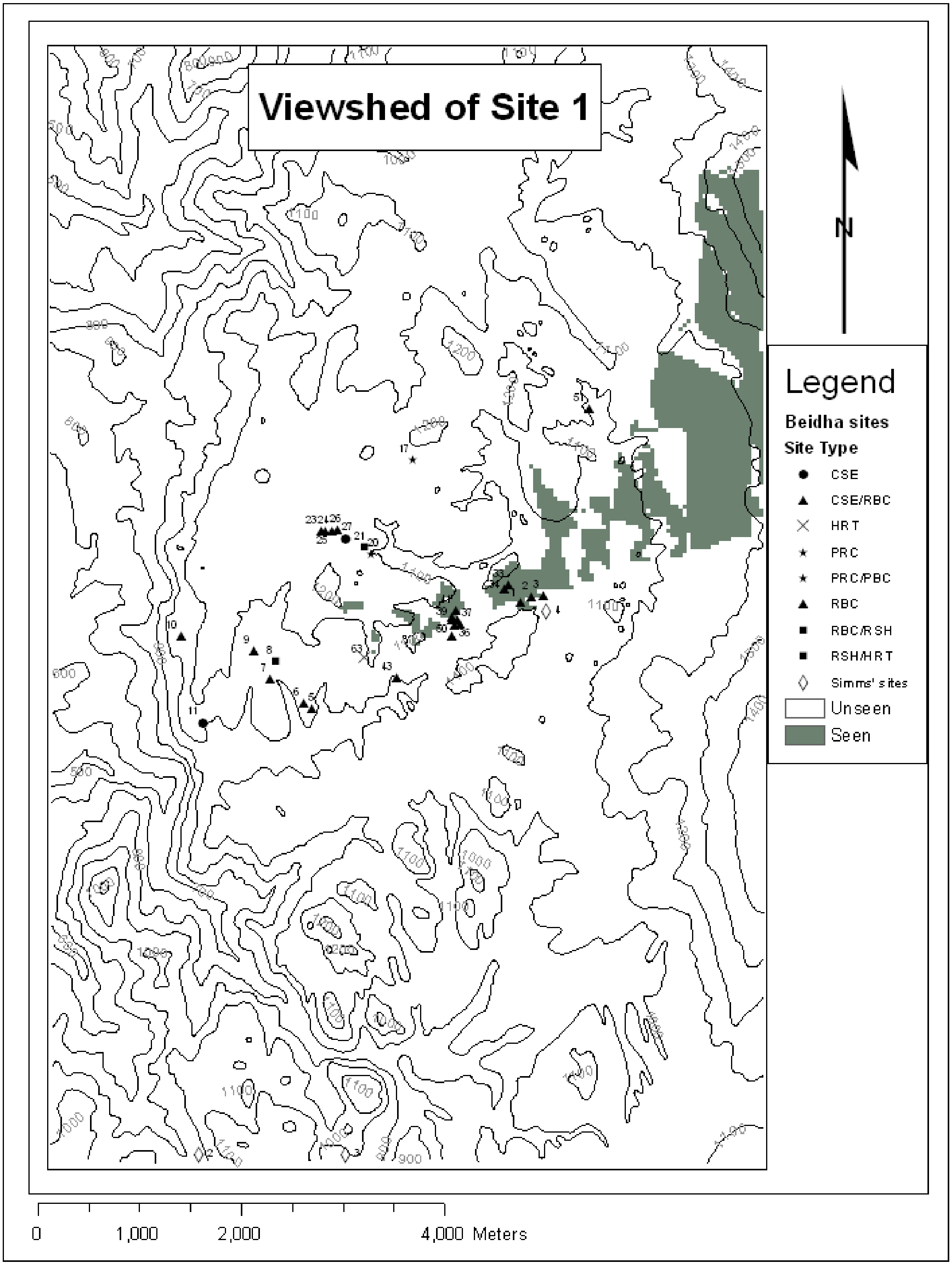


Map 6. Satallite and map overlay showing geologic provinces.

shapefile. These spot elevations covered the areas of the map containing the most complex relief. A TIN file was then created from the contour and spot elevation shapefiles using the 3-D analyst extension. The same extension was used to build a Digital Elevation Model (DEM) from the TIN, and this was saved as an ESRI multiband GRID raster file. All wadi channels and roads were also encoded directly off the scanned map into polyline shape files (Map 5). The ridgelines were encoded from a combined overlay of the contour map and the 3-D TIN file, and were simple, free-drawn, approximations of the line of highest elevation along the tops of the major ridges that separated the wadi channels. All these shapefiles files were then converted to 3-D shapefiles using the 3-D Analyst extension which encoded them with z-values derived from the Beidha DEM raster.

Banning and Köhler-Rollefson's original field map was digitized and rectified using the same methods described above. First, the site points were encoded directly off this map into a point shapefile, whose database included a field for site number and site type. Then these points were rendered into 3-D space using the same method outlined above. Finally, the boundaries of Banning and Köhler-Rollefson's sampling universe were encoded from the 1982 field map into a polygon shapefile.

The last shapefile to be encoded was the geologic province map; however, because of the lack of an appropriately scaled geologic map of the area, it was necessary to do this in a slightly different fashion. The geologic provinces were digitized by freehand tracing into a polygon shapefile over a rectified SPOT satellite image with descriptive help from the Aqaba – Ma'an sheet of the Geological Map of Jordan 1:250,000 scale map (German Geological Mission in Jordan 1968), the Geologic Map of Petra 1:5,000 map (Geology Directorate of the National Resources Authority 1991) and the Space Atlas of Jordan (Royal Jordanian Geographic Centre 2000) (Map 6).


Viewshed of Site 1
N
Legend
Beidha sites
Site Type
CSE
CSE/RBC
HRT
PRC
PRC/PBC
RBC
RBC/RSH
RSH/HRT
Simms' sites
Unseen
Seen
0
1,000
2,000
4,000 Meters

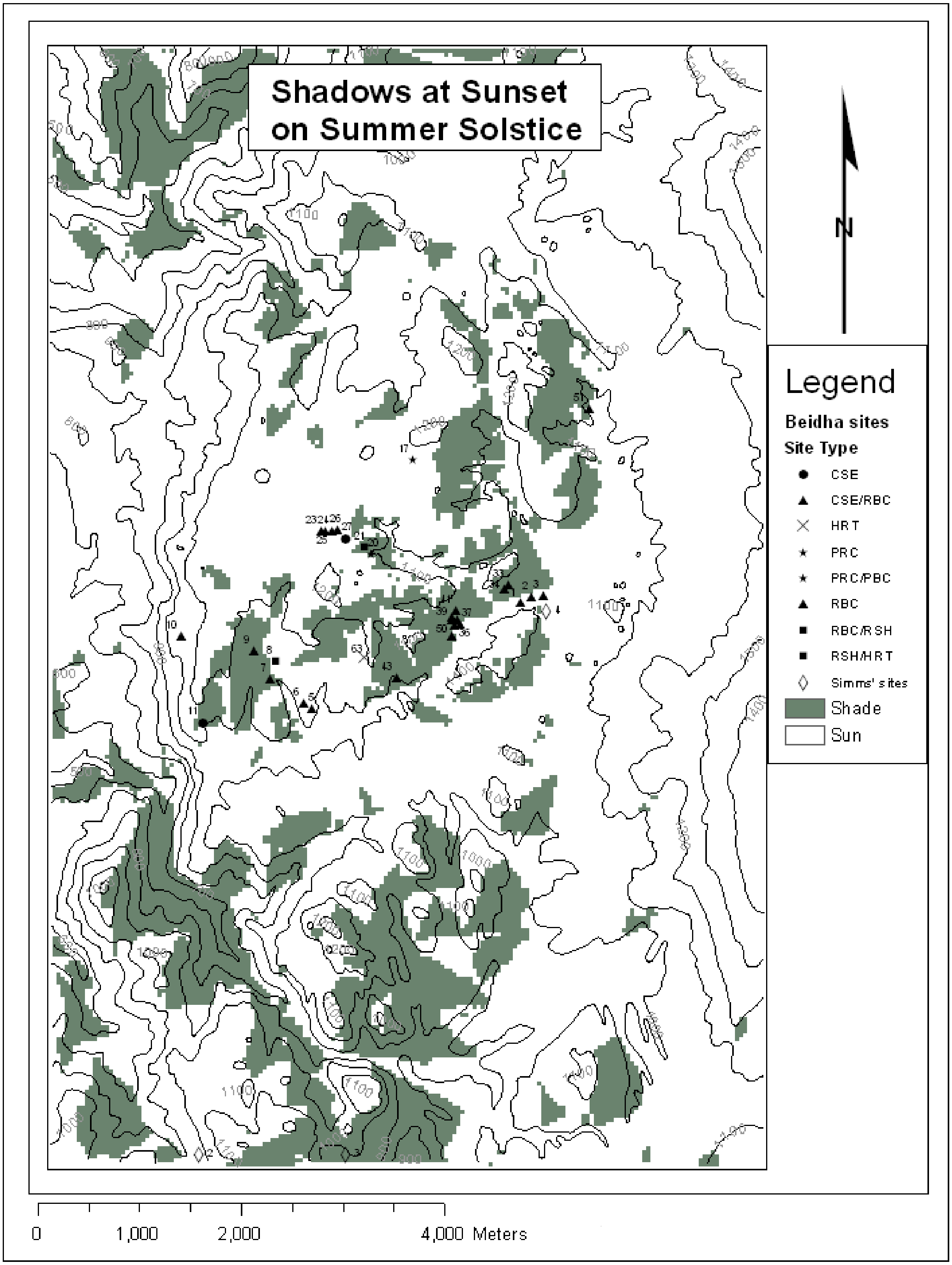
Map 7. Sample viewshed map.

The satellite image was a spatially rectified geotiff file available from the NIMA website (National Imagery and Mapping Agency 2003) and is copyright CNES/SPOT, 1992-1994.

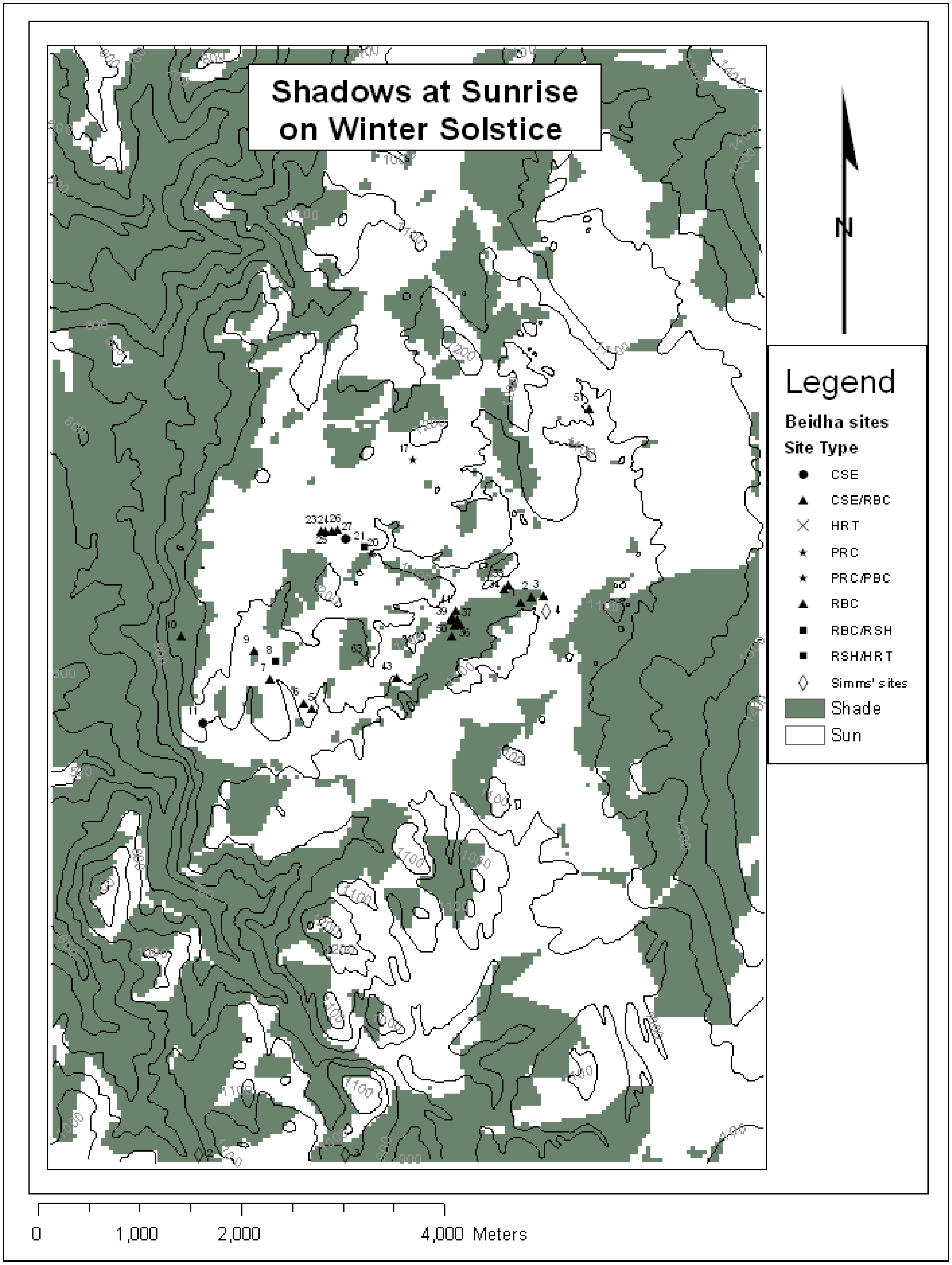
Obtaining data from the spatial model

All distance data between the Beidha site points and map features encoded in shapefiles (wadis, roads, ridges, and geologic provinces) was collected by the same method. The distance to the nearest feature was calculated by joining each feature shapefile to the site points shapefile using the Join command in ArcMap. This command adds the attributes and distances of the feature class nearest each site point to that points' row in the attribute database. This process resulted in new point shapefiles whose associated databases contained the shortest linear distance to the nearest wadi channel, ridgeline, road, and to each of the geologic provinces.

Each individual site's viewshed was calculated in the 3-D Analyst extension of ArcMap Using the Beidha DEM and the site points shapefile (Map 7). This process results in single band raster which encode 1 for all territory within the viewshed, and 0 for all territory outside the viewshed. These output rasters were then reclassified to show only pixels with values of 1 which allows the area of the viewshed to be calculated using the area and volume command in the 3-D Analyst extension. There does not seem to be any way to calculate the average ordinal direction of viewshed within ArcGIS 8.3, so the general direction of viewshed was recorded by hand from the viewshed rasters. This process is not extremely accurate, so only generalized cardinal directions were recorded. There also does not seem to be any way to automatically return the type and number or amount of features that the viewshed overlaps in ArcGIS 8.3. These data were also recorded by hand, and they included the amount of wadis present in the viewshed as well as the general direction of view to these wadis, and if any sections of road were within the


Shadows at Sunset
on Summer Solstice
Legend
Beidha sites
Site Type
CSE
CSE/RBC
HRT
PRC
PRC/PBC
RBC
RBC/RSH
RSH/HRT
Simms' sites
Shade
Sun
N
0
1,000
2,000
4,000 Meters

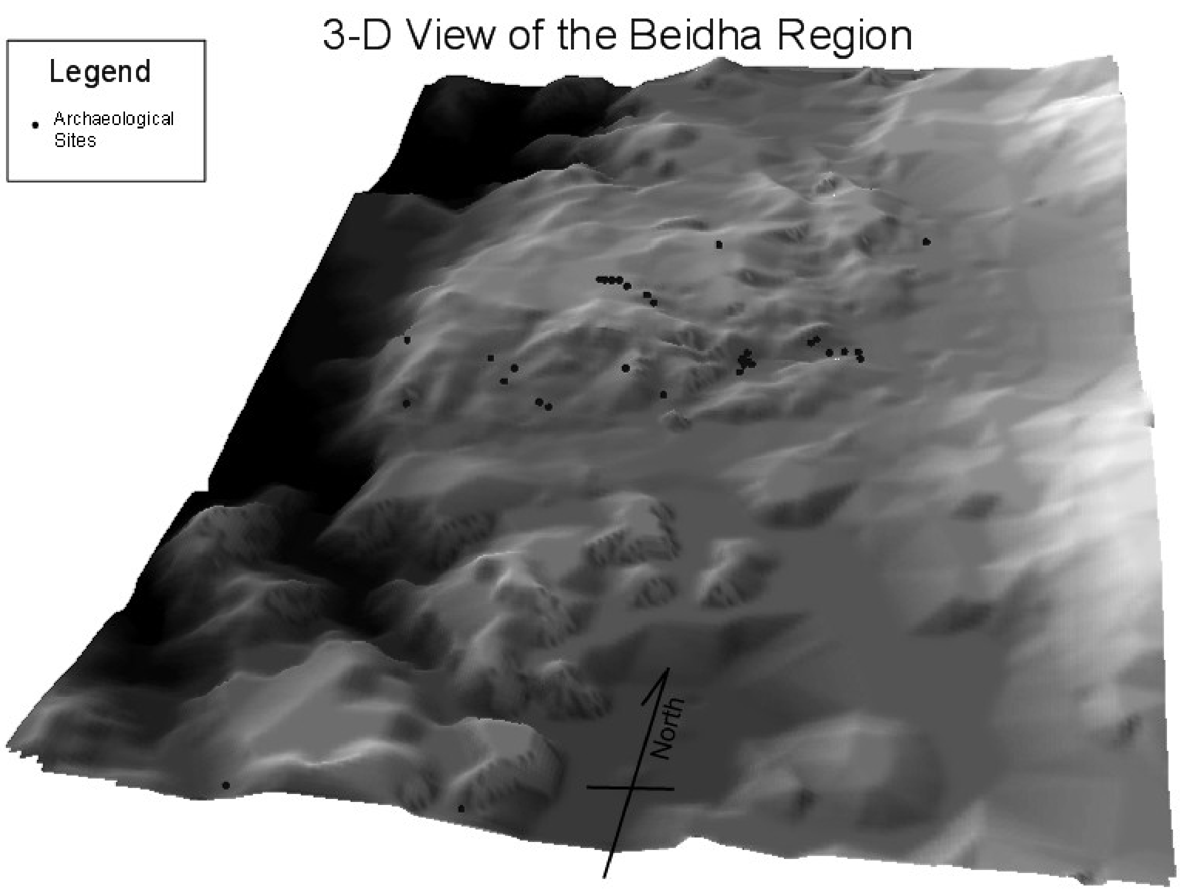
Map 8. Shadows at sunset on the summer solstice.



Map 9. Shadows at sunrise on the winter solstice.

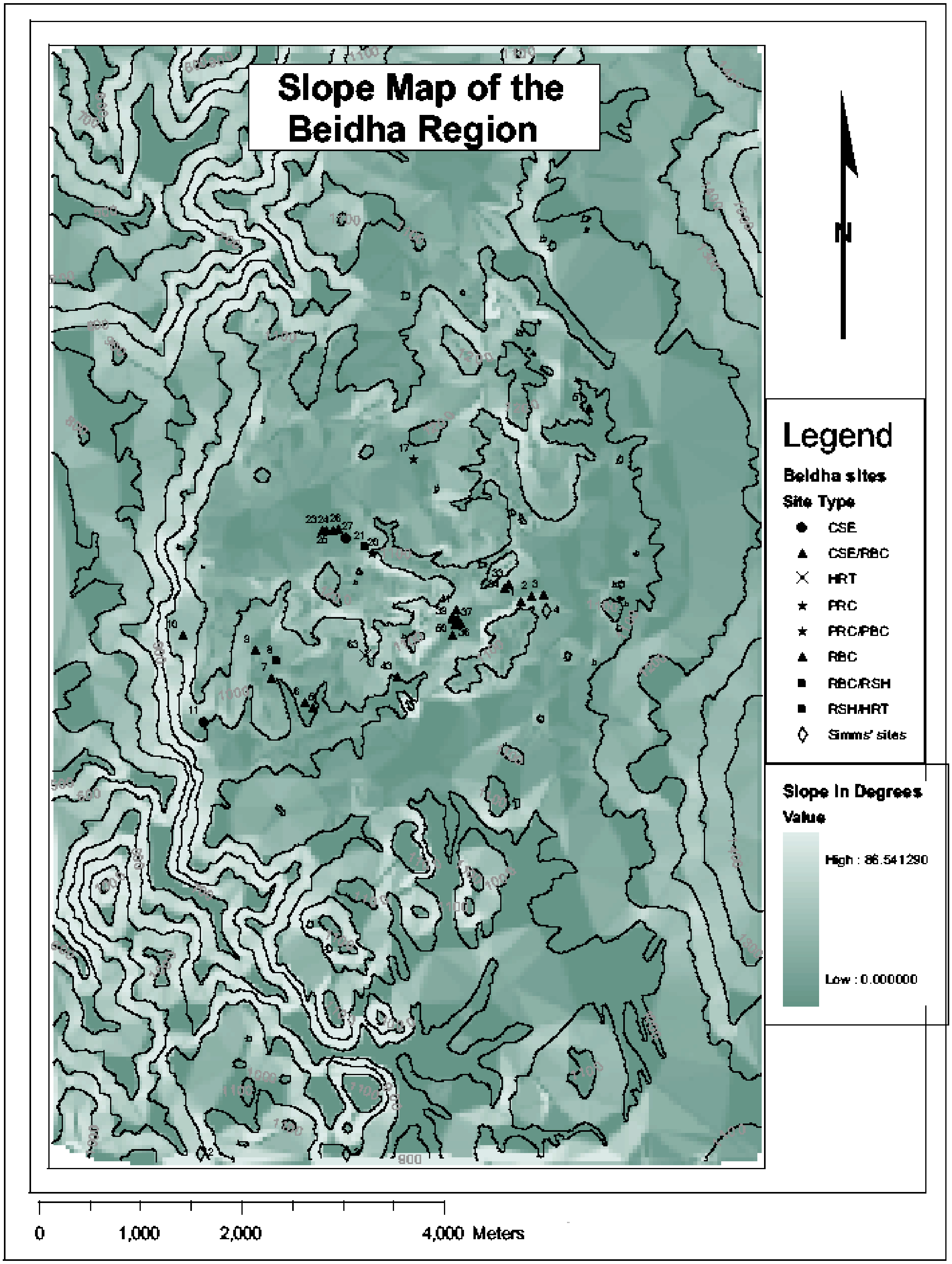
viewshed. The number of other sites of the same type present in the viewshed were counted in this way, but, in order to correct for the problems created by the cluster sampling technique used by Banning and Köhler-Rollefson, only other sites within the 100 m radius sampling zone of the nearest sampling point to that site were recorded. This radius was set up using the create buffer tool in the Spatial Analyst extension.

The distance to shade was calculated from the Beidha DEM using the Hillshade utility in the 3-D Analyst extension of ArcMap with the "model shadow" option engaged. This utility allows manual adjustment of the altitude and azimuth of the sun so that the shade at different



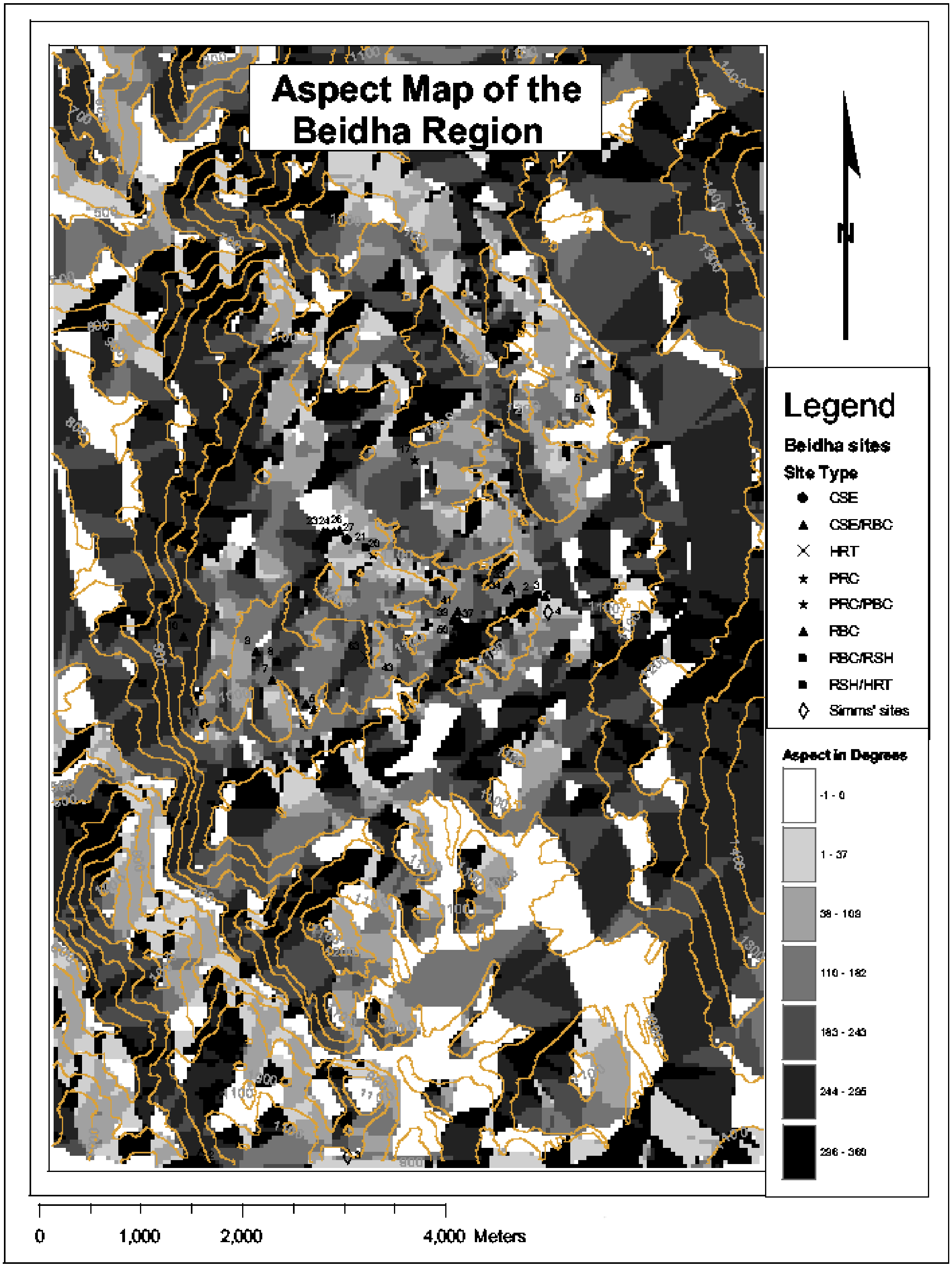
Map 10. 3-D rendering of the Beidha area.

times of day and in different seasons can be modeled fairly easily and accurately. The hillshade just after sunrise, at midmorning, at noon, at mid afternoon, and just before sunset was modeled



Slope Map of the Beidha Region
Legend
Beidha sites
Site Type
CSE
CSE/RBC
HRT
PRC
PRC/PBC
RBC
RBC/RSH
RSH/HRT
Simms' sites
Slope In Degrees
Value
High : 86.541290
Low : 0.000000
N
0
1,000
2,000
4,000 Meters

Map 11. Slope map of Beidha.



Map 12. Aspect map of Beidha.

using altitude and azimuth data and sunrise and sunset times obtained from the US Naval Observatory's Astronomical Applications Department website (U.S. Naval Observatory 2003a, U.S. Naval Observatory 2003b) for the winter and summer solstices in 1982, the dates of which were obtained via an online astronomical utility provided by Hermetic Systems (Hermetic Systems 2003) (Maps 8 and 9). The Hillshade function produces single band rasters that encode "0" for cells that are in the shade of another cell at the specified altitude and azimuth of the sun and a range of "1 – 266" for cells with other varying intensities of light. In order to discover the distance from each site to the nearest shadowed cells, the hillshade rasters were reclassified to show only cells encoded "0", and the shortest distance to the nearest shaded area were calculated for each site using the zonal statistics utility in the Spatial Analyst extension of ArcMap.

Finally, because the GIS stores 3-D data internally (Map 10), the Beidha DEM was also used to produce a slope (Map 11) and an aspect (Map 12) raster using the slope and aspect functions in the 3-D Analyst extension of ArcMap. The slope and aspect were calculated for each site using the zonal statistics utility in the Spatial Analyst extension. The data for all the model parameters were then exported out of ArcMap in form of dBase database files, and imported into Excel spreadsheets for analysis.

Data and Analysis

The tested and adjusted model parameters are presented in Table 2 below. Several observations are of note in the finished model. Several of the possible model parameters were found to have no significant correlation to site-location decisions in the Beidha region. These parameters were the distance to the nearest road, the shortest distance to the Bayda Porphyry geologic province, and the shortest distance to the Alluvial Fan Sediments geologic province. These parameters were found to be to imprecise at the satisfactory level of accuracy, and therefore, not acceptable for use in this model. Since there was no shade in the simulation of noon on the summer solstice, that category had to be discounted as well. The shade data for summer, with the exception of the shade before sunset, is probably not very useful as they are all located in the sun and not very close to any shade. Most of the other parameters could be split into summer site-location ranges and winter site-location ranges. The only exceptions to this are the distance to the nearest wadi channel, the geologic province of the site, the direction of viewshed, and the amount of roads and wadis in the viewshed, which all were similar between the summer and winter sites.

Table 2. The final model parameters: ATTRIBUTE is the description of the measurement. USAGE is the season during which the measurement is valid. DESCRIPTION OF RANGE (seasonally divided if necessary) is the actual language of the model. NUMERIC RANGE (seasonally divided if necessary) is the actual number-data of the measurement used in the model. An 'x' in a cell means that that cell is not usable in the model.

ATTRIBUTE	**Distance to roads (meters)**	**Distance to wadi channels (meters)**	**Distance to ridge tops (meters)**	**Site aspect (degrees)**	**Site Slope (degrees)**
USAGE	Unused, Not precise	Not very different between seasons	Seasonal	Seasonal	Seasonal

DESCRIPTION OF RANGE (ALL or SUMMER)	x	Close to or in wadi channels	Summer range is from tops to quite far away	Summer range is Flat ground or anything but due north	Summer range is none to very shallow slope
NUMERIC RANGE (ALL or SUMMER)	x	-32.75198283	-18.2572109	Flat or 130.0545	-0.237525353
	x	324.1507232	420.839495	270.3028329	21.1626742
DESCRIPTION OF RANGE (WINTER)	x	x	Winter range is in the middle of the slopes	Winter range is basically facing south	Winter range is none to steeper slopes
NUMERIC RANGE (WINTER)	x	x	172.2816482	46.870657291	-0.420215315
	x	x	435.4926204	330.144797352	8.104058778

ATTRIBUTE	**Site geologic province**	**Distance to volcanics (meters)**	**Distance to alluvial fan sediments (meters)**	**Distance to other sandstone (meters)**	**Distance to Wadi Sediments (meters)**
USAGE	No difference between seasons	Unused, Not precise	Unused, Not precise	Slightly seasonal	Seasonal
DESCRIPTION OF RANGE (ALL or SUMMER)	Most are located on "other sandstone" or upper Umm Ishirin sandstone"	x	x	Summer range is on it to only 9 meters away	Summer range is on them to over a kilometer away
NUMERIC RANGE (ALL or SUMMER)	x	x	x	-7.291056154	-171.1475257
	x	x	x	9.378796599	1392.863315
DESCRIPTION OF RANGE (WINTER)	x	x	x	Winter range is on it to 17 meters away	Winter range is on them to only a quarter of a kilometer away
NUMERIC RANGE (WINTER)	x	x	x	-9.228856143	-27.87085169
	x	x	x	17.45725169	255.6221106

ATTRIBUTE	**Distance to upper Umm Ishrin sandstone (meters)**	**Distance to shade, summer, sunrise (meters)**	**Distance to shade, summer, midmorning (meters)**	**Distance to shade, summer, noon (meters)**	**Distance to shade, summer, mid afternoon (meters)**
USAGE	Seasonal	Summer, not very useful	Summer, not very useful	Unused, No shade present.	Summer, not very useful
DESCRIPTION OF RANGE (ALL or SUMMER)	Summer range is on it to half a kilometer away	Within half a kilometer of shade	Far from shade	x	Far from shade
NUMERIC RANGE (ALL or SUMMER)	-4.93266363	-42.67673982	691.5201068	x	903.0418554
	533.388286	415.9589495	1811.220764	x	2294.857124
DESCRIPTION OF RANGE (WINTER)	Winter range is on it to less than a tenth of a kilometer away	x	x	x	x
NUMERIC RANGE (WINTER)	-19.6542629	x	x	x	x
85.19999742	85.1999974	85.19999742	85.19999742	85.19999742	85.19999742

ATTRIBUTE	**Distance to shade, summer, sunset (meters)**	**Distance to shade, winter, sunrise (meters)**	**Distance to shade, winter, midmorning (meters)**	**Distance to shade, winter, noon (meters)**	**Distance to shade, winter, mid afternoon (meters)**
USAGE	Summer	Winter	Winter	Winter	Winter
DESCRIPTION OF RANGE (ALL or SUMMER)	Located in or fairly close to shade	x	x	x	x
NUMERIC RANGE (ALL or SUMMER)	-43.7374770	x	x	x	x
	424.2922636	x	x	x	x
DESCRIPTION OF RANGE (WINTER)	x	Located in or close to shade	Located in sun, but not too far from shade	Located in sun, fairly far from shade	Located in sun, far from shade

NUMERIC RANGE (WINTER)	x	-18.47125287	80.64099438	199.3066288	232.492473
	X	62.85631027	337.3552678	333.7814642	347.4334583

ATTRIBUTE	**Distance to shade, winter, sunset (meters)**	**Viewshed area (square meters)**	**Number of other sites within viewshed**	**Direction of viewshed**	**Amount of roads and wadis in viewshed**
USAGE	Winter	Seasonal	Seasonal	Not different between seasons	Not different between seasons
DESCRIPTION OF RANGE (ALL or SUMMER)	x	Summer range is from 1 to 4 million square meters	Summer range is 1 to 4 other sites	Generally looking east	None to little of each in viewshed
NUMERIC RANGE (ALL or SUMMER)	x	1918863.918	0.502633404	NE – SE	x
	x	4219594.398	4.297366596	x	x
DESCRIPTION OF RANGE (WINTER)	Located in or close to shade.	Winter range is from 0 to 3 million square meters	Winter range is from 1 to 6 other sites	x	x
NUMERIC RANGE (WINTER)	-26.3321412	-298766.3271	0.713130849	x	x
	72.50117997	3032609.652	6.517638382	x	x

Table 3 lists the results of the test of the model against the three Simms sites, the two PRC/PBC's and the two CSE's, and shows several interesting phenomenon. First of all, it clearly illustrates the need to use as many model parameters as possible. Only by comparing the results from many parameters can we obtain a result with which we have any confidence whatsoever. Logically, each attribute will have different levels of importance in the location decision for each site. This is because the location of each site was decided at specific point in time from a large population of constantly changing variables. Any single statically measured model variable cannot hope to account for this fact, and the error can only be overcome through grouping several of them together. The results are therefore slightly arbitrary and this technique presents us with a new problem: How do we assess the results? How many model variables must a site be successfully defined by to be counted as "predicted" by the model? Which are the most important model variables for the site to be counted by? This last question can be answered through the testing process described above, but the first two are a little bit more difficult. The modeler may arbitrarily decide a minimum number of successful hits needed before a site is counted as predicted. This technique is problematic, however, as it reduces the control the modeler has over the model, and will cause the model to ignore sites that tightly fit a few variables, but disregard the rest of the model parameters. The modeler must pay close attention to how well each site fits each model parameter as well as how many model parameters the site fits into before making a decision.

Table 3. Results of the model's application to the testing populations: Description of measurement is in bold type. Sites from the Simms and Russel survey are labeled 'Simms *n*', '*n*' being the site number assigned by Simms and Russel (1996) and which can be seen on Map 4. The other sites are referred to by the site number given to them when they were recorded by Banning and Köhler-Rollefson, and can also be seen on Map 4. An 'x' in a cell means that that cell was not used in the model.

	Site type	**Distance to roads (meters)**	**Distance to wadi channels (meters)**	**Distance to ridge tops (meters)**	**Site aspect (degrees)**	**Site Slope (degrees)**
Simms 4	RBC	X	All	Summer	All	No
Simms 3	RBC	X	No	Winter	Winter	Winter
Simms 2	RBC	X	All	All	No	No
20	PRC	X	All	All	No	No
17	PRC/PBC	X	No	No	No	Winter
27	CSE	X	All	Summer	No	All
11	CSE	X	All	Summer	Summer	Winter

	Site type	Site geologic province	Distance to volcanics (meters)	Distance to alluvial fan sediments (meters)	Distance to other sandstone (meters)	Distance to Wadi Sediments (meters)
Simms 4	RBC	No	x	x	No	Summer
Simms 3	RBC	Yes	x	x	No	No
Simms 2	RBC	Yes	x	x	No	No
20	PRC	Yes	x	x	No	Summer
17	PRC/PBC	Yes	x	x	All	No
27	CSE	Yes	x	x	All	Summer
11	CSE	Yes	x	x	All	Summer

	Site type	Distance to upper Umm Ishrin sandstone (meters)	Distance to shade, summer, sunrise (meters)	Distance to shade, summer, midmorning (meters)	Distance to shade, summer, noon (meters)	Distance to shade, summer, mid afternoon (meters)
Simms 4	RBC	All	Yes	Yes	x	Yes
Simms 3	RBC	All	Yes	No	x	No
Simms 2	RBC	Summer	Yes	Yes	x	Yes
20	PRC	All	Yes	Yes	x	Yes
17	PRC/PBC	No	No	No	x	No
27	CSE	All	Yes	Yes	x	Yes
11	CSE	No	Yes	No	x	Yes

	Site type	Distance to shade, summer, sunset (meters)	Distance to shade, winter, sunrise (meters)	Distance to shade, winter, midmorning (meters)	Distance to shade, winter, noon (meters)	Distance to shade, winter, mid afternoon (meters)
Simms 4	RBC	Yes	No	Yes	No	No
Simms 3	RBC	Yes	Yes	No	No	No
Simms 2	RBC	Yes	Yes	No	No	No
20	PRC	Yes	Yes	No	No	No
17	PRC/PBC	No	No	No	No	No
27	CSE	Yes	No	Yes	Yes	Yes
11	CSE	Yes	No	Yes	No	No

	Site type	Distance to shade, winter, sunset	Viewshed area (square meters)	Number of other sites within viewshed	Direction of viewshed	Amount of roads and wadis in viewshed

		(meters)				
Simms 4	RBC	Yes	No	All	Yes	No
Simms 3	RBC	Yes	Winter	No	Yes	Yes
Simms 2	RBC	Yes	Winter	No	No	Yes
20	PRC	Yes	Winter	No	Yes	Yes
17	PRC/PBC	No	No	All	Yes	Yes
27	CSE	No	Summer	No	No	Yes
11	CSE	No	No	No	Yes	Yes

In general, the Simms sites were well predicted by the model. The seasons for site 4 and 3 can be fairly confidently assigned as summer and winter respectively, but site 2 can only be tentatively assigned as a winter site. The PRC/PBC's were only weakly predicted by the model, and this is most probably due to the fact that the physical and social environment was significantly different when these sites were occupied and their inhabitants probably had different locational criteria in mind. The CSE's were fairly strongly predicted by the model, and are assigned fairly confidently as summer sites. These large circular rock rings are most probably the remains of brushwood corrals that are used to pen up the herd overnight, and are mainly used in the summer when the flocks are taken further afield (Banning and Köhler-Rollefson 1992), and it is interesting that a model based on residential camp location also predicts the location and season of these corrals.

Conclusion

This experiment shows both the validity and the necessity of further research of the archaeology of nomadic pastoralists in the Near East. State-of-the-art computer technology can be combined with established theoretical techniques to produce powerful new tools to aid the archaeologist in this quest. This paper has presented a technique for using GIS software in the process of predictive modeling of nomadic sites. While the GIS produces a spatial model that is only an approximation of reality, at a small enough scale it is an extremely close approximation. While certain aspects of the environment, such as the location and relief of every rock, tree, and bush, cannot be modeled, the remaining aspects can be modeled in such a way as to make them available for investigation and manipulation in a way that is not possible in reality.

The main result of this investigation is a potentially very powerful tool for archaeologists interested in nomadic pastoral sites. Not only has this paper shown the method for using a GIS to develop locational models, it has demonstrated the power that method has for simplifying the complex procedure of using multiple measurements and multivariate statistics in their development. The resultant model is robust and tests well against independent data for the Beidha region. It can be used not only to determine areas of probable campsite location on a landscape, but it can also help determine the probable season of occupation of these sites. It should be stressed, however, that model is not a static formula with a set number of variables into which the researcher may simply "plug in" their data. While such a model would be desirable for its simplicity, it would be counteractive in its lack of accuracy. The researcher should instead use the categories and their relative ranges as guidelines that should be tailored to a specific region, culture group, or problem. Categories that are not relevant should be discarded, and new ones added if necessary. Likewise, ranges for the categories should be expanded or contracted as necessary.

The model as presented in Table 2 is a finished product that is ready to be used. However, while it has been tested in the lab against independent data, its utilization in the field has not yet been tested. It is only a small step towards the modernization of the archaeology of nomads and it needs to be applied in the design of new surveys to discover and record nomadic pastoral sites. This type of study needs to be repeated in all the areas where nomadic pastoralism is or was practiced. Eventually, after a sufficient corpus of data has been accumulated, the other important questions, such as its history, origins, and its importance in the development of sedentary societies, can be tackled with renewed vigor. I hope that this latest tool will spark an invigoration of pastoral archaeology.

Acknowledgements

First and foremost I would like to thank Dr. Ted Banning for his guidance, patience, and good advice. Dr. Banning provided the computing power and GIS software, without which this study could not have been completed. Thanks to Dr. Banning and to Dr. Ilse Köhler-Rollefson for allowing me use of their original survey maps and site records. Thanks also to Dr. Steve Simms for providing me with his unpublished data and reports from the Bedul ethnoarchaeological project and for his advice and encouragement early on in my quest. Finally, I would like to thank Dr. Robert Elston for starting me off on this topic four years ago, and for all his encouragement since then.

Selected Biliography of Nomadic Pastoralism

Abdisho bar, B. i. a., and F. V. Winnett. 1929. *Paradise of Eden*. Toronto: University of Toronto Press.

Abu-Rabia, A. 1986. Control and allocation of grazing lands among the Bedouin tribes of the Negev. *Nomadic Peoples*:5-10.

—. 1994. *The Negev Bedouin and Livestock Rearing: Social, Economic and Political Aspects*. Oxford: Berg Publishers Ltd.

—. 2001. The long walk III - pastoral nomads and anthropology: an interview with Emanuel Marx. *Nomadic Peoples* 5:7-27.

Alvard, M. S. 2001. "Deferred harvest: the transition from hunting to animal husbandary." *UC Davis Seminars in Ecology, UC Davis, 2001*.

Alvard, M. S., and L. Kuznar. 2001. Deferred harvest: the transition from hunting to animal husbandary. *American Antiquity* 103:295-311.

American Schools of Oriental Research, F. V. Winnett, and W. L. Reed. 1964. *The excavations at Dibon (Dhåibãan) in Moab. Part I: The first campaign, 1950-1951*. New Haven,: American Schools of Oriental Research.

Amitai, R. 2001. "The influence of pastoral nomad populations on the economy and society of Post-Safavid Iran," in *Nomads in the Sedentary World*. Edited by A. Khazanov and A. Wink, pp. 128-152. Richmond: Curzon Press.

Aref El-Aref, O. B. E., and H. W. Tilley. 1944. *Bedouin love, law and legend, dealing exclusively with the Badu of Beersheba; a version in English of the book in Arabic*. Jerusalem,: Cosmos Pub. Co.

Avni, G. 1992. "Survey of deserted Bedouin camps in the Negev Highlands and its implications for archaeological research," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, vol. 10, *Monographs in World Archaeology*, pp. 241-254. Madison: Prehistory Press.

Awad. 1962. "Nomadism in the arid lands of the Middle East," in *The Problems of the Arid Zone*. Paris: UNESCO.

Azarya, V. 2001. "The nomadic factor in Africa: dominance or marginality," in *Nomads in the Sedentary World*. Edited by A. Khazanov and A. Wink, pp. 250-284. Richmond: Curzon Press.

Baer, G. 1963. *Population and Society in the Arab East*. Oxford: Oxford Univ. Press.

Banning, E. B. 1985. Pastoral and Agricultural Land Use in the Wadi Ziqlab, Jordan: An Archaeological and Ecological Survey. Doctoral Thesis, University of Toronto.

—. 1993. Where the wild stones have been gathered aside: pastoralist campsites in Wadi Ziqlab, Jordan. Camels and camel pastoralism in Arabia. *Biblical Archaeologist* 56:212-221.

—. 1995. Herders or homesteaders? A Neolithic farm in Wadi ZiqlabJordan. *Biblical Archaeologist* 58.

Banning, E. B., and I. Köhler-Rollefson. 1986. Ethnoarchaeological survey in the Beda area, southern Jordan. *Zeitschrift des Deutschen Palastina-Vereins* 102:152-170.

—. 1992. "Ethnographic lessons for the pastoral past: camp locations and material remains near Beidha, southern Jordan," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, vol. 10, *Monographs in World Archaeology*, pp. 181-205. Madison: Prehistory Press.

Barfield, T. J. 1993. *The Nomadic Alternative*. Englewood Cliffs: Prentice Hall.

Bartram, L. E., E. M. Kroll, and H. T. Bunn. 1990. "Variability in camp structure and bone food refuse patterning at Kua San hunter-gatherer camps," in *The Interpretation of Archaeological Spatial Patterning*. Edited by E. M. Kroll and T. D. Price. New York: Plenum Press.

Bar-Yosef, O. 1996. "Earliest food producers-Pre-pottery Neolithic," in *Archaeology of Society in the Holy Land*. Edited by T. Levy, pp. 190-204. London: Leicester University Press.

Bar-Yosef, O., and A. Khazanov. 1992. "Introduction," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, *Monographs in World Prehistory*. Edited by O. Bar-Yosef and A. Khazanov, pp. 1-10. Madison: Prehistory Press.

Batanouny, K. H. 2001. *Plants in the Desert of the Middle East. Adaptations of Desert Organisms*. Berlin: Springer.
Behnke, R. H. 1980. *The Herders of the Cyrenaica; Ecology, Economy, and Kinship of the Bedouin of Eastern Libiya*. Vol. 12. *Illinois Studies in Anthropology*. Chicago: University of Illinois Press.
Benzabih, H. A. 1982. "The Jabal Akl-Akhdar:- a half century of nomadic livelihood," in *Social and Economic Development of Libya*. Edited by E. Joffe and K. McLachlan, pp. 195-206. Cambridgeshire: Middle East & North African Studies press ltd.
Bienkowski, P. 1985. New caves for old: Bedouin architecture in Petra. *World Archaeology* 17:150-160.
Bokonyi, S. 1989. "Definitions of animal domestication," in *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, *One World Archaeology*. Edited by J. Clutton-Brock, pp. 22-27. London: Unwin Hyman Ltd.
Bonte, P. 1981. "Ecological and economic factors in the determination of pastoral specialization," in *Change and Development in Nomadic and Pastoral Societies*, *International Studies in Sociology and Social Anthropology*. Edited by J. Galaty and P. Salzman. Netherlands.
Bottema, S. 1989. "Some observations on modern domestication processes," in *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, *One World Archaeology*. Edited by J. Clutton-Brock, pp. 31-45. London: Unwin Hyman Ltd.
Bourdieu, P. 1973. "The Berber House," in *Rules and Meanings*. Edited by M. Douglas, pp. 98-110: Penguin Education.
Brewer, D. 2002. "Hunting, animal husbandry and diet in Ancient Egypt," in *A History of the Animal World in the Ancient Near East*. Edited by B. J. Collins, pp. 427-456. Leiden: Brill.
Chang, C., and H. Koster. 1986. Beyond bones: toward an archaeology of pastoralism. *Advances in Archaeological Method and Theory* 6:97-148.
—. 1994. *Pastoralists at the Periphery: Herders in a Capitalist World*. Tucson: The University of Arizona Press.
Clutton-Brock, J. 1989a. "Cattle in ancient North Africa," in *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, *One World Archaeology*. Edited by J. Clutton-Brock, pp. 200-206. London: Unwin Hyman Ltd.
—. 1989b. "Introduction to Pastoralism," in *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, *One World Archaeology*. Edited by J. Clutton-Brock, pp. 115-118. London: Unwin Hyman Ltd.
—. 1999. *A Natural History of Domesticated Mammals*, 2 edition. Cambridge: Cambridge University Press.
Cohen, R. 1992. "The nomadic or semi-nomadic Middle Bronze Age I settlements in the Central Negev," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, *Monographs in World Prehistory*. Edited by O. Bar-Yosef and A. Khazanov, pp. 105-132. Madison: Prehistory Press.
Cole, D. P. 1975. *Nomads of the Nomads: The Al Murrah Bedouin of the Empty Quarter*. Arlington Heights: Harlan Davidson Inc.
—. 1981. "Bedouin and social change in Saudi Arabia," in *Change and Development in Pastoralist Societies*. Edited by J. Galaty and P. Salzman, pp. 128-149. Leiden: E.J. Brill.
Coon, C. S. 1969. "The camp in the desert," in *Peoples and Cultures of the Middle East*. Edited by A. Shiloh, pp. 119-135. New York: Random House.
Cribb, R. 1991a. "Mobile villagers: the structure and organization of nomadic pastoral campsites in the Near East," in *Ethnoarchaeological Approaches to Mobile Campsites: Hunter-Gatherer and Pastoralist Case Studies*, vol. 1, *Ethnoarchaeology Series*, pp. 371-93. Ann Arbor: International Monographs in Prehistory.
—. 1991b. *Nomads in Archaeology*. Cambridge: Cambridge University Press.
Danin, A. 1998. "Man and the natural environment," in *Archaeology of Society in the Holy Land*. Edited by T. Levy, pp. 24-39. London: Leicester University Press.
Degen, A. A., R. W. Benjamin, and J. C. Hoorweg. 2000. Bedouin households and sheep production in the Negev desert, Isreal. *Nomadic Peoples* 4:125-147.
Dever, W. G. 1992. "Pastoralism and the end of the urban Early Bronze Age in Palestine," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, *Monographs in World Prehistory*. Edited by O. Bar-Yosef and A. Khazanov, pp. 83-92. Madison: Prehistory Press.
Diamond, J. 1999. *Guns, Germs, and Steel*. New York: W.W. Norton & Co.

Dickson, H. R. P. 1951. *The Arab of the desert; a glimpse into Badawin life in Kuwait and Sau'di Arabia*, 2d edition. London,: Allen & Unwin.
—. 1969. "The tent and its furnishing," in *Peoples and Cultures of the Middle East*. Edited by A. Shiloh, pp. 136-156. New York: Random House.
Ducos, P. 1989. "Defining domestication: a clarification," in *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, *One World Archaeology*. Edited by J. Clutton-Brock, pp. 28-30. London: Unwin Hyman Ltd.
Dunnell, R. C., and J. K. Stein. 1989. Theoretical issues in the interpretation of microartifacts. *Geoarchaeology* 4:31-42.
Eldar, I., D. Nahlieli, and Y. Nir. 1992. "Bedouin and their campsites in the Dimona region of the Negev: a comparative model for the study of ancient desert settlements," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, vol. 10, *Monographs in World Archaeology*, pp. 205-7. Madison: Prehistory Press.
Eldar, I., Y. Nir, and D. Nahlieli. 1992. "Bedouin and their campsites in the Dimona region of the Negev: a comparative model for the study of ancient desert settlements," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, vol. 10, *Monographs in World Archaeology*, pp. 205-218. Madison: Prehistory Press.
Finkelstien, I. 1992. "Pastoralism in the highlands of Canaan in the third and second millennia B.C.E.," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, *Monographs in World Prehistory*. Edited by O. Bar-Yosef and A. Khazanov, pp. 133-142. Madison: Prehistory Press.
Finkelstien, I., and A. Perevolotsky. 1990. Processes of sedentarization and nomadization in the history of the Sinai and the Negev. *Bulletin of the American Schools of Oriental Research* 297:67-87.
Frantz, C. 1978. "Ecology and social organization among Nigerian Fulbe (Fulani)," in *Nomadic alternative*. Edited by W. Weissleder, pp. 97-118. The Hague: Mouton Publishers.
Galaty, J. G. 1989. "Cattle and cognition: aspects of Maasai practical reasoning," in *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, *One World Archaeology*. Edited by J. Clutton-Brock, pp. 215-239. London: Unwin Hyman Ltd.
Gilbert, A. 1983. On the origins of specialized nomadic pastoralism in western Iran. *World Archaeology* 15:105-19.
—. 2002. "The native fauna of the ancient Near East," in *A History of the Animal World in the Ancient Near East*. Edited by B. J. Collins, pp. 3-75. Leiden: Brill.
Gilead, I. 1992. "Farmers and herders in southern Isreal during the Chalcolithic Period," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, *Monographs in World Prehistory*. Edited by O. Bar-Yosef and A. Khazanov, pp. 29-42. Madison: Prehistory Press.
Goldberg, P. 1998. "The changing landscape," in *Archaeology of Society in the Holy Land*. Edited by T. Levy, pp. 40-57. London: Leicester University Press.
Goldberg, P., and I. Whitbread. 1993. "Micromorphological study of a Bedouin tent floor," in *Formation Processes in Archaeological Context*, vol. 17, *Monographs in World Archaeology*, pp. 165-88. Madison: Prehistory Press.
Haiman, M. 1992. "Sedentarism and pastoralism in the Negev Highlands in the Early Bronze Age: Results of the Western Negev Highlands emergency survey," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, *Monographs in World Prehistory*. Edited by O. Bar-Yosef and A. Khazanov, pp. 93-104. Madison: Prehistory Press.
Haiman, M., and Y. Goren. 1992. ""Negbite" pottery: New aspects and interpretations and the role of pastoralism in designating ceramic technology," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, *Monographs in World Prehistory*. Edited by O. Bar-Yosef and A. Khazanov, pp. 143-152. Madison: Prehistory Press.
Henry, D. O. 1992. Seasonal movements of fourth millennium pastoral nomads in Wadi Hisma. *Studies in the History and Archaeology of Jordan* 4:137-141.
Hesse, B., and P. Wapnish. 2002. "An archaeozoological perspective on the cultural use of mammals in the Levant," in *A History of the Animal World in the Ancient Near East*. Edited by B. J. Collins, pp. 457-491. Leiden: Brill.
Hobbs, J. J. 1989. *Bedouin Life in the Egyptian Wilderness*. Austin: University of Texas Press.
Hole, F. 1978. "Pastoral nomadism in western Iran," in *Explorations in Ethnoarchaeology*, pp. 127-67. Albuquerque: University of New Mexico Press.

—. 1979. "Rediscovering the past in the present; ethnoarchaeology in Luristan, Iran," in *Ethnoarchaeology*, pp. 192-218. New York: Columbia University Press.
—. 1989. "A two-part, two-stage model of domestication," in *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, *One World Archaeology*. Edited by J. Clutton-Brock, pp. 97-104. London: Unwin Hyman Ltd.
—. 1996. "The context of caprine domestication in the Zagros region," in *The Origins and Spread of Agriculture and Pastoralism in Eurasia*. Edited by D. R. Harris, pp. 263-281. London: University College of London.
—. 1998. "The sprea of agriculture to the eastern arc of the Fertile Crescent: food for the herders," in *The Harlan Symposium*. Edited by A. B. Domonia, J. Valkoun, G. Wilcox, and C. O. Guaket. Aleppo: FAO of the UN.
Hoyland, R. G. 2001. *Arabia and the Arabs: From the Bronze Age to the Coming of Islam*. London: Routledge.
Ibrahim, S. E., and D. P. Cole. 1978. *Saudi Arabian Bedouin: an Assessment of Their Needs*. American University in Cairo.
Ingold, T. 1980. *Hunters, Pastoralists, and Ranchers*. Cambridge: Cambridge University Press.
—. 2000. *The Perception of the Environment*. London: Routledge.
Janzen, J. 1986. *Nomads of the Sultanate of Oman: Tradition and development in Dhofar*. London: Westview Press.
Katakura, M. 1977. *Bedouin Village*. Tokyo: Univ. of Tokyo Press.
Kaufmann, J. C. 2000. The long walk I - pastoral nomads and anthropology: an interview with Anatoly M. Khazanov. *Nomadic Peoples* 4:5-21.
Kay, S. 1978. *The Bedouin*. New York: Crane, Russak & Co. Inc.
Keohane, A. S. 1994. *Bedouin: Nomads of the Desert*. London: Kyle Cathie Ltd.
Khazanov, A. 1978. "Characteristic features of nomadic communities in the Eurasian steppes," in *Nomadic alternative*. Edited by W. Weissleder, pp. 119-126. The Hague: Mouton Publishers.
—. 1994. *Nomads and the Outside World*. Madison: University of Wisconsin Press.
—. 2001. "Nomads in the history of the sedentary world," in *Nomads in the Sedentary World*. Edited by A. Khazanov and A. Wink, pp. 1-23. Richmond: Curzon Press.
Köhler-Rollefson, I. 1992. "A model for the development of nomadic pastoralism on the Transjordanian Plateau," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, vol. 10, *Monographs in World Archaeology*, pp. 11-18. Madison: Prehistory Press.
—. 1993. Camels and camel pastoralism in Arabia. *Biblical Archaeologist* 56:180-188.
—. 1996. "The one-humped camel in Asia: origin, utilization and mechanisms of dispersal," in *The Origins and Spread of Agriculture and Pastoralism in Eurasia*. Edited by D. Harris, pp. 282-295. London: UCL Press.
Lancaster, W. 1981. "The logic of the Rwala response to change," in *Contemporary Nomadic and Pastoral Peoples: Asia and the North*. Edited by J. Galaty. Williamsburg: College of William and Mary.
Lancaster, W., and F. Lancaster. 1986. The concept of territory among the Ruwalla Bedouin. *Nomadic Peoples* 20:41-48.
Legge, T. 1996. "The beginnings of caprine domestication in Southwest Asia," in *The Origins and Spread of Agriculture and Pastoralism in Eurasia*. Edited by D. Harris, pp. 238-262. London: UCL Press.
Levy, T. E. 1983. Emergence of specialized pastoralism in the Levant. *World Archaeology* 15:15-37.
—. 1992. "Transhumance, subsistence, and social evolution in the Northern Negev Desert," in *Pastoralism in the Levant*, vol. 10, *Monographs in World Archaeology*, pp. 65-82. Madison: Prehistory Press.
Lewis, B. 1966. *The Arabs in History*. New York: Harper & Row Publishers.
Marean, C. W. 2000. Age, sex, and old goats. *Science* 287:2174-2175.
Marx, E. 1967. "Bedouin of the Negev," pp. xv, 260. Manchester,: Manchester U.P.
—. 1978. "The ecology and politics of nomadic pastoralists in the Middle East," in *Nomadic alternative*. Edited by W. Weissleder, pp. 41-74. Paris: Mouton.
—. 1992. "Are there pastoral nomads in the Middle East?," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, vol. 10, *Monographs in World Archaeology*, pp. 255-260. Madison: Prehistory Press.
Marx, E., and A. Shemu®eli. 1984. *The Changing Bedouin*. New Brunswick: Transaction Books.

Meadow, R. H. 1989. "Osteological evidence for the process of animal domestication," in *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, *One World Archaeology*. Edited by J. Clutton-Brock, pp. 80-90. London: Unwin Hyman Ltd.
—. 1992. "Inconclusive remarks on pastoralism, nomadism, and other animal-ralated matters," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, *Monographs in World Prehistory*. Edited by O. Bar-Yosef and A. Khazanov, pp. 261-269. Madison: Prehistory Press.
Musil, A. 1928. *The manners and customs of the Rwala Bedouins*. New York,.
Nevins, E., and T. Wright. 1969. *World Without Time: The Bedouin*. New York: The John Day Company, Inc.
Ovadia, E., 1992, pp.). 1992. "Domestication of the ass and pack transport by animals: a case of technological change," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, vol. 10, *Monographs in World Archaeology*, pp. 19-28. Madison: Prehistory Press.
Patai, R. 1978. "The culture areas of the Middle East," in *The Nomadic Alternative*, *World Anthropology*. Edited by W. Weissleder, pp. 3-40. Paris: Mouton Publishers.
Peterson, M. A. 2000. The long walk II - 'For as long as I can remember anthropology has been reinventing itself': an interview with Donald Powell Cole. *Nomadic Peoples* 4:7-19.
Potts, D. T. 1990. *From Prehistory to the Fall of the Achaemenid Empire*. Vol. 1. *The Arabian Gulf in Antiquity*. Oxford: Clarendon Press.
Powell, G. L., M. M. Geib, and A. Spengler. 1975. *Atlas of the Middle East*. Dubuque: Kendal Hunt.
Richerson, P. J., M. B. Mulder, and B. J. Vila. 1996. *Principles of human ecology*. Needham Heights, MA: Simon & Schuster Custom Pub.
Robertshaw, P. 1989. "The development of pastoralism in East Africa," in *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, *One World Archaeology*. Edited by J. Clutton-Brock, pp. 207-214. London: Unwin Hyman Ltd.
Rosen, S. A. 1992a. "The case for seasonal movement of pastoral nomads in the Late Byzantine/Early Arabic period in the South Central Negev," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, vol. 10, *Monographs in World Archaeology*, pp. 153-164. Madison: Prehistory Press.
—. 1992b. Nomads in archaeology: a response to Finkelstein and Perevolotsky. *Bulletin of the American Schools of Oriental Research* 287:75-85.
Rosen, S. A., and G. Avni. 1993. The edge of empire: the archaeology of pastoral nomads in the southern Negev highlands in late antiquity. *Biblical Archaeologist* 56:189-199.
Saidel, B. A. 2000. "A preliminary report on the Bedouin Ethnoarchaeological Survey Project in southern Jordan," in *Annual of the Department of Antiquities of Jordan*. Edited by F. Al-Khraysheh, M. Zaghloul, and M. Shaer. Amman: Department of Antiquities, The Hashemite Kingdom of Jordan.
Shamekh, A. A. 1975. *Spatial Patterns of Settlement in Al-Quasim Region Saudi Arabia*. Lexington: The University of Kentucky Department of Geography.
Shemueli, A. 1984. "The desert frontier in Judea," in *The Changing Bedouin*. Edited by E. Marx and A. Shmueli, pp. 17-38. New Brunswick: Transaction Books.
Sherratt, A. 1980. Water, soil and seasonality in early cereal cultivation. *World Archaeology* 11:313-330.
—. 1983. The secondary exploitation of animals in the Old World. *World Archaeology* 15:90-104.
Shilov, V. P. 1989. "The origins of migration and animal husbandry in the steppes of eastern Europe," in *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, *One World Archaeology*. Edited by J. Clutton-Brock, pp. 119-126. London: Unwin Hyman Ltd.
Simms, S. R. 1988. Archaeological structure of a Bedouin camp. *Journal of Archaeological Science* 15:197-211.
—. 1997. Tur Imdai rockshelter: archaeology of recent pastoralists in Jordan. *Journal of Field Archaeology* 24:459-473.
Simms, S. R., and K. W. Russell. 1996. *Ethnoarchaeology of the Bedul Bedouin of Petra, Jordan: Implications for the Food producing Transition, Site Structure, and pastoralist Archaeology*.
Smith, A. B. 1992. *Pastoralism in Africa*. London: Hurst & Company.

Smith, S. E. 1978. "The environmental adaptation of nomads in the West African Sahel: A key to understanding prehistoric pastoralists," in *The Nomadic Alternative*. Edited by W. Weissleder, pp. 75-96. The Hague: Mouton Publishers.

Swetnam, J. 1999. ""Hydrophilia" and "Aerophobia" as determinants in residential site location -- An ethnoarchaeological reconnaissance of Wadi Feinan Jordan 1." *Meetings of the American Anthropological Association, San Francisco, 1999*.

Tani, Y. 1989. "The geographical distribution and function of sheep flock leaders: a cultural aspect of the man-domesticated animal relationship in southwestern Eurasia," in *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, *One World Archaeology*. Edited by J. Clutton-Brock, pp. 185-199. London: Unwin Hyman Ltd.

Thomas, P. K. 1989. "Utilization of domestic animals in pre- and protohistoric India," in *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, *One World Archaeology*. Edited by J. Clutton-Brock, pp. 108-111. London: Unwin Hyman Ltd.

Uerpmann, H. 1996a. "Animal domestication-accident or intention?," in *The Origins and Spread of Agriculture and Pastoralism in Eurasia*. Edited by D. Harris, pp. 227-237. London: UCL Press.

Uerpmann, H.-P. 1989. "Animal exploitation and the phasing of the transition from the Paleolithic to the Neolithic," in *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, *One World Archaeology*. Edited by J. Clutton-Brock, pp. 91-96. London: Unwin Hyman Ltd.

—. 1996b. "Animal domestication-accident or intention?," in *The Origins and Spread of Agriculture and Pastoralism in Eurasia*. Edited by D. Harris, pp. 227-237. London: UCL Press.

Vajnshtejn, S. I. 1978. "The problem of origin and formation of the economic-cultural type of pastoral nomads in the moderate belt of Eurasia," in *Nomadic alternative*. Edited by W. Weissleder, pp. 127-136. The Hague: Mouton Publishers.

Vierra, R. K. 1983. "Data management for the reconstruction of occupational surfaces," in *Prehistory of the Ayacucho Basin, Peru*, vol. 4. Edited by R. S. MacNeish and Robert S. Peabody Foundation for Archaeology., pp. 16-21. Ann Arbor: University of Michigan Press.

Weir, S. 1990. *The Bedouin*. London: British Museum publications.

Weissleder, W. 1978. *The Nomadic Alternative: Modes and Models of Interaction in the African-Asian Deserts and Steppes*. Paris: Mouton Publishers.

Western, D., and T. Dunne. 1979. Environmental aspects of settlement site decisions among pastoral Maasai. *Human Ecology* 7:75-98.

Winnett, F. V. 1937. *A study of the Lihyanite and Thamudic inscriptions*. *University of Toronto studies. Oriental series no. 3*. Toronto, The University of Toronto Press,.

—. 1949. *The Mosaic tradition*. *Near and Middle East series ; 1.* Toronto: University of Toronto Press.

—. 1957. *Safaitic inscriptions from Jordan*. *Near and Middle East series ; 2*. Toronto: University of Toronto Press.

Winnett, F. V., and G. L. Harding. 1978. *Inscriptions from fifty Safaitic cairns*. *Near and Middle East series ; 9.* Toronto ; Buffalo: University of Toronto Press.

Winnett, F. V., and W. L. Reed. 1970. *Ancient records from North Arabia*. *Near and Middle East series 6*. Toronto: University of Toronto Press.

Winnett, F. V., J. W. Wevers, and D. B. Redford. 1972. *Studies on the ancient Palestinian world; presented to Professor F. V. Winnett on the occasion of his retirement 1 July 1971*. Toronto, Buffalo: University of Toronto Press.

Wright, N. C. 1954. "Domesticated animals in desert areas," in *Biology of Deserts*, pp. 168-172. London: Institute of Biology.

Young, W. C. 1996. *The Rashaayda Bedouin: Arab Pastoralists of Eastern Sudan*. Fort Worth: Harcourt Brace College Publishers.

Zarins, J. 1989. "Pastoralism in southwest Asia: the second millenium BC," in *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, *One World Archaeology*. Edited by J. Clutton-Brock, pp. 127-155. London: Unwin Hyman Ltd.

—. 1992. "Pastoral nomadism in Arabia: ethnoarchaeology and the archaeological record-a case study," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, vol. 10, *Monographs in World Archaeology*, pp. 219-241. Madison: Prehistory Press.

Zohar, M. 1992a. "Megalithic cemeteries in the Levant," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, *Monographs in World Prehistory*. Edited by O. Bar-Yosef and A. Khazanov, pp. 43-65. Madison: Prehistory Press.

—. 1992b. "Pastoralism and the spread of the Semitic languages," in *Pastoralism in the Levant: Archaeological Materials in Anthropological Perspectives*, *Monographs in World Prehistory*. Edited by O. Bar-Yosef and A. Khazanov, pp. 165-180. Madison: Prehistory Press.
Zohary, M. 1962. *Plant Life of Palestine*. New York: The Ronald Press Company.
—. 1973. *Geobotanical Foundations of the Middle East*. Vol. 1-2. Stuttgart and Amsterdam: Gustav Fischer Verlag and Swets & Zeitlinger.