On the Frontier: Looking at Boundaries, Territoriality and Social Distance with GIS

Thomas G. Whitley[1]

[1] Brockington and Associates, Inc.
Atlanta, Georgia, USA
tomwhitley@brockington.org

Abstract. Archaeological spatial analysis is a typically normative process. We tend to focus on the centralized locations of "things" such as sites or artifacts at the expense of identifying and evaluating "buffer zones" or boundaries. But how do we measure interactions between neighbors? Are there ways in which we can evaluate, understand and explain the creation and implementation of buffers, boundaries, territories, and trade routes? This paper will address means of extracting objective measures of "social distance" and relating them to the landscape in general. The perspective will be from an "immersive" point of view and one in which cognitive decision-making is emphasized. Several examples will be presented to illustrate the concepts.

1. Introduction

As we witness the more ubiquitous application of GIS in different areas of archaeology, there tends to be a point at which the technology has outdistanced the interpretative or theoretical profundity of the research. As an example, applications in mainstream North American archaeology often use GIS as a mapping-organizational device, rarely as an analytical tool, and almost never for behavioral interpretation (cf. Verhagen et al. 1995:188–189; Harris and Lock 1995:349). This means that most archaeological spatial analysis is still done the same way as before the advent of GIS, only now it is done faster and more effectively. Although the diversity of ways in which spatial data is displayed has increased, few of those ways actually suggest innovative ideas for causally explaining human behavior.

The real advantage of GIS is its ability to function as a powerful set of analytical and interpretive tools that can help bridge the gap between material culture and cognition (Wheatley and Gillings 2002:18–20). This requires a fundamentally different means of application, and the incorporation of theoretical structures from other spatial and cognitive disciplines; such as psychology and human geography (e.g. Kitchin and Blades 2003). With innovative approaches we have the ability to address causality (cf. Salmon 1998) and to begin to understand and explain complex spatial archaeological contexts. We need to encourage exploratory ways in which GIS and related technologies can contribute to the current theoretical and interpretative debates in archaeology. One of these ways is through the examination of spatial boundaries.

But what do we mean when we talk about boundaries? There are many different ways in which cultures, societies, ethnic groups, neighbors, and families assign territorial ownership and interface with each other; and here I am talking about spatial interaction *between* communities, not within-group social roles or diversity (e.g. Stark 1998). From large scale political borders to small scale urban neighborhoods, such spatial boundaries have both conceptual and physical attributes.

Prehistoric people envisioned territorial boundaries in the same way as others have historically and as we employ today. Archaeologists, however, have often used only the simplest interpretations in their models of social interaction. Diffusion of genetic material, technology and subsistence practices, as well as goods and artifact stylistic traits, have long been topics of concern for archaeologists. But few studies have examined the ways in which the people involved may have cognitively conceptualized of the advantages and limitations to their social interaction.

2. Crisp Boundaries

In general terms, we can describe three "crisp" categories of spatial boundary. The term crisp is used in the same sense here as its application in fuzzy logic (cf. Zadeh 1965) and fuzzy systems modeling (e.g. Yager and Filev 1994), where membership in a category (in this case cultural ownership) is absolute. These can be defined by the classification of neighboring land units, and include; adjoining, overlapping, and buffered territories (Figure 1).

2.1 Adjoining Territories

Most commonly envisioned, is the creation of simple adjacent polygons to represent adjoining territories. Such polygons can be characterized as belonging to the "container model" of space (Lakoff and Johnson 1980). Note that at this point we are talking about synchronic space, not a representation through time. With such containers, cultural affiliation in an archaeological context is generally determined by artifact or feature attributes associated with key or indicator sites located primarily in the central region of the container.

Clusters of sites with such attributes are used to create an understanding of each group's "home range" or principal

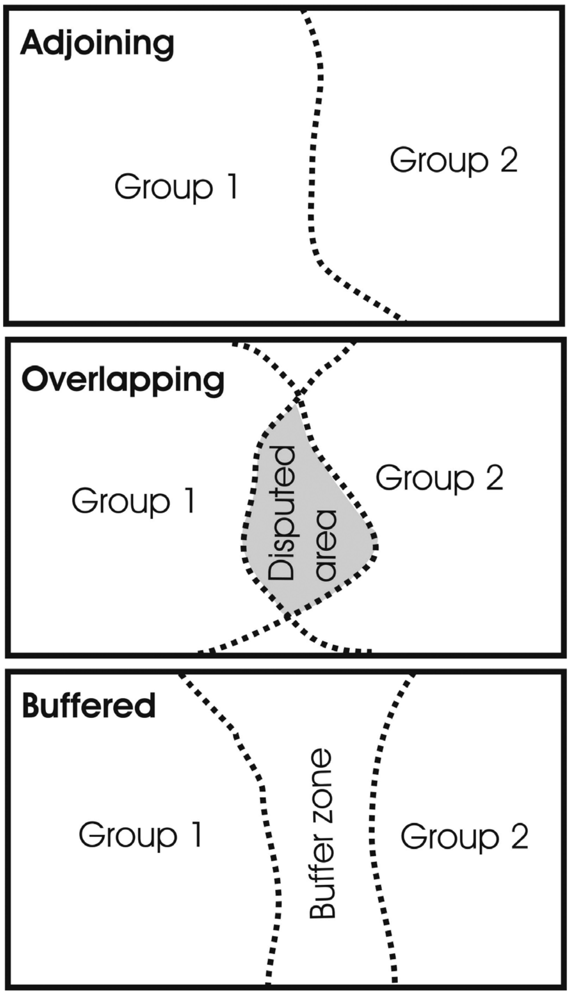

Fig. 1. Classification of neighboring land units.

settlement strategy. Centrality may be used to identify which affiliation is represented in the polygon as a whole, but the assumption is made that ownership does not change until the boundary is reached.

Today, we see crisp adjoining territories as the principal means of defining nation-states, and they are typically used on political maps of the world. Such borders are also generally defended by the military, and passage through them is often highly regulated. Thus they tend to be linked to highly visible physical characteristics (such as rivers or mountain ranges), absolute conceptual markers (such as longitude or latitude lines), or include constructed barriers (such as walls or fences). They are also punctuated by gateway communities which tend to regulate and subsist off of trade relationships.

Archaeologically, crisp adjoining territories might be most easily identified by the presence of constructed barriers or distinctive natural impediments. But it should not be assumed that the presence of such must represent definitive territorial markers. We are often quick to assign *de facto* cultural significance to major linear features, especially rivers and mountain ranges, but even such ephemeral ones as watersheds (which are typically not visually discernible much less a physical impediment).

Perhaps a more distinctive archaeological characteristic would be to find the remnants of military outposts. Such remains might indicate that there was an intent to prevent someone from either coming into, or leaving, a defined territory. A strong assertion of sovereignty is a clear sign that territorial ownership is conceptually absolute, at least in the minds of one of the archaeologically represented populations.

2.2 Overlapping Territories

A second common boundary type is that of overlapping territories (see Figure 1). These typically are represented in archaeological applications once again as crisp polygons, but they differ in that they share territory between them. This may occur as disputed regions, claimed by both populations, but it may also be envisioned as distinctive of changing territories through time. In fact, when typically applied in an archaeological context overlapping polygons are most commonly used to represent the latter.

In situations where two or more cultural groups share territory there are fewer potential opportunities to establish permanent military centers or trading communities. Since the territory and its resources are shared, there is little incentive for exchange, except in the case of goods which may be exotic to one or more of the groups.

2.3 Buffered Territories

Like the adjoining and overlapping categories, buffered territories can be defined by crisp natural or cultural markers (see Figure 1). However, unlike the other two, buffered cultural groups are conspicuous by their lack of interaction. Each of the affiliations assigned to two or more cultural groups may be defined by physical or constructed barriers, but between them is a zone which is claimed by no one. This "no-man's land" is usually an area of low resource utility or one in which the costs of acquiring resources is so high that there is little benefit to those which might be extracted.

Today, buffer zones usually occur in inhospitable regions with few visible landmarks (such as the Arabian and Saharan Deserts, where political borders are often portrayed as vague shaded areas) or in regions where conflict has been so intense that an artificial buffer was created to reduce negative interaction (such as the demilitarized zone between North and South Korea).

Prehistorically, population levels may have been such in many regions that buffer zones were quite common even in areas where resource productivity was actually quite high. As population levels increased and groups began to more commonly encroach upon each other, buffer zones would have diminished in size and frequency.

3. Fuzzy Boundaries and Point Fields

Crisp boundaries are, however, mere simplifications of the way in which people actually identify and cognitively assign spatial ownership. To understand the conceptualization of space we need to consider several additional factors. The first is that none of these categories are truly mutually exclusive; any one boundary may include areas of joining, overlap, and/or buffering. Secondly, the assumption that such boundaries must be thought of as crisp is misleading. There are other ways in which boundaries and territories can be conceptualized; such as fuzzy interfaces.

A fuzzy boundary is not absolute, nor is it mutually exclusive. Instead, membership in the category ranges on what we might classify as a scale of 0 to 100 percent. For example, given overlapping territories such as a shared resource area, one might consider a land unit to be 37 percent affiliated with one cultural group and 63 percent with another. For that matter, affiliation between three or more groups is also possible.

Granted, people do not wander around on the landscape calculating what percentage affiliation they have with their current location. Instead, they measure their spatial ownership in more immediately tangible or pragmatic terms; such as how likely they are to encounter neighboring groups, or the relative distance they are from their home or some other spatial landmark. Cultural affiliation diminishes with distance from the nearest known territorial marker. In essence, this is the "point field" concept of spatial cognition; originally discussed in the context of linguistic terminology (Lehman 1980; Bennardo and Lehman 1992), and currently seeing some intriguing applications in archaeology (Herdich 2002; Herdich and Clark 1996).

Where we generally think of linear territorial markers (such as rivers, roads, or mountain ranges) as providing a limit beyond which contained ownership does not extend, the point-field concept envisions markers spread across the landscape to which affiliation is attached. As distance increases from those points, ownership diminishes. Boundaries are derived between competing point fields on the basis of their relative "strengths" (Herdich 2002:5–6). Likewise, as Herdich (2002) has illustrated, cultural affiliation may diminish through time and must be re-strengthened through some means of emphasizing relationships with those landmarks.

Although most of the point field research has focused on Oceania and Southeast Asia, as a European example we might look at megalithic monuments as possibly representing something quite similar. The barrow tombs spread across the English landscape are considered to be indicators of the socially elevated status of elite individuals (e.g. Ashbee 1970; Midgley 1985). They are, along with henge-type monuments, conspicuous landmarks which may have been employed as point field cultural and territorial markers.

Rather than assume that such landmarks were contained in discrete culturally defined polygons, it is possible that they were the focal points by which groups, families and even individuals identified their cultural affiliation. The strength of that association is a measure of social distance, and this is, in essence, the nature of *attractors*. This term (derived from complexity theory) has many qualities which are useful in archaeology (cf. Whitley 2000).

4. GIS Modeling of Fuzzy Boundaries

Now, what kind of effect can this discussion have on archaeological applications using GIS. To start, we need to consider that most GIS applications are still inference-driven. Meaning data is compiled first and inferences are derived in such a way that hypotheses are created regarding the nature of that data. Additional data is then used to verify or refute those hypotheses. However, this is untenable when discussing many theoretical ideas about agency and cognition (see Whitley 2003). Since ideas of agency and cognition often deal with infrequent phenomena, or ones which leave little or no archaeological component, the "propensity" or "frequency" notions of probability do not apply (cf. Salmon 1998:204–205).

Instead, we should be developing theory-driven notions of how past spatial cognition *may* have affected the cultural landscape and following that up with detailed spatial models (cf. Church et al. 2000). Then we should compare the preserved and revealed archaeological record to those modeled landscapes. To do so we need to create ways of quantifying social distances (such as cultural ownership).

4.1 Quantifying Territoriality

One of the easiest ways of portraying fuzzy territoriality in a point field format is with a direct linear distance evaluation. Fig. 2 depicts several autonomous social landmarks, weighted equally, with linear distance value mathematically transformed into a representation of cultural affiliation. As one progresses away from the landmark cultural ownership of each land unit decreases (illustrated here by increasingly darker values). At some point (shown by the black lines) affiliation with one landmark decreases to a point where it is equal with the next. In an absolute adjoining container space, this is where a political boundary would be placed.

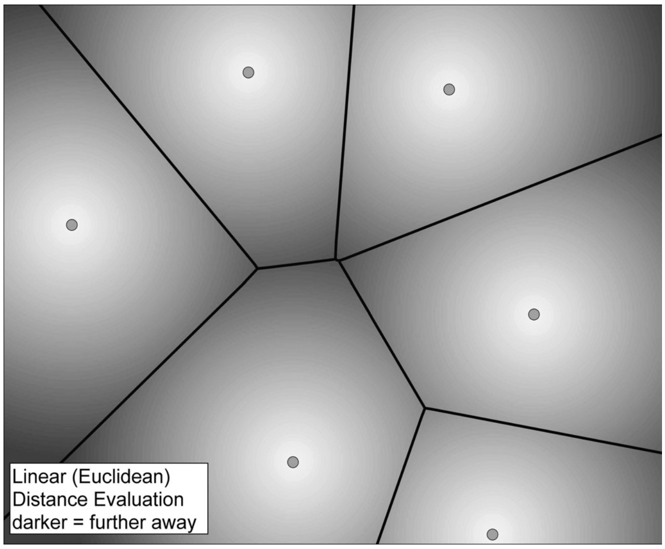

Fig. 2. Autonomous social landmarks.

Variations on such a surface can also be created with exponential or logarithmic transformations. But probably the most appropriate means of transformation is through the use of a cost weighted distance evaluation (Fig. 3). With simple distance, the assumption is that any location in the spatial manifold is as easily accessed as anywhere else. With a cost-weighted distance evaluation, things like terrain slope, surface conditions and vegetation, as well as physical and social barriers or prohibitions, can be considered as mitigating

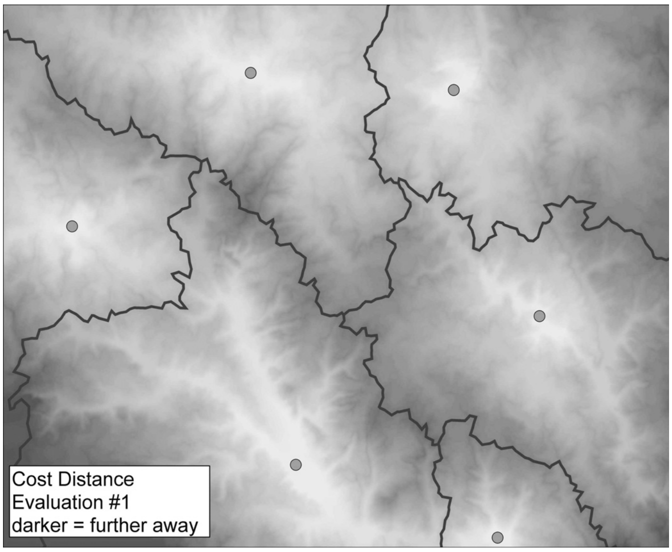

Fig. 3. Cost weighted distance evaluation.

factors in the assessment of social distance. Bear in mind that these do not have to be strictly negative cost variables, but may also be positive benefit attractors, such as resource distributions. Thus, this is more accurately a cost-benefit weighted distance evaluation.

In Fig. 3 the surface topography has been used to create a cost-benefit weighted distance evaluation which was then (using the same formula as Fig. 2) transformed into another representation of territoriality. This kind of assessment more closely matches the egocentric frame of reference (cf. Hart 1981) because cost-benefit weighted distance may be used as a representation of accumulated knowledge or familiarity. Adjoining territorial boundaries in such cases (represented by the red lines) more often fall along physical or cultural features in the landscape.

One example of incorporating a cognitive or cultural benefit attractor into this means of mapping territoriality would be to combine a visibility analysis with the topography and its costly physical attributes. In some settings, cultural ownership may be enhanced or strengthened by greater visibility (such as the viewshed from a hillfort). By combining a cost-benefit weighted distance evaluation with a viewshed analysis one can derive a surface which emphasizes increasing cultural affiliation with both nearness and visibility.

This is a two way street, though, since in some cases visibility may not necessarily be *from* the landmark, rather *to* the landmark. For example, the territorial influence of a megalithic monument may have been increased in areas where it was visible, even if they were further away than some areas in which it was not.

Such conceptual surfaces represent proxies for cultural ownership. We need not actually assume the presence of any defined boundaries since affiliation is fuzzy, but to illustrate the point, Figures 2 and 3 assume simple adjoining boundaries. When the presumed boundaries are overlaid in a single graphic (Fig. 4), you can see how variable they are based strictly on the methods of calculating weighted distance. Bear in mind also that, in this series of examples, I have affiliated territories with each single data point. However, there could just as easily have been several associated landmarks which would have created different spatial boundaries.

We can also limit the cost-benefit weighted distance evaluation to a chosen threshold value and create territories which produce natural buffer zones (Fig. 5). This may be useful for envisioning trade corridors (especially in conjunction with least cost path evaluations) or social interaction during periods of lower regional population. Fig. 5 illustrates this concept using an arbitrary cutoff value of 2500 cost units; meaning that anything greater than this set cost-benefit weighted distance away from the landmark is too far for cultural ownership.

If social distance can be calculated from each point collectively, then it is also possible to weight them individually. This is done by setting the maximum threshold to different values according to their hypothesized relative strengths. The results could represent different levels of social importance, or as with an attempt to increase one's social standing, the efforts of a chieftain or king to strengthen his

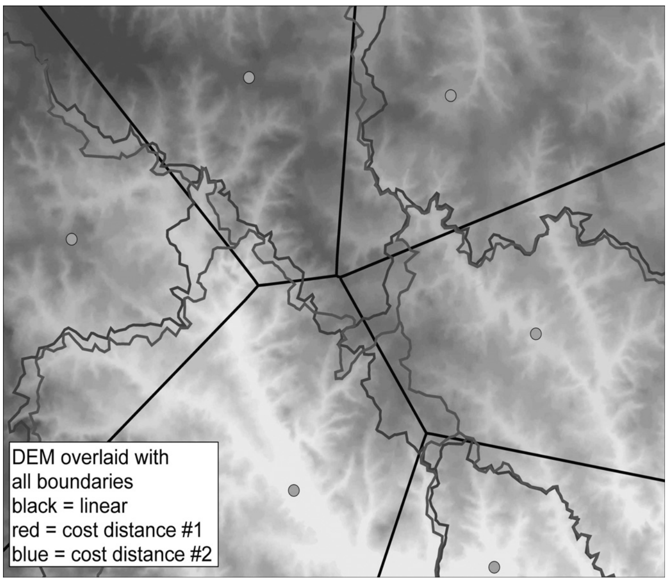

Fig. 4. Graphic with boundaries overlaid.

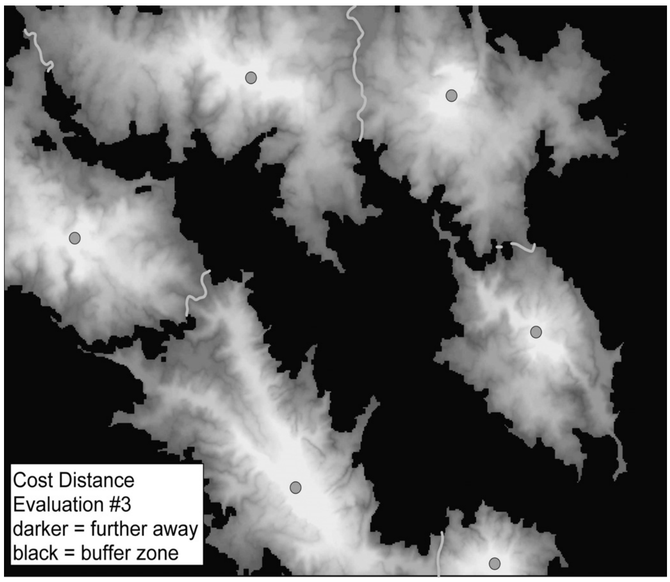

Fig. 5. Cost-benefit weighted distance evaluation.

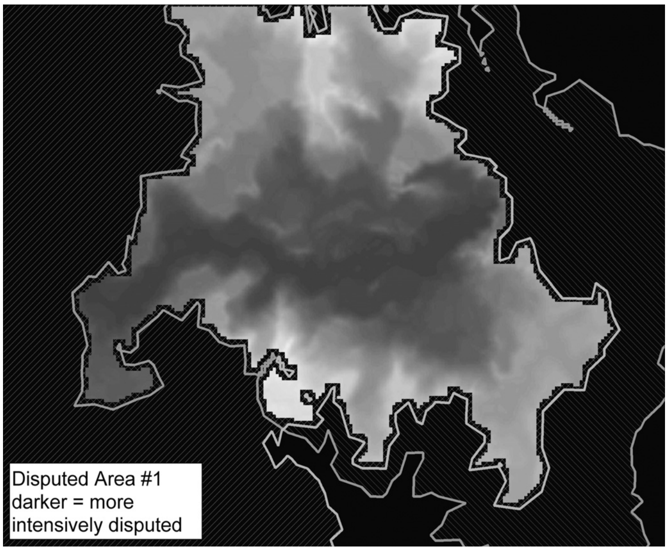

Fig. 6.

power or authority. Since individual threshold values create overlapping boundaries, potential areas of territorial sharing, opposition or conflict can be identified.

A closer examination of one such area (Figure 6) illustrates the variability in the intensity of the potential dispute. By intersecting the two grid surfaces a composite cost-benefit weighted evaluation shows areas within which cultural interaction is more likely to occur. This may take the positive form of increased trading, or the more negative military conflict. Establishment of a well-defined crisp boundary by one of the cultural groups could represent an attempt to mediate such conflict.

Archaeologically, if two neighboring cultural territories have been modeled in such a way, I would expect that the presence of trading or military sites would be significantly higher in overlapping areas. This is an especially useful means of addressing decision-making in response to the risks of military engagement (see for example Whitley 2000:Chapter 8; and Whitley 2002).

5. Conclusions

The purpose of this paper has been to explore the idea that GIS has the capability to model much more than the physical or archaeological environments, it is typically used for. Eschewing the notion that scientific explanation must be deterministically derived (cf. Salmon 1998), we now have the ability to attach meaningful cognitive values to four-dimensional space-time. We also have the potential to control and manipulate such datasets to broadly and deeply enrich our interpretations of archaeological contexts. To do this we need to reinvigorate theoretical discussions on several fronts, as well as understand and incorporate such debates in other cognitive and spatial disciplines.

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