



**Environmental History at an Early Prehistoric
Village: An Application of Cultural Site Analysis at
Beidha, in Southern Jordan**

Journal of GIS in Archaeology, Volume I

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Environmental History at an Early Prehistoric Village: An Application of Cultural Site Analysis at Beidha, in Southern Jordan

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Introduction and Overview

Beidha is located within the World Heritage Site of Petra, in southern Jordan. It is well known among archaeologists as a site that displays many of the most important attributes of settled village life at a very early time. Among these attributes is the use of masonry architecture. Diana Kirkbride excavated Beidha in the late 50s and early 60s, with a final field season in 1983. Her findings at the site have been used to define the cultural period known as the Pre-Pottery Neolithic B.

Notable among the cultural developments associated with the Pre-Pottery Neolithic B is institutionalized animal domestication. Plant domestication is associated with the Pre-Pottery Neolithic A, just previous in the chronological sequence established by Kirkbride and other archaeologists of her time. Kirkbride found a Natufian occupation below the Pre-Pottery Neolithic B settlement at Beidha. The Natufian occurs just prior to the Pre-Pottery Neolithic A, and therefore, just before plant domestication.

In 1999, the author began a cultural site analysis of Beidha and its environs.¹ Cultural and environmental data sets were collected and used to produce themes in a GIS. A major objective was to investigate how cultural and environmental changes were related during

¹ The analysis was funded through an American Center of Oriental Research (ACOR) Near and Middle East Research and Training Program (NMERTP) post-doctoral research fellowship. Technological support was provided through the US/ICOMOS Cultural Site Analysis Initiative, which was established through the ESRI Conservation Program. Much of the remote sensing data used in the analysis had been collected and analyzed since 1997 in collaboration with Dr. Talal Akasheh of the Hashemite University of Jordan as a part of an ongoing effort to establish and enrich a geographical information system (GIS) database for the Petra World Heritage Site. Al Qantara, a nonprofit research organization affiliated with the University of Palermo, conducted geological and environmental studies and mapping with use of GPS in support of this research. Dr. Paolo Madonia supervised the activities of Al Qantara. The NASA Jet Propulsion Laboratory provided SIR-C/X-SAR radar data that was used in the analysis.

the transition from a nomadic, hunting and gathering way of life to a settled lifestyle that included dwellings constructed for occupancy over many years. Environmental parameters pertinent to this at Beidha were found to include topography, environmental variation, diverse geology, soil composition, and distributions of key plant and animal species. It is argued here that the environment at Beidha offered great rewards to human populations that elaborated social institutions and practices that had developed during the Pre-Pottery Neolithic A. Elaborations took the form of the institutions and practices most associated with the Pre-Pottery Neolithic B (e.g., animal domestication, differentiated architecture, craft specialization, and production of artifacts associated with ancestor cults). Finally, increased and more effective exploitation of certain resources might have led to the abandonment of Beidha as these resources became depleted. This is suggested in that, although Beidha is reoccupied just as precipitation and humidity peak during the Climatic Optimum (rendering the site attractive to human habitation), it is depopulated approximately 1,000 years before the climate once more declines significantly in temperature and precipitation.

Cultural Site Analysis

The archaeological landscape analysis of Beidha was conducted according to the general procedures established by the author as a part of the US/ICOMOS Cultural Site Analysis Initiative. Cultural site analysis is a method for identifying natural and cultural features that are relevant to human use of an area and increasing understanding of the specific ways in which natural and cultural features are codetermined. It considers (Comer, 1999):

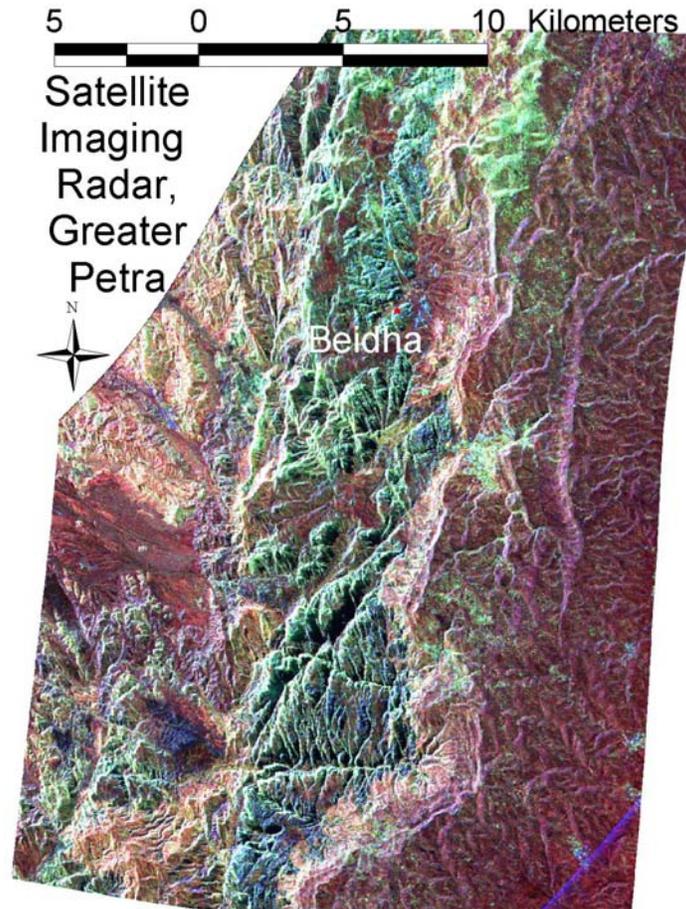
- Environmental parameters
- Information retrieved through archaeological excavations and the study of historic sites (and associated documents)
- Traditional use areas
- Current infrastructure (e.g., roads and utilities) and condition of the landscape

Findings pertinent to cultural and environmental changes associated with the transition to a settled way of life are outlined below.

Environmental Parameters

Environmental parameters were investigated by (1) analysis of satellite and aerial remote sensing imagery, (2) fieldwork during which geologic features and soils were studied and analyzed, (3) interviews with local populations, and (4) review of previous studies of the environment including the distribution of plant and animal species domesticated by the Pre-Pottery Neolithic inhabitants of Beidha.

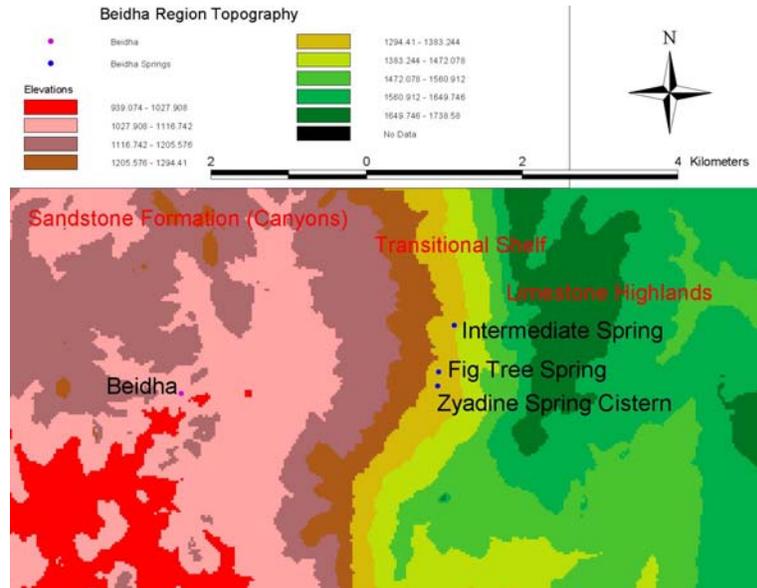
Figure 1
Radar Image of Greater Petra Area



Analysis of SIR-C/X-SAR radar data collected by the space shuttle Endeavour in 1994 of the environs of Beidha revealed three distinct geological zones and an important transitional area between two of them. On the right (east) of the image created from this data (Figure 1) is a limestone formation from the Cretaceous Era, 100 million B.P., which appears as a wide, generally smooth, deep purple band; in the middle lies the Cambrian/Ordovician sandstone formation (ca. 450 million years old) appearing bluish-green, cut through in many places by canyons of varying widths; and to the far left, alluvium, which appears as a band of variegated purples, greens, and tans. Between the limestone and sandstone appears a thin bright line representing a disconformity between these two geologic zones. Important aspects of this geologic structure are illuminated by topographic data.

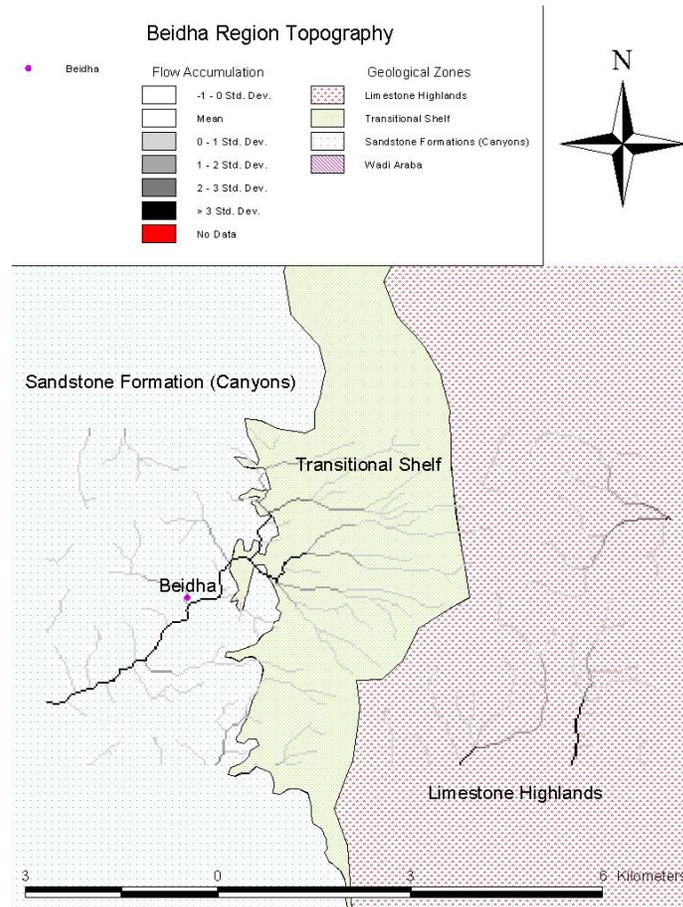
A digital elevation model (DEM) produced by Dr. Talal Akasheh from aerial stereo pairs was used to produce the elevation model seen in Figure 2.

Figure 2
Beidha Region Elevation Zones



As can be observed, elevations are more than 1,700 meters in the highlands formed by the Cretaceous limestone. Elevations in the canyon system found in the Cambrian sandstone are about 1,000 meters, and Beidha itself is at 1,040 meters. The alluvium seen in the radar image (which falls outside of the DEM) slopes away to the west to approximately sea level when it reaches Wadi Araba, the extension of the African Great Rift. Combining information extracted from the radar analysis and the DEM, a hydrological model was constructed, seen in Figure 3. As can be seen here, any precipitation sufficient to produce runoff would be channeled near the location of Beidha. Indeed, Beidha seems ideally situated to harvest runoff, yet it is protected from flooding to some degree because of a large rock formation that is located between the site and the water channel (or *wadi*) and by the fact that the elevation of the village is somewhat higher than that of the surrounding canyon floor.

Figure 3
Beidha Region Geology and Hydrology



Soil samples were taken at the site at locations plotted on Landsat images. Future use of these samples will be to develop signatures for soils of different chemical composition. The significance of the samples to current site interpretation is discussed below

Archaeological Excavations

Archaeological excavations conducted by Diana Kirkbride were reported both by her (1966, 1968, 1989) and by Brian Byrd (1987), who participated in the final field season in 1983. Excavations discovered a Pre-Pottery Neolithic B occupation from about 7,500 to 9,200 B.P. Also discovered were earlier occupations, from about 11,000 to 11,300 B.P. and 12,000 to 12,500 B.P., both of which were Natufian.

The Natufian occupations are best characterized as hunting encampments. Great quantities of *caprine* bone were recovered. Some of this was ibex (*Capra ibex*), but Kirkbride's analysis indicated that most was the Bezoar goat (*Capra aegagrus*), the ancestor of the domesticated goat. Only a few artifacts indicated collecting of wheat and barley, grains that were later domesticated at Beidha. Just two grinding artifacts and a

few sickle blades and nongeometric lithics mounted in sickles to form harvesting implements were found. The only features discovered were hearths and roasting areas, the latter found in association with large animal bones. Absent were walls, structures, storage facilities, burials, and stone paving.

Seven levels were found in the later Pre-Pottery Neolithic B occupation at Beidha, each displaying architecture of increasing sophistication. Round and somewhat irregularly shaped structures of the earliest levels (levels VII–V) change by steps into the more regular, strictly rectilinear structures of Level III. Rooms are increasingly differentiated into storage rooms, work shops, and living areas. Other signs of rapidly increasing cultural complexity lay in flora and fauna recovered. Kirkbride wrote in 1989 that barley constituted most of the botanical material she recovered from the earliest level with permanent buildings (Level VI). Carbonized plant remains and imprints in clay roofs and walls established that *Hordeum spontaneum*, the wild, hulled two-row barley, was being cultivated. She could say at that time that, "This cultivation of wild cereals is a stage in the process of domestication that was known of theoretically, but had never yet been demonstrated in the field" (1989:120). Similarly, Dexter Perkins, who conducted the analysis of the faunal material recovered by Kirkbride, wrote that "...the Madamagh-Beidha faunas strongly suggest that goats were domesticated at Beidha during the Neolithic" (1966:66).

Traditional Use Areas

Traditional uses of an area that occur in the present day can provide clues as to how the area was used in the more distant past. Sets of resources may remain similar. If these have been exploited successfully in the past by certain technological and social practices, use of such practices may continue. Furthermore, occupancy by groups with similar cultural structures can be intermittent. The archaeological record in countless places demonstrates that groups with technologies and social organizations similar to those of past inhabitants often take occupancy of an environmental niche when conditions there return to those that existed when it was inhabited in the past. (A case in point is the intermittent Natufian occupation of Beidha.)

The valley in which Beidha is located is now occupied by Amareen and Bdul Bedouin. A family group has taken up residence just outside the fenced-in area excavated by Diana Kirkbride. This group is headed by Ali Ed-Badbul. Much of what is said here about traditional uses of the area are based on observation, which has been clarified by asking questions of Mr. Ed-Badbul. The location of the Ed-Badbul tent, for example, was selected largely because it was a high place, well-drained, and away from the course of the wadi, which is subject to flash flooding. The family also markets trinkets to tourists, but since visitation to Beidha is not yet heavy, Mr. Ed-Badbul says that income derived from this activity is not the primary motivation for occupying the site. Among other attractions, it is in an area of the canyon where rock fall is less frequent (a preliminary survey of locations of Bedouin tents by Al-Qantara indicated that all in the immediate canyon system were located where sandstone was more mechanically sound than elsewhere). The Bedouin tend to establish camps in Beidha Canyon in the summer, when cool breezes from the limestone highlands are amplified in velocity as they are channeled through canyons. In fact, weddings are typically scheduled for this time of year, when families tend to congregate in the area. For those who stay all year, the canyons offer protection from cold winds that tend to come from the north in winter. Canyons are

warmed by the sun on the north side, which is the preferred location of year-round habitations.

Family groups own goat herds and farm certain fields. The Ed-Badbul family obtains seed from an individual who also tills the soil prior to the first planting. Crops are divided equally with this person. Children tend goat herds and are responsible for keeping them out of fields owned by other families when crops are growing. Hoof prints in fields are inspected by those tending fields, and herds that have produced prints can be identified in this way. The head of a family who tends a field in which prints have been found will pay a visit to the head of the family who own the goats that produced the prints. Tea will inevitably be offered by the host and in the course of the ensuing conversation the guest will mention that he observed hoof prints in his field that were not made by his goats. This will usually suffice to alert the host to the problem. The host will then generally take steps to ensure that his goats are kept out of his guest's fields. If not, today the family who owns the field being damaged can take legal steps to correct the situation. After fields have been harvested, goats are allowed into fields to eat stubble. Goats will also be allowed into fields to eat plants if the crop fails because of lack of precipitation. Bedouin are aware that goat droppings provide fertilization to fields.

Current Infrastructure

As late as her last field season in the early 1980s, Kirkbride noted that no agriculture was occurring in the valley where Beidha is located; she assumed that agriculture was, therefore, not possible given the current climatic conditions. What, then, makes agriculture possible today? One factor is that water is now brought to the valley and environs by truck and used to fill ancient Nabataean cisterns. Some of these cisterns have been restored by the German preservation organization, GTZ. While this water is not used for irrigation, it is used to water goats and for cooking and washing. Thus, systems of delivery and storage of water have improved. Better transportation systems might also have increased access to farm machinery, seeds, and other supplies that render occupation of the site more practical.

Informing an Environmental History Through Cultural Site Analysis

Table 1 shows the periods during which Beidha was occupied in relation to climatic and cultural periods. These periods constitute the variables. Geology and topography have changed little. Soils may have changed but have retained key characteristics that derive from geology and topography.

Table 1
Chronology of Beidha Occupation

Time B.P.	Period	Settlement Size	Plant Domestication	Animal Domestication	Beidha Occupied?	Climatic Period	Climate
14,000						Late Glacial Maximum	Cold and Dry
13,000					No	Allerød Amelioration	Warmer, Wetter than Glacial
12,000	Natufian	Small	No	No	Yes		
11,000					?		
10,000					Yes		
10,000	PPNA	Large	Yes	No	No	Younger Dryas	Cold and Dry; Return to Glacial
9,000	PPNB	Varied	Yes	Yes	Yes	Climatic Optimum	Rapid Increase in Warmth and Humidity for first 500 yrs., then Warm and Humid
8,000					No		
7,000					No	Mid-Holocene Climate Change	Cooler, Drier

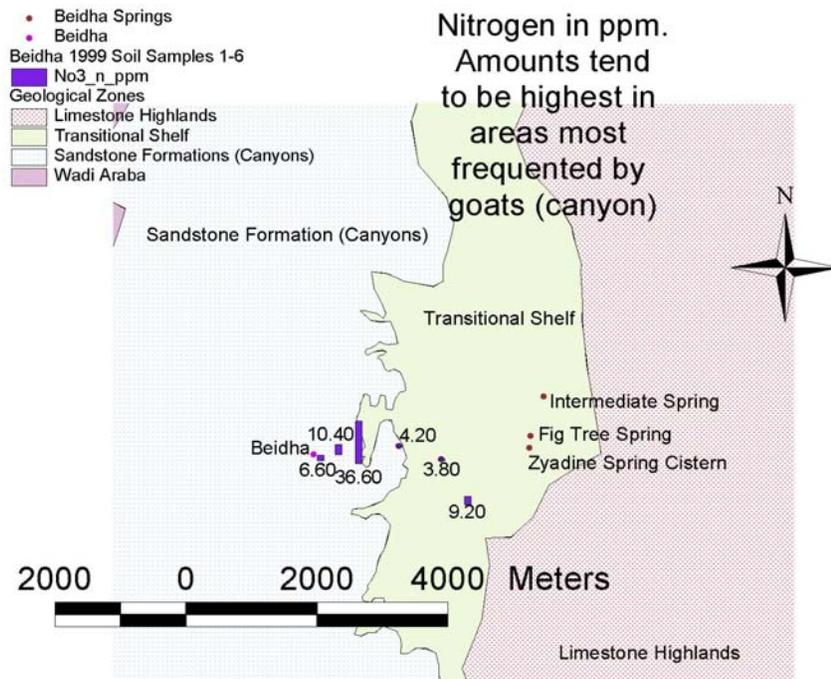
What is most immediately noticeable as one regards this chart is that periods of occupation correspond closely with periods of wetter and warmer climate. The Natufian occupations occur during the Allerød Amelioration and the PPNB in the Climatic Optimum. During these periods, water would very probably have been present at the site. Figure 3 demonstrates that any runoff would have been channeled near Beidha and into the canyon system in which Beidha is located. As well, springs might have occurred near Beidha during these periods, as water falling on the limestone highlands migrated through rock and surfaced at fissures or other disconformities.

Bruce D. Smith places the native range of *Capra aegagrus* somewhat to the north of Beidha (1998:59). For this reason, he has questioned the classification of faunal material taken from Beidha as *Capra aegagrus*, wondering if the material might actually represent *Capra ibex*. Modern day inhabitants of the canyon in which Beidha is located, however, have found it to be an environment highly suited to the domesticated strain descended from *Capra aegagrus*, so long as water is brought into the canyon. Thus, it seems as likely that faunal remains recovered from Kirkbride's excavations were in fact *Capra aegagrus*, as she claimed, and that the species was drawn south by increased precipitation, which brought water to the canyon.

Recall, also, that Kirkbride thought that certain faunal remains retrieved from PPNB levels at Beidha represented an intermediate phase between wild and domesticated goats (1966:66). From this, it would seem that the animal domestication that is one of the hallmarks of the PPNB was being established as a cultural practice during this occupation. Plant domestication was established earlier, during the PPNA, at sites that have in common a high water table (Smith, 1998:74). As noted by Bar-Yoseph and Meadows, "In the Near East...where we have our earliest evidence for the domestication of food species, there is no site known in which the herding of domestic animals can be shown to have taken place without the population having had access to cultivated plants" (1995:83). Although the sequence seems well established, the question as to what induced populations to make this next step into cultural complexity remains. Culture is a means by which human populations remake the world according to what they invariably perceive as immutable patterns, and is, therefore, as many anthropologists have noted, essentially conservative (see Comer, 1996). The transition from a reliance upon domesticated plants to a reliance upon both domesticated plants and animals would have been, however, been an especially logical one at Beidha, with adequate precipitation there. Populations of *Capra aegagrus* were, as indicated by archaeological findings, drawn farther south into the sandstone canyon system in which Beidha is located. Social institutions developed during the PPNA, including those that dealt with alienable property and rights to the use of territory, could have been extended from the cultivation of plant species to the husbandry of animal species.

The juxtaposition of areas suitable—and in fact, synergistic—to both endeavors might have reinforced the first developments taken toward this transition. Soils developing from limestone are generally those best suited to agriculture (Gregg Young, personal communication). The limestone highlands just to the east of Beidha would have produced soils rich in potassium and phosphorus, and mitigated acidity. All soil conditions necessary to a good grain crop would therefore have been provided, with the exception of nitrogen. The ability to control the activities of goat herds would have provided this needed nitrogen. As in the present day at Beidha, with appropriate social practices, herds of goats can be kept from consuming crops while they are growing but allowed to consume stubble when crops are harvested. Moreover, goats are attracted to high protein plants, which is to say plants rich in nitrogen. After scouring the landscape for such plants, goats can be kept in fields yet to be planted, where they will provide nitrogen fertilization in the form of droppings. That this is occurring in the present day is indicated by Figure 4, which displays nitrogen levels along a line of soil tests taken from the canyon in which Beidha is located to the upper elevations of the limestone highlands. Note that levels are highest within the canyons where herds of goats are kept. These levels would be sufficient to produce a good grain crop (Young, personal communication).

Figure 4
Beidha Area Soil Nitrogen



Cultural practice, then, played a role in the development of plant and animal domestication as surely as did the opportunities provided by climatic fluctuation and landscape characteristics. It should be noted, as further evidence of this, that, in the chart below, human occupations are not precisely aligned with time periods established as producing environments most conducive to occupation, that is, times of increased precipitation and temperature. Natufian occupations, for example, do not begin until midway through the Allerød Amelioration. The PPNB occupation, although it begins just as warmth and humidity peak after the first 500 years of the Climatic Optimum, ends well before the conclusion of the Climatic Optimum. In both cases, this might indicate overriding cultural factors. In the latter instance, one might suspect degradation of some essential aspect of the environment after intensive occupation over many hundreds of years. Testing of such a hypothesis must await future research.

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