A Geographical Information System (GIS) is a computer-based tool for collecting, managing, integrating, visualizing, and analyzing geographically referenced information. The use of GIS is scale-independent and may be applied to the study of archaeological data at the continental (or smaller) scale (e.g., Gkiasta et al. 2003; Holmes et al. 2006), at the regional or landscape scale (e.g., Bevan 2003; Howley 2007; Winterbottom and Long 2006), or for intrasite or larger-scale analyses (e.g., Bird et al. 2007; Craig et al. 2006; Marean et al. 2001; Moyes 2002). A number of related technologies overlap with GIS, including remote sensing, geodesy, and digital cartography, but are sufficiently distinct in their methods to warrant separate treatment. However, all these computer technologies can be grouped under the umbrella term of “spatial technologies.” These are linked to the emerging discipline of Geographical Information Science (GISc), which is more broadly concerned with developing integrated method and theory of the use of computer-based tools for building understanding of natural and social spatial processes. A parallel development in archaeology, better described as “computational archaeology” or “archaeoinformatics,” is similarly concerned with developing an integrated method and theory for archaeological computing.

The growth of GIS and its early expansion from geography into other social sciences, including archaeology, has been described as nothing short of a revolution. There are now a significant number of archaeologists—both commercial and academic—whose primary activity is using and developing GIS and related spatial technologies. This is partly expected and arises from our shared interest with geographers in understanding and explaining the spatial organization of human behavior and its complex, long-term, and multiscalar interrelationship with the natural world.

The purpose of this contribution is to outline the value and application of GIS to landscape archaeology and to outline a conceptual rather than practical introduction to the forms of GIS analyses that archaeologists have found useful. It is, in fact, impossible in a review paper to offer practical guidance on the implementation of the various techniques or indeed on the use of GIS itself: for this, readers are recommended to consult textbook-length works, such as Conolly and Lake (2006) or Wheatley and Gillings (2000). GIS software vendors also provide introductory learning tools for novice users: among the more helpful ones are those included in ESRI’s ArcGIS suite of programs. An alternative excellent free and OpenSource GIS is GRASS (Geographic Resources Analysis Support System: http://grass.itc.it/). This has a slightly steeper learning curve than some other desktop packages, but is a very powerful tool used by many academic and government agencies worldwide.
History and Development

The history of archaeology's engagement with GIS is well-documented and covered elsewhere (e.g., Lock 2003), so here it is necessary to highlight only a few pivotal moments. The archaeological use of GIS (as distinct from spatial analysis, vis-a-vis Hodder and Orton 1976) can be traced initially to a series of articles published in the 1980s on predictive modeling (Kohler and Parker 1986; Kwanme 1983, 1986, 1989). GIS was also being highlighted as a new method by Judge and Sebastian (1988) while computers were being used to visualize spatial data, such as artifact distributions and settlement patterns (e.g., Aspinall and Haign 1988; Boismier and Reilly 1988; Harris 1988).


In more recent years, archaeological GIS entered a more self-reflexive and critical phase that has addressed many concerns raised about its contribution to knowledge (as distinct from "information") (cf. Taylor 1990). For example, the relevance and meaning of viewsheds (Llobra 2001; Tschan et al. 2000), the validity of energetic least cost-surfaces for predicting movement (Bell and Lock 2000; Llobra 2000), issues of environmental determinism (Gaffney and van Leusen 1995), and the potential statistical errors in predictive modeling (Wheatley 2004; Woodman and Woodward 2002) have all received significant critical evaluation.

The end result is that, toward the end of the first decade of the new millennium, GIS is both sufficiently mainstream that it is no longer a unique selling point—the days of being told somewhat meaningless that a project will "undertake a GIS analysis" are thankfully gone—and its contributions to the study of past human behavior are also more substantive and theoretically aware.

Recent applications that have weathered the critical storm of the 1990s reflect these developments: for example, studies of visibility and movement are methodologically and theoretically more sophisticated (Bell et al. 2002; Lake and Woodman 2003; Llobra 2003; grappled with (Molyneaux and Lock 2006). As a parallel development, sources of bias and error in region-scale datasets, which are the bread and butter of a majority of GIS-based studies, are being addressed (Banning et al. 2006; Hawkins et al. 2003).

Applications

It is difficult to pigeon-hole GIS applications in archaeology neatly, but one useful division is to divide current usage into four areas: (1) collection and management of spatial data; (2) data visualization; (3) spatial analysis; and (4) quantitative modeling. In reality, GIS users may dart between all four areas seamlessly and have difficulty distinguishing when, for example, management becomes data visualization or when analysis becomes modeling. This grouping is thus used here only as a convenience to organize the range of applications that GIS offers to landscape archaeology.

Spatial Data Collection and Management. The first category concerns the use of GIS as a form of spatial database to manage archaeological information that possesses a strong spatial component (for example, arising from landscape survey). Much primary data in archaeology are now collected in digital form—for instance, from a total station or global positioning system (GPS) survey—or are converted into digital format by scanning or digitizing paper records. A large proportion of GIS work, especially within the framework of Cultural Resource Management (CRM), concerns the management and integration of these datasets (Conolly and Lake 2006: 33–50; Garcia-Sanjuan and Wheatley 1999). Although this may seem a pedestrian area of study, only through properly structured and managed databases can we identify relationships and patterns in a digital dataset. The near ubiquity of GIS usage for "Sites and Monument Records"—the term used in the UK for the archaeological records maintained by local government bodies—exemplifies the value of GIS for the maintenance of the primary record (Bevan and Bell 2004). Research projects are also increasingly reliant on GIS for spatial data management, to the extent that the research aims of many complex projects depend on GIS to scaffold the building of understanding of the complex interrelationships between multiscale spatial data (e.g., Barton et al. 2002; Bevan and Conolly 2004).

Much of the ability of GIS to manipulate spatial data so effectively is founded on its core geodatabase that stores and relates data within a common spatial framework (that is, within a specific map projection, such as Universal Transverse Mercator [UTM], or a national, regional, or local-common spatial framework, such as Universal Transverse Mercator [UTM], or a national, regional, or local-
representation, which constitutes the backbone of GIS, can be implemented in a variety of different ways, depending on the software in question. Spatial data may be represented by using a vector data model, in which spatial objects are defined discretely (that is, they are defined by their precise geometric location in space) using a combination of points, lines, or polygons constructed by one or more x, y coordinate pairs and the topological connections between them; or by using a raster data model, in which spatial objects are defined by a matrix of pixels (cells) of a defined size and shape. Virtually all modern GIS systems are able to manipulate both types of data models, and the choice of vector data or raster data is now based on the appropriateness of the model for representing the phenomenon in question, and the forms of analysis to which each is suited.

Accessing and retrieving data from a GIS typically involves a spatial query, which retrieves data on the basis of a spatial location, or relationship, which may be combined with additional nonspatial attribute criteria (for example, “find all survey units that contain bronze age ceramics that are located between 100 and 200 m elevation and within 1 km of the coast”). The interface for such queries is usually called from within the GIS program itself, and it has also increasingly common for archaeological organizations to mount their data on bespoke web interfaces to permit public access and interrogation of primary data. These may be built on web-GIS mapping software such as ESRI’s ArcIMS (www.esri.com/software/arcgis/arcims/index.html), the open source equivalent, MapServer (http://mapserver.gis.umn.edu), or through a combination of other technologies. An early but good example of the last type is the spatial search tool of the Archaeobotanical Computer Database developed by Tomlinson and Hall (1996). A more recent example is York Archaeological Trust’s The Archaeology of York Web Series, which uses an innovative mix of interactive maps and databases to publish excavation reports (www.yorkarchaeology.co.uk).

Finally, GIS users must be aware of the potential spatial errors that can arise during the collection of spatial data and/or the integration of data from different map projections and/or different scales of recording. A necessary part of spatial data management is the keeping of properly structured metadata that records such details as acquisition methods and spatial errors. Further details on these methodological issues can be found in Conolly and Lake (2006) and Wheatley and Gillings (2002).

**Spatial Data Visualization.** This area of GIS importance of the visual display of spatial data in archaeology. The many varieties of visualization techniques that arise from spatial technologies have provided archaeologists with new ways of examining and thinking about landscape data. It is useful to consider GIS as a tool for scientific visualization, because these basic yet critical techniques are instrumental for gaining understanding and insight into data patterns—archaeologists have always plotted data on maps to illuminate patterns, structure, and process. GIS and other spatial technologies offer a range of techniques in this regard, such as by facilitating the creation of distribution maps and then allowing these to be draped on aerial photographs; by manipulating remote sensing imagery to inspect the relationship between landforms and archaeological data; by viewing the structure in a network analysis of connections between settlements (Figure 56.1); by visualizing the spatial variability in soil type and its relationship to archaeological settlements (Figure 56.2); or simply by inspecting the patterning of artifacts across a survey area (Figure 56.3). The popularity of Google Earth for exploring the regional context of archaeological data (as well as for distributing data) is one of the more recent examples of the uses of this form of visual interrogation.

A further application afforded by GIS is the ability to visualize temporal change, either through “time slice” techniques or through more dynamic means, such as those developed by the University of Sydney’s TimeMap (www.timemap.net; Johnson and Wilson 2003). The latter provides a toolkit for visualizing temporal datasets through a variety of means, such as by filtering objects so that they are visible only within specific time ranges.

Remote sensing has created additional sources for the scientific visualization of archaeological
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Although considerable insight can be gained through these methods, they have yet to be developed sufficiently to have generated more widespread application than the few published examples cited here.

**Spatial Analysis.** GIS is often an entry point for landscape archaeologists into more sophisticated forms of spatial analysis than are typically encountered in desktop statistical packages. Although it is possible to work within GIS and not confront spatial statistics—that is, the engagement with a spatial dataset may begin and end with its compilation and visualization—this ignores a powerful set of tools for identifying and understanding spatial patterns and structure.

The form of archaeological engagement with the tools of spatial analysis can be loosely divided into three categories: those that are concerned with (1) spatial pattern analysis, (2) spatial structure within a spatial dataset, and (3) multivariate location analysis. All the techniques described below are available as plug-ins or extensions using third-party statistical tools.

**Spatial Pattern Analysis.** The first category pertains to questions about the type and degree of spatial arrangement (that is, deviation from random arrangement toward clustering or regularity), typically applied to point distributions (of artifacts, features, sites, and so on). Questions of this variety have a long history in landscape archaeology: early applications of Clark and Evans’s nearest-neighbor *R* statistic (Clark and Evans 1954) include Hodder and Hassell (1971) and Whallon (1974), and it has been used more recently by Ladefoged and Pearson (2000) and Perlès (2001: 134–38). More sophisticated techniques of point-pattern analysis include Ripley’s *K* (Ripley 1977), which deals more effectively with irregularly shaped sampling regions and multiscale distributions that are often encountered in landscape archaeology (Bevan and Conolly 2006). Membership of clusters can be identified by using techniques such as *k*-means, hierarchical cluster, or kernel density estimates: these and related clustering methods are defined in more detail in textbooks such as Conolly and Lake (2006) and Wheatley and Gillings (2002). Getis’s G* statistic (Ord and Getis 1995) can be used to identify “hot spots” in data compiled by enumeration units, such as sherd’s of a specific date within survey or excavation units. This has relevance for archaeological applications in which basic exploratory questions of the form “is my data clustered?” need to be answered. Contributions to the statistic (that is, the statistic’s *Z* score) can also be plotted to view the clustering and to aid in the identification of the patterning of the attribute in question (see Figure 56.4).

![Figure 56.2](image1) Location of archaeological sites in relation to soil agricultural potential.

![Figure 56.3](image2) QuickBird imagery draped over a digital elevation model (DEM). Black dots represent the location of prehistoric pottery (source: Antikythera Survey Project, www.tuarc.trentu.ca/asp).
Spatial Structure. Examination of the spatial structure within the attributes of spatially located objects is also important. An important test in this category is the degree of spatial autocorrelation in a spatial dataset. This term refers to the influence that proximity has on the similarity between pairs of observed values in spatial phenomenon (that is, the extent to which there is “patterned variation”). It has been applied in a variety of regional analyses from the size of artifacts (Hodder and Orton 1976) to radiocarbon dates (Kvamme 1990; Premo 2004; Williams 1993), although its wide applicability for understanding spatial structure in the archaeological record has yet to be fully exploited. A further tool for building understanding of spatial structure is offered by Geographically Weighted Regression (GWR), which provides a method for identifying and exploring the manner in which local regions deviate from global trends (Fotheringham et al. 2002). This relatively advanced technique is considered in further detail below, under the heading of statistical modeling.

Locational Analysis. Locational analysis is related to “site-catchment” analysis developed in the 1970s (Higgs and Vita-Finzi 1972; Vita-Finzi and Higgs 1970), insofar as the approach seeks to understand relationships between sites and their locational characteristics and how these change through time and space. GIS-based methods differ from early formations in their more rigorous and quantitative approach to isolating significant variables from those that are potentially significant. Locational analysis may be undertaken to build understanding of the factors that influence choice of site location (for example, to compare the logic of site choice in two periods of settlement in a defined region), or it may be the preliminary stage of a predictive model (described in the following section) to determine the probability of site locations in unsampled areas.

The form of quantitative analysis used in locational studies is distinct from spatial-pattern analysis and analysis of spatial structure insofar as it uses standard parametric and nonparametric statistics to assess the probability of an association between the phenomena in question. A simplistic example is an analysis that seeks to clarify the relationship between site location and soil type: numbers of sites found on different soils may be obtained from the GIS (as a basic query function) and this observation can then be compared either to several sets of random samples of points (that is, as in a Monte-Carlo simulation) or by deriving an expected distribution based on the amount of each soil type found in the study area. Parametric or nonparametric tests (such as Student’s $t$ or Kolmogorov-Smirnov, see Shennan 1997) are then used to establish the probability that the sites are not randomly located with regard to the variable in question.

Although analysis of site patterning against a single variable like this is rarely wholly informative of past behavior, the examination of many potentially significant variables against site location can provide insight into the combined factors that have measurable influence on the choice of location for settlements. For example, Woodman (2000) used

![Figure 56.4](image-url)
14 topographic and environmental variables, such as relief, aspect, angle of view, and exposure, as part of her study in Mesolithic site location. These (and other) variables that have been shown to be useful in locational analysis, such as terrain curvature, hydrology, and watersheds (Bevan 2003), are derived in GIS from digital elevation models. The creation of these datasets from digital elevation base maps, although straightforward, does require some understanding of sources of error in elevation models, and so further advice should be obtained from the sources cited previously.

Locational analysis may also encompass less formulaic variables, such as visual characteristics of a landscape, the presence of contemporaneous settlements (that is, “communities”), landscape potential for different types of subsistence activities, and spatial relationships to other cultural features, such as roads, known (or modeled) pathways, burial mounds, and other potentially significant features. Although archaeologists accept that experiential variables are also significant in influencing the choice and characteristics of settlement, they have yet to be widely used in GIS because of the difficulty of implementation (but see Wheatley and Gillings 2002: 166–68).

Modeling

One of the most exciting and least-developed areas of research in GIS-based studies of landscape is (mathematical) modeling. There are an enormous variety of contemporary approaches that can be characterized in this way, and only a sample that relate specifically to GIS and landscape studies can be highlighted. Current archaeological uses can summarily be reviewed in three categories: (1) statistical modeling, including predictive models; (2) cellular models, often based on topography, including visibility, movement, erosion, hydrology; and (3) agent-based models. There are additional approaches to modeling, such as social network analysis (e.g., Allen 1990: 175–210; Bentley and Shenman 2003; Broodbank 2000; Conolly and Lake 2006: chapter 11; Mackie 2001) and phylogenetic/geographic analysis (e.g., Coward et al. 2007; O’Brien et al. 2001) that have significance to regional studies in archaeology, but as these endeavors often take place independently of GIS, they are not considered here.

Statistical Models. Two related techniques that mathematically model the relationship between a dependent and independent (spatial) variable are spatial regression and geographically weighted regression (GWR). Like many of the history, achieving its most widely cited application in the definition of the strong correlation between the quantity of obsidian found at archaeological sites in southwest Asia and their linear distance from the geological source of material (Renfrew and Dixon 1976). Spatial regression has also been used to examine such phenomena as the spread of agriculture (Ammerman and Cavalli-Sforza 1971; Gkiasta et al. 2003; Pinhasi et al. 2005); the effect of changing surface visibility on artifact density in survey data (Fanning and Holdaway 2004); and the relationship between terrain curvature and prehistoric site location (Bevan 2003). GWR is a relatively new statistical technique that has yet to find widespread applicability in archaeology but is of growing importance in geography (Fotheringham et al. 2002). It corrects a source of error in standard regression when one is working with a spatially autocorrelated variable, by identifying local variability in global patterns, which is of potential importance in a wide range of landscape-based studies in archaeology. It also may deal effectively with “Simpson’s Paradox,” when two or more distinct local patterns are combined and collectively produce a potentially spurious global relationship. For example, the local variability within the global regression of early Neolithic radiocarbon dates against distance from Jericho (Gkiasta et al. 2003) is likely to hold considerable value for interpretations that seek to understand regional variations in the uptake of farming, and how these relate to different topographic and social contexts (e.g., Davison et al. 2006).

Trend surface analysis is another common GIS-based statistical model that has been used in archaeology, which takes as its input the values of a set of observations that are located in space and then attempts to generalize the rate of change across that space. Mathematically it is identical to a regression analysis in three dimensions, and the output can thus be viewed as a map that depicts the rate of change. Archaeological examples include Allen and Fulford (1996), Kvanme (1990), and Neiman (1997).

Finally, predictive modeling has been a traditional concern of GIS, partly because GIS is well-suited to the logic of this type of empirical investigation (Kvanme 1992). The principal of this approach is that there is explanatory value in the (typically environmental) variables related to site location and that their relative importance can be empirically derived (following the methods explained in “locational analysis,” above). Variables that are determined to have been important can then be combined quantitatively, usually through a modeling technique called linear logistic regres-
expresses the contribution of each variable to site location. Then, given any location on the landscape in which those variables can be measured, one can calculate a probability for site presence. Provided a training sample has been withheld, the accuracy of the model can also be determined.

Predictive modeling was one of the first applications of GIS-based statistical investigations of landscape data, but it has also come under the most scrutiny for its apparent environmental determinism (e.g., Gaffney and van Leusen 1995; Wheatley 2004, among others). However, it is still one of the most widely used approaches to the formal modeling of site location and has spawned a specialized literature within the CRM community (e.g., Westcott and Brandon 2000).

Cellular Models. Within this category are a range of diverse approaches that include environmental, movement, and visibility models. The manner in which these are constructed in GIS may be as simple as clicking on a tool-bar button (for example, as is the case if one wishes to derive a map of slope values from a digital elevation model/DEM, itself a cellular model of landscape) or by defining a few options such as the minimum size catchment for a watershed model before clicking on a menu item. Other models may require more extensive input variables, such as erosion models that may use a dozen or more parameters to calculate the rate of sediment flow across a landsurface.

Cellular models take one or more raster map layers as inputs and use a combination of neighborhood functions and/or matrix algebra (that is, “map algebra” in GIS terminology) to produce a new map. Each cell value in the output map may be derived from several input values. For example, the end product of a predictive model may be a raster map in which each cell expresses a value reflecting the local probability of site presence based on a large number of input maps (such as location of known sites, local soils, geology, elevation, slope, hydrology, and so on). Neighborhood calculations on raster maps work by deriving new values for each cell by looking to values of the surrounding cells. Neighborhood calculations can also be used to construct models of spatial phenomenon: for example, the slope of a landsurface may be derived from a DEM by establishing the maximum difference in elevation between one cell and its neighbors, and thus the vertical angle between them, and repeating the calculation. Hydrological models work in a similar fashion, but look for neighboring cells with the lowest value to establish flow direction. Other neighbor-

important in GIS, include filtering, smoothing, and enhancing visual patterns in image data by combining surrounding values in various ways (for example, such as running a moving window filter to replace locally high or low values in an image with the mean value of the cell’s surrounding eight neighbors). For example, a “high-pass filter” for emphasizing areas of change (that is, “edge detection”) in raster datasets can be created by subtracting a measure of local variability (typically the mean value of cells in a 3 x 3 cell window) from the original map (Conolly and Lake 2006: 200–01).

Other forms of cellular models use distance from one or more points to construct a new map layer. This is the basis for Theissen polygon models, commonly, if uncritically, used to estimate territorial boundaries around sites (e.g., Perlès 2001: 139–40). Cells are simply allocated to the nearest site, thereby creating a model of equidistant boundaries (e.g., Wilkinson 1998: fig. 6; Perlès 2001: fig. 7.9). (Note, however, that Theissen polygon modeling is now more usually performed as a vector than a raster operation, but the principle is the same.) Such models of “territoriality” are obviously a great abstraction of a more complicated past social reality, but they nevertheless provide landscape archaeologists with a starting set of possibilities about the social organization of settlements (Conolly and Lake 2006: 208–33).

A further application of cellular models to landscape archaeology concerns “viewsheds,” which are calculations of the potentially visible area from a defined spot on an elevation model, given a specified height of an observer and target. Viewsheds are derived from line-of-sight calculations that determine whether a target point is visible from an observer’s location. This calculation is repeated for every potential target within a defined radius, providing a map that identifies the visible areas (Figure 56.5). These are straightforward to calculate, with most GIS providing viewshed and/or line-of-sight tools, but there are some sampling biases that need to be taken into account with viewshed analysis, particularly the issue of edge effects (Conolly and Lake 2006: 229). In addition, background sampling of the visual characteristics of the landscape, usually by quantitatively comparing the viewsheds of several sets of random locations against the locations under investigation, is crucial to justify any claims that sites are preferentially located with respect to their visual affordances (e.g., see Jones 2006 for an example of where the lack of any background sampling seriously undermines claims of patterning). These
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A related approach to visibility is cumulative viewshed analysis (CVA), which calculates the number of “times seen” of a given location (Wheatley 1995), which has been applied to intervisibility studies of monuments (Lake et al. 1998; Wheatley 1995). Other approaches have developed methods for examining the morphology of the horizon from stone circles (Lake and Woodman 2003); for creating “fuzzy viewsheds,” which record an uncertainty value that expresses the potentiality of a target being seen (Fisher 1992; Ogburn 2006); and for extending the concept of CVA to a “total viewshed,” which calculates the “times seen” value for every cell in a study region (Llobera 2003). Total viewsheds are extremely computationally intensive, and have yet to see any practical archaeological application, but they do have potential significance for understanding the interrelationship between “viewscapes” and landscape features such as ancient monuments and pathways.

Finally, the derivation of movement has also been the subject of considerable interest, with several studies using GIS to construct “least-cost” path models. These are technically complex, because energy expenditure in movement is determined at a minimum by terrain and slope, with a host of other variables, such as headwind, contributing to difficulty. In GIS-based studies of movement, slope is usually used as the basis for generating a “cost-surface,” and these can be either isotropic (cost is the same in all directions) or anisotropic (cost varies depending on direction of movement). Anisotropic cost surfaces are more complicated to construct, because they require factoring the direction of movement in order to determine costs. Both models, however, have been used in archaeological investigations (e.g., Bell et al. 2002; Bell and Lock 2000; Harris 2000; Madry and Rakos 1996; Silva and Pizzio 2001). Theoretical issues of deriving and integrating movement into archaeological interpretation have also been considered by Llobera (2000).

Agent-Based Modeling. An increasingly important area of study is the integration of GIS with agent-based modeling (ABM), which has roots in the pioneering studies of modeling and simulation in the 1970s and 1980s (Clarke 1972; Renfrew and Cooke 1979; Sabloff 1981). Early applications of ABM used artificial landscapes within which agents with defined characteristics (for example, goals, movement, reactions) would interact and their collective behavior examined, often in order to understand the emergent properties of complex social systems (Kohler and Gumerman 2000). More recent applications, however, allow GIS maps to be used as the setting for agent interaction, permitting the agents to react and respond to real variability in the landscape and environment. Good examples of this approach include Lake (2000), who constructed a simulation model of hunter-gatherer land-use and its anticipated archaeological patterning to compare against the results of fieldwork, as well as papers in the volumes edited by Gimblett (2002) and Kohler and van der Leeu (2007).

A highly specialized area of research that requires some understanding of computer programming, the linkage of ABM to GIS is a potential breakthrough in modeling of past human behavior. It provides a means of examining how the combined effect of many individuals’ behavior (albeit in a simplified and abstract form) may lead to the sorts of emergent patterns we see in the archaeological record, such as changes in settlement patterns, the emergence of settlement hierarchies, or even changes in subsistence strategies. These “bottom-up” approaches to complexity suffer less from the criticisms that were leveled at the “top-down” systemic models of earlier decades (Bentley and Maschner 2003). Their application is a specialized area of archaeological investigation, but they may eventually provide significant insights into some long-standing archaeological problems that seek to understand the dynamics of, for example, settlement morphogenesis and emergent social

Figure 56.5 Viewshed analysis. (a) Location of observer on digital elevation model (darker colors indicate increasing altitude); (b) output map displaying areas of landscape visible and not visible to observer (source: Antikythera Survey Project, 2003), as well as in the general textbooks previously cited. Some of the most successful applications of viewshed analysis are drawn from the open moorlands of northern Britain (e.g., Fisher et al. 1997; Lake and Woodman 2000; Winterbottom and Long 2006).

Figure 56.5 Viewshed analysis. (a) Location of observer on digital elevation model (darker colors indicate increasing altitude); (b) output map displaying areas of landscape visible and not visible to observer (source: Antikythera Survey Project,
Conclusions

This brief review of the applicability of GIS to landscape studies should have provided sufficient detail on the range of archaeological questions and problems to which this technology is well-suited. It remains to be noted, however, that GIS has been subject to a fair amount of theoretical criticism from proponents of a landscape archaeology that are at times at odds with GIS. Specific oft-heard criticisms include GIS’s tendency to focus on environmental variables, leading to a revisitation of 1970s-style functionalism (Wheatley 2004); its conceptualization of space in a dehumanized, 2D Euclidean framework such that relationships between phenomena, especially cultural phenomena, are conceived of as mathematical (rather than experiential, contextual, or social) (see Llobera 1996; Thomas 1993: 25); a tendency of archaeologists interested in GIS to focus on explanations that are processual and behavioralist, rather than experiential and symbolic (Gaffney et al. 1996); the inability to represent in mathematical (that is, digital) format the subjective and experiential landscape with which past peoples are said to have participated (e.g., Tilley 1994: 9–11); and a tendency to use positivist approaches for developing understanding of archaeological data (Gaffney et al. 1996; Wheatley 1993).

Although it is true that environmental variables provide the starting point of much GIS work, many of these criticisms can be countered by demonstrating that understanding of the past does flow from the GIS-based approaches described above, as the many examples cited in this paper attest. There are, in addition, a number of researchers interested in integrating GIS to aid understanding of socially textured and politicized space: the work of Boaz and Uleberg (2000), Chapman (2000), Hamilton and associates (2007), Howley (2007), Maschner (1996), Zubrow (1994), and, outside archaeology, Robbins (2003), are particularly interesting in this regard. In addition, experiential space, particularly as related to vision and movement, is also developing from the pioneering work of Gillings (2005), Lake and Woodman (2003), Llobera (2000, 2003), Wheatley (1995), and Wheatley and Gillings (2000). Yet, it remains true that most of these examples and almost all other GIS work are undertaken within a strongly quantitative and empirical framework. Whether this is because GIS constrains the types of analyses that can be undertaken or because GIS attracts researchers who prefer to work within a more rigorously empirical paradigm is debatable, but it is likely to be a mix of the two. In any event, cannot be overemphasized. As this brief review shows, GIS provides both a powerful tool to think with and an intellectual environment for developing innovative forms of analysis that collectively help build understanding of the human past.

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