Detection of Body Dump Sites and Clandestine Burials: A GIS-Based Landscape Approach.

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Abstract

Forensic archaeology has been of inestimable help in the location and excavation of clandestine burials (Hunter 1996a:16-17, 1996b; Killam 2004; Levine et al. 1984). Landscape archaeology techniques have been adapted and widely applied for such purposes. In this article, an adaptation of one of the most common applications of archaeological GIS, that is predictive site location, is applied to the detection of body dump sites and clandestine burial sites, bringing together in the process the fields of landscape archaeology, forensic sciences, and GIS.

1 Introduction

Predictive site modeling can be described as the application of Geographic Information Systems (GIS) landscape analysis aimed toward the location of archaeological sites that have not yet been catalogued (Wheatley and Gillings 2002:165). The conceptual basis of this work is that body dump sites and archaeological sites locations are both subject to environmental and social conditionings and, therefore, they can be predicted using the same tools but adapting the model to the specific characteristics of each site. To illustrate this technique, a predictive clandestine burial site location map has been developed for the entire landscape of Leicestershire (United Kingdom). This model is not intended to offer a "ready-to-use tool." It can be employed as a base in which all different kinds of relevant data can be joined together, such as geophysical survey maps or data derived of the pertinent criminal investigations.

There is a substantial difference between general dump sites—in which the body may not be buried or concealed in some way—and burial sites. They require different theoretical approaches but, since the fate of the corpse is rarely known before it is located, both situations will be dealt with, at least in the first part of this analysis. The transportation and concealment of a victim's body from a murder scene to a dump site can offer great benefits to the murderer because most of the potentially revealing forensic evidence will be lost (Ressler and Shachtman 1992; Fox and Levin 1994:30-31; Simon 1991:78). As Rossmo has stated (2000:32), "concealment of the corpse was more likely in child abduction murders (52%) than in murder generally (14%)." In any case, corpse concealment percentages are significant and—as body search situations have a strong social impact—they demand a fast and efficient police reaction. It is for that reason that development of adequate tools for body searches is becoming an important field within forensic sciences.

2 A Perspective on the Subject

The application of GIS to forensic settings has a long history. A geographical approach to crime patterning has been around since the earliest developments of the discipline. As Phillips (1972) has illustrated, in 1830 the cartographic or geographic school already related social data such as wealth or population density to crime distribution. During the same century, physician John Snow was able to identify the geographical spread of cholera, tracing it back to a seaman traveling from the Far East (Snow 1855, in Ruffell and McKinley 2005:241). In the twentieth century, the work of Shaw and McKay (1942) mapping juvenile delinquency in Chicago stands as a landmark in the field of crime mapping.

The application of GIS in contemporary settings is both diverse and widespread. However, as Harries has stated (1999:129), "the literature on GIS in policing is almost exclusively dedicated to urban case studies. … the application of GIS to low density suburbs and rural environments is a new frontier and has been extremely limited." Those non-urban areas are precisely in the scope of this paper since they offer the best chances to conceal a body with high possibilities of not being immediately discovered. Kim Rossmo's (2000:175) data analysis gathered from 104 American body dump sites showed that most of those sites were in non-urban areas: 11.5% were found in Farms, fields or open areas; 20.2% in lakes, rivers, or marshes; 21.2% in forests or woods; 4.8% in hills or mountains; and 3.8% in desert or wasteland. Although different environments will influence the different means of body disposal, these data reflect the high percentage of non-urban dump sites.

The other aspect related to the modeling technique developed in this paper is the archaeological application of predictive site modeling. First developments of this technique were achieved in United States in the 1970s as a result of the interest of various government agencies in predicting the location of archaeological sites in large areas on the basis of data obtained from small surveys (Judge and Sebastian 1988). Predictive site location has been a highly criticized technique in the archaeological literature (Ebert 2000; Wheatley and Gillings 2002:166, 179-181; Woodman and Woodward 2002), not just because map data are not accurate enough and do not reflect small variations, but also because it tends to reduce cultural phenomena to a few measurable factors. However, many of the mistakes pointed out by Ebert (2000) about the current use of predictive archaeological site location are not applicable to the predictive modeling of buried or dump sites. First, contrary to what happens in "classic" archaeological predictive site modeling, in forensic burial searches there has not been any landscape change to acknowledge in the models. Second, site definition problems do not need to be considered when searching for a concealed body. Clandestine burials or body dump sites are not components of a system in the sense that they are not influenced by the location of other sites. Equally, they do not have a typology determining their function and, consequently, best locations for them to be found.

3 Data and Methodology

The first step in the development of this predictive model was a theoretical research into which factors would influence the offender's dump site choice. Some basic assumptions were extracted from the relevant literature and are enumerated here.

1. 1) Carrying of a corpse will necessarily require the use of a covered, motorized vehicle to the vicinity of the dump site. It has been commonly asserted that the majority of corpses have been found in close proximity to roads or parking areas (Streed 1989, in Killam 2004:17). Therefore, a search following the road network will have many more probabilities of success than a normal extensive search (Rossmo 2000:130).
2. 2) Due to physical limitations, the usual distance covered dragging a body is about 50 ft on plain terrain (McLaughlin 1974:28, Morse et al. 1983:6). Keppel and Birnes (1995) have estimated the maximum distance to carry a body to 150 ft, even though, they agree with the 50 ft estimate as the usual distance. Following Burton (1998), Rossmo (2000:130) states that child bodies, being much lighter, can be carried for 200 ft. Of course, this will vary depending with the slope, kind of terrain, vegetation, and other factors. Effectively, 90% of the bodies are recovered downhill because it is easier for the offender to drag the victim (Sacks 1999; Hunter 1996b:92; Robbins 1977; Cherry and Angel 1977). The fact that from the road the visibility downhill is poor can be equally important regarding the offender's choice of going downhill.
3. 3) Terrain slope can be also very important when the body is buried: an excessive slope will render difficult the process of digging a grave.
4. 4) As Killam (2004:17), following Streed (1989), has noted, "bodies are usually found off the right passenger side of the road, outbound from the city or town." That is an important clue: knowing the departure site of the offender is important in order to give priority to the passenger side of the road in body search activities.
5. 5) Most disposal sites are located within a 30-45 minute drive from the place where the body was picked up (Streed 1989, in Killam 2004:17). As Rossmo (2000:174) has shown, those sites are located at a mean distance of 33.7 km from the crime site. Fifty percent of those were located at more than 20 km. This data shows the wider distance range of body dump sites to which, consequently, is difficult to apply distance-decay parameters.
6. 6) Lakes, deep rivers, and canals traditionally have been disposal points (Killam 2004:16, 18). Returning to Rossmo's analysis (2000:175), of the 104 body dump sites considered, 20.2 % were located in rivers, lakes, or marshy areas.
7. 7) Other places in which people are prone to hide bodies are wells, shafts, mines, or any other pre-existing hole (Killam 2004:16, 18; Levine et al. 1984)
8. 8) It is possible to map those areas in which burial is feasible according to soil profile, land use, and underlying geology (Hunter 1996a:17 and 1996b:92).
9. 9) Obviously, the most feasible place to look for a victim's body will be determined by the crime's particular circumstances. The first places to investigate will be the suspect's properties (Killam 2004:14), mainly his or her residence. For obvious reasons, residences are not included in this project. Other urban areas are regarded as having low clandestine burial potential due to the high chance of the offender to be discovered.
10. 10) As Killam has suggested (2004:18), dump sites will be out of sight of neighboring houses, but, as bodies are usually discarded at night, they have to be easily accessible in the dark.
11. 11) The results of the criminal investigation will be determinant in the application of this model. Those investigations can reduce the global search area allowing much more detailed models to be created. Nonetheless, the collected evidence will be the ultimate basis for predicting the remains' location.
12. 12) Finally, in developing this map model, two assumptions were made. The first assumption was that the offender was working alone. Regarding American serial killers, Newton (1992) estimated that the 87% of them were unaccompanied in their crimes. The second assumption was that he or she was carrying the body from an urban nucleus where the crime was initially committed. As is commonly acknowledged, "higher population density means more potential for crime in a given area" (Harries 1999:128).

It was decided to develop just one model based upon these assumptions, but those variables can be easily interchanged to produce different models adapted to particular circumstances.

Once the factors influencing the offender's dump site choice are selected, the data representing those factors must be gathered. To develop an appropriate representation, different maps in different data formats were explored. The predictive model's information layers were obtained from the junction and selection of data found in the following maps:

- Ordnance Survey Meridian vector maps SK 20-23, 30-33, 40-43, 50-53, 60-63, 70-73, 80-83, 90-93 and SP 27-29, 37-39, 47-49, 57-59, 67-59, 77-79, 87-89, 97-99. From the processing of those maps the following layers were obtained: urban areas, roads, canals, and river.
- Ordnance Survey Panorama vector maps SK 20, 22, 40, 42, 60, 62, 80, 82, and SP 26, 28, 46, 48, 66, 68, 86, 88. Those panorama maps yielded the layers corresponding to lakes/reservoirs and contour lines, the later being used to create a digital elevation model (DEM).
- Several raster maps of the study area were selected from the British Geological Survey: Mines and quarries, Waste sites, Wells, Bedrock geology, Superficial depositions. From those maps the following layers were extracted: boreholes and type of soil.

The premises outlined above directed the work developed upon those layers. First, a series of buffers were created around urban areas covering a total distance of 21 km. Those buffers were classified in a graduated color scheme showing the increasing possibilities of burial occurrence as the offender moves away of populated areas. As explained above, urban areas were classified as having a low possibility of clandestine burial occurrence. Another buffer was created around small populated areas at a distance of 200 m, as it was thought that the offender would not operate under sight of an inhabited place. The overall result can be seen in Figure 1b.

Second, a layer of road buffers covering the expected distance—45 m—for a body to be dragged from the car was created. Although literature shows that dump sites are found off the right passenger side of the road, those buffers were covering both sides of the road since the departure point of the offender is not known. This buffer layer was combined with the "distance to urban nuclei buffers" obtaining the predictive model of "close-to-roads clandestine burial" occurrence, according to the distance from urban areas (Figure 1c).

Third, the three layers containing information about

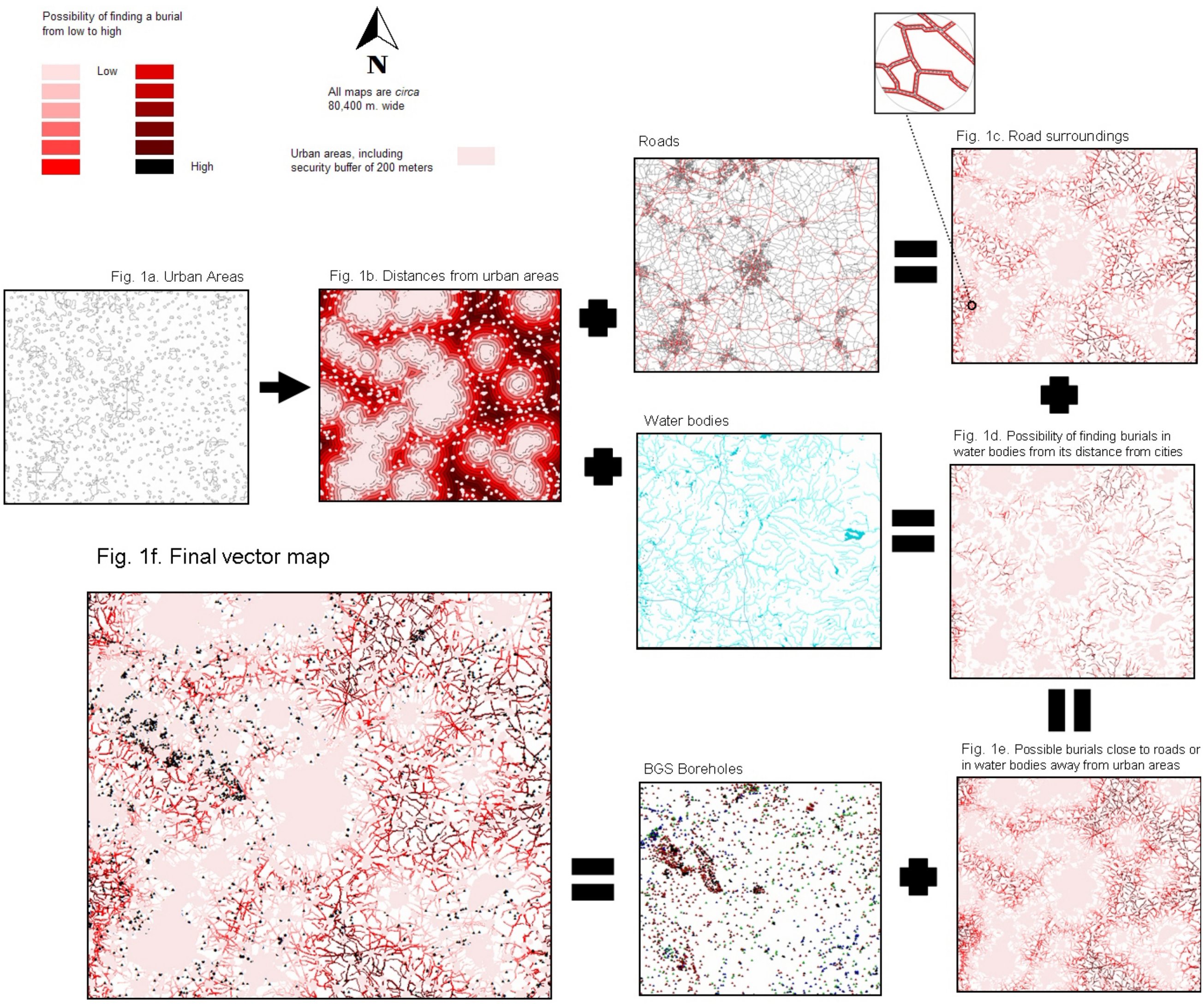

Figure 1. Stages in the development of the predictive vector model.

Fig. 2a

Fig. 2b

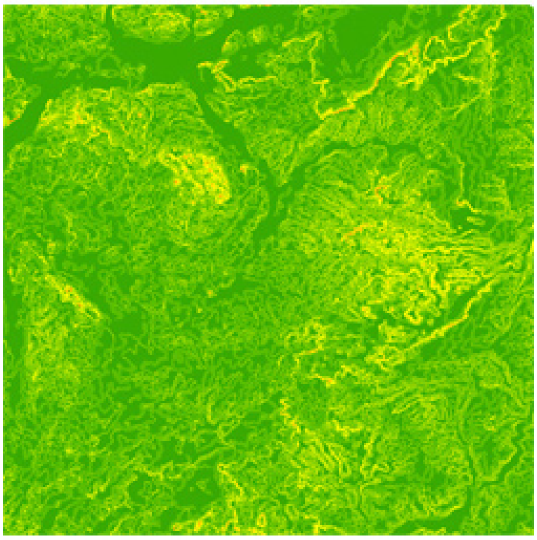

Fig. 2c

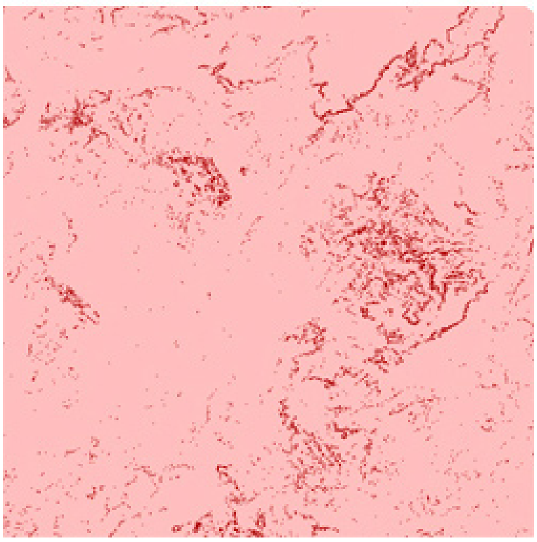

Figure 2. From DEM to sloped areas not allowing burials.

water bodies—river, canals, and lakes/reservoirs—were joined together and this resulting layer was also combined with the "distance to urban areas" buffer in order to create a disposal occurrence in water bodies, according to the distance from urban areas (Figure 1d).

The next step consisted of joining together both resulting roads and water bodies' layers in one layer reflecting the possibilities of finding a clandestine burial in water bodies or in close proximity to roads, according to the distance from urban areas (Figure 1e).

Finally, those layers extracted from the British Geological Survey mapping the location of boreholes—wells, mines, quarries, and waste sites—joined together with the map showing the possibilities of finding a burial close to roads or in water bodies. This map will be the vector map basis for prediction of clandestine burial occurrence (Figure 1f).

Over this vector background—suitable for the analysis of both body dump sites and clandestine burials sites—a series of different raster layers can be implemented for the exclusive location of burial sites. This can be done regarding the necessary terrain characteristics to dig a grave: it is difficult to dig in slopped terrain and, in the same way, soil must be deep and soft enough. Adding those variables to the vector map, clandestine burial site locations can be significantly reduced.

From the DEM (Figure 2a), the slope angles for the entire landscape (Figure 2b) were calculated. This layer was then reclassified in two categories: less than 10º of slope was regarded as suitable and more than 10º as non-suitable (Figure 2c).

Equally, those maps obtained from the BGS (bedrock geology and superficial depositions) were reclassified in suitable and non-suitable soil. As Hunter (1996a:17) has stated, "why, for example, search an area of landscape where the bedrock geology is too hard for burial and the soil cover too thin?"

Other kind of raster maps, that have not been included in this model, can offer important insights in search planning and resource management. Digital geo-referenced orthophotos can be extremely useful. Because they offer more or less direct representations of reality, depending on their quality they can show data not represented in maps such as small buildings, disperse vegetation, or areas under cultivation—always important on planning search parties. Magnetic anomalies and gravity anomalies (both available from the British Geographic Survey) can offer important "advise" when deciding which kind of geophysical prospecting method is best to apply in a search area. In this sense, Hunter (2001) has noticed a tendency for police forces to employ geophysical search methods with little regard for the nature of the local environment. Also, vegetation cover maps will show forested areas, where strong tree roots will not allow burying the corpse but, in the case of a deciduous forest, the body may be hidden using leaves.

Following Locard's Exchange Principle—every contact leaves a trace; whenever two objects come into contact there is an exchange of material between them—additional utilities for the data embedded in those maps can be pursued. For example, it is possible to find samples of soil in the clothes, shoe soles, or car tires. This soil can be analyzed and thus the search may be reduced to areas with the same type of soil. It is even possible to process those same soil samples for pollen analysis and, thus, reduce the search to the areas displaying the appropriate combination of type of soil and vegetal environment.

4 Conclusion

The importance of a landscape approach to clandestine burial or body dump sites has been frequently stated (Hunter 1996a:17; Killam 2004:6). The implementation of GIS into landscape archaeology plus the development of forensic archaeology offers an excellent framework for the contribution of archaeology to crime studies.

Unfortunately, access to the actual data concerning the recovery of human remains in Leicestershire was denied because of victim's privacy reasons. This lack of data prevented the author from evaluating and, consequently, improving the model. In any case, it is believed that, with the appropriate data available, this location model can offer a good background to test the premises related to body dump sites upon which the model was constructed. It will also provide a useful query and analysis tool for the investigation of dump site patterns. As an example, by simply classifying the different dump sites according to the time passed since burial, one could obtain a picture of those more "successful" burials in terms of body concealment. These can then be analyzed in order to identify which features made them more difficult to be discovered than other dump sites.

With this model, a challenge to the classic approach to crime maps has been intended: landscapes are not two-dimensional. Three-dimensional (3D) maps have not been used in the creation of crime analysis models. Computer crime mapping is still imitating wall pin maps in many aspects. One of the possibilities of many GIS software packages is 3D spatial analysis. It is important to implement its use since people are constantly influenced in their choices by their physical environment, with elevation being one of the measurable variables. A good example of this is role of slope in the choice of a body dump site.

In the case presented, a study area covering 5,689 km^2 has been dramatically reduced to a few high probability spots. It is true that, regarding the large proportions of the area, those high probability spots are impossible to properly survey in the field. Nevertheless, with the addition of concrete data about the suspect, witnesses' reports, or any other kind of crime-related information, this model can form a good starting point.

The wide availability of the data needed to create this model, the decreasing prices of GIS packages, and the fast improvement in both price and analytical power of computers render model development a cheap, fast, and uncomplicated process. Future improvements in the quality of the map data and analytical capabilities of GIS tools will improve their predictive accuracy. This process will allow the development of more adequate theories and their subsequent testing and improvement.

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