LANDSCAPE LINES

10

Geographic Information Systems

INTRODUCTION

Geographic Information Systems (GIS) are used to input, store, manipulate, analyze, and map spatial data. Although GIS is often considered a type of computer system, the first GIS systems involved manual techniques to perform some of the same functions now performed by computers. In the late 1960s, the noted landscape architect Ian McHarg popularized the technique of using transparent film map overlays to perform landscape analysis, about the time when computers were being configured with software for rudimentary mapping. Computers and GIS software have become much more sophisticated and can generate new data and maps far faster than is possible by hand. The utility of GIS in cultural landscape management is now universally recognized.

Perhaps because of its roots in landscape analysis, the analytical capabilities of GIS are considered among the most important uses of the technology. Given the necessary historic data, GIS can be a powerful tool for examining cultural landscape changes over time. For example, if a park has digitized historic land use maps that are appropriately georeferenced, GIS can overlay the historic data on current land use data to determine the magnitude and spatial extent of the changes. GIS can also model or predict various outcomes of different treatment alternatives presented in a Cultural Landscape Report (CLR).

Mapping, or cartographic output, is another important use of GIS, and is often valuable for more intuitive, less explicit, visual analysis. (See Figure 1.) For many years the quality of cartographic output available through GIS software could not equal that achieved with manual methods or computer aided drafting (CAD) systems. But this is no longer the case. Numerous mapping tools are now available in most GIS packages, including desktop systems, which offer the added benefit of being easy enough to learn and use for even non-GIS specialists.

GIS also offers an efficient method for storing and retrieving cultural landscape data. Unlike hardcopy maps, digital data does not decay over time (although the storage media may need to be updated), is easily copied with no loss of data quality, and requires little physical space. And while CAD systems may be just as effective in storing and retrieving spatial data, GIS is far superior for managing attribute information; that is, data describing spatial features, such as the year in which a building was constructed.

APPLYING GIS TO CULTURAL LANDSCAPE MANAGEMENT

The National Park Service (NPS) has used GIS extensively to document and analyze cultural landscapes. The system can provide cartographic models analyzing the effect of visitor use and assist planners in developing alternatives for a visitor facility or placing roads and trails. GIS can also be used for viewshed analysis in which the computer, using a digital elevation model, generates a data layer of all areas visible from critical points within a park. This data layer can then be used in conjunction with data about neighboring properties to predict how local planning, zoning, and development proposals might impact park views.

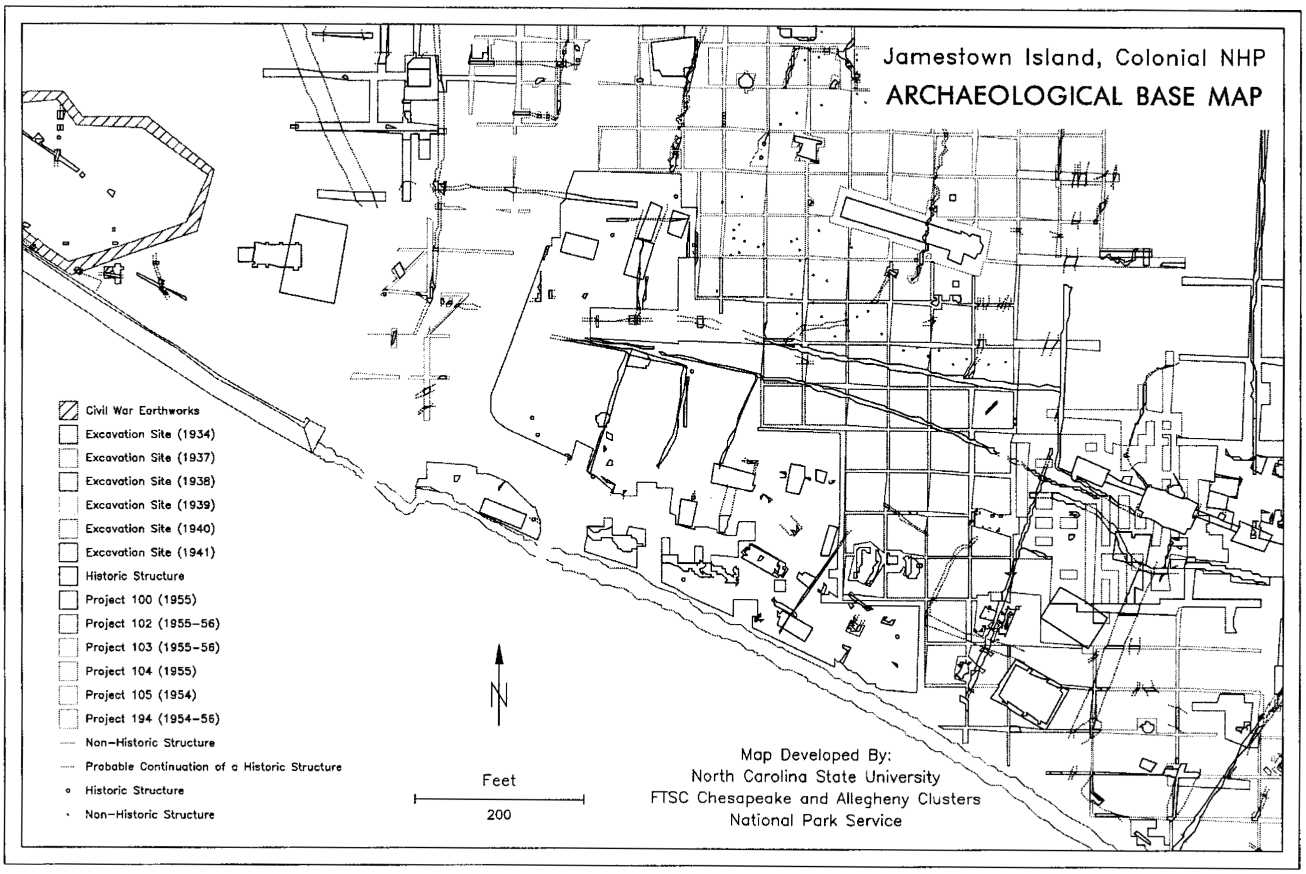

Figure 1. GIS map of an archeological survey. Jamestown National Historic Site. (Map courtesy of North Carolina State University, n.d.)

For example, Manassas National Battlefield Park used GIS to protect its viewshed. The park was able to simulate the effects of a proposed shopping mall and office development within view of the battlefield. This helped the NPS garner public support to oppose the development and eventually stop the project.

Inventories of park cultural features have often been facilitated by the use of GIS. (See Figure 2.) Using Global Positioning System (GPS) receivers, Richmond National Battlefield collected locations of all earthworks inside the park. The digital data was then entered directly into the park's database. The park also used GIS to inventory and monitor every tree in its historic orchard. Similar databases have been developed at many parks throughout the national park system.

Technical Considerations

Data

Data is a critical element in GIS and it represents the biggest investment of resources. None of the previously mentioned implementations of GIS in cultural landscape management would have been possible without good data. Poor or inadequate data can lead to erroneous results, which is often

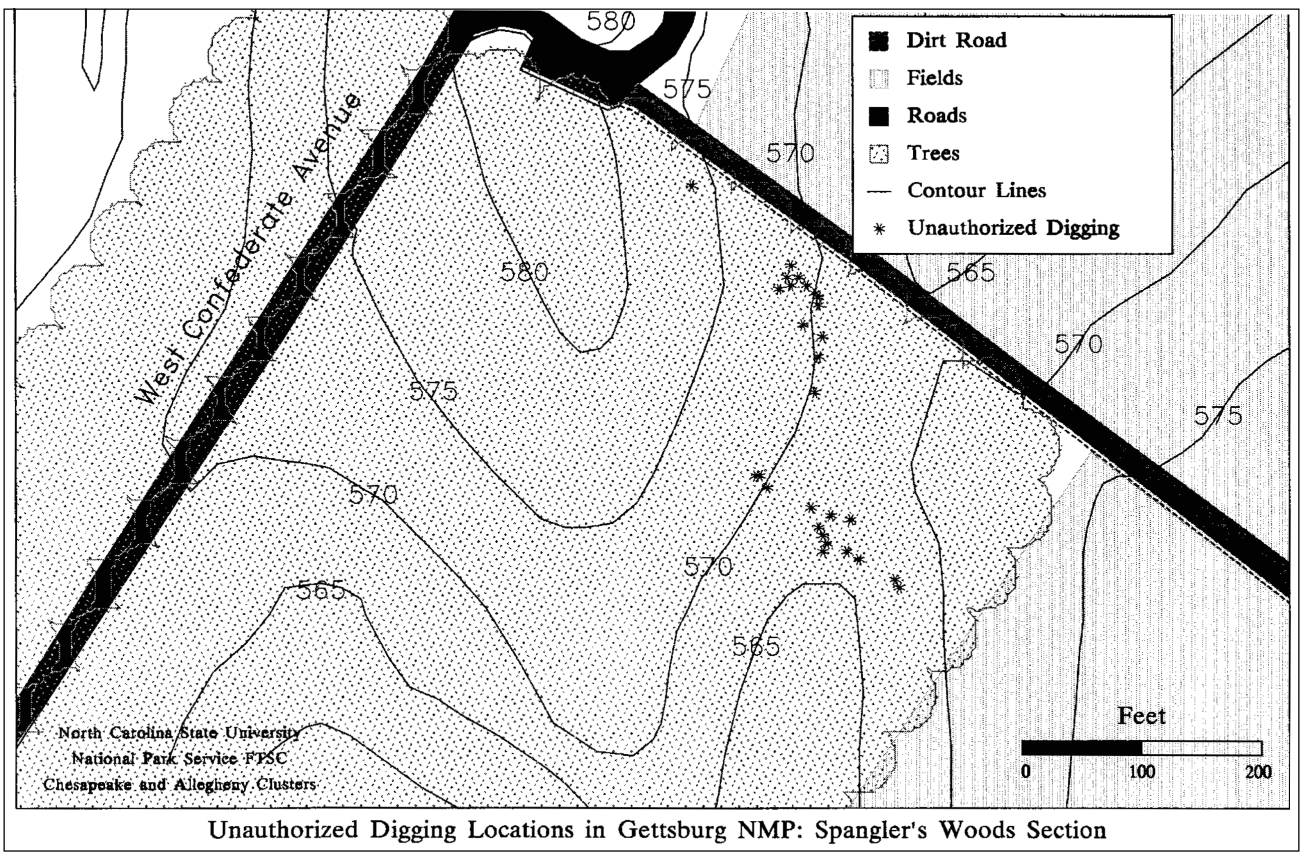

Figure 2. GIS plan of unauthorized digging in Spangler's Woods. The plan indicates topography, circulation, and vegetation, along with the location of digging. The plan was created using Atlas GIS and AutoCAD. Gettysburg National Military Park. (Plan courtesy of North Carolina State University, n.d.)

worse than having no data at all. Care must always be taken to use data that is appropriate for the task at hand.

Types of Data

There are two basic types of data used in GIS: vector and raster. Vector data includes points, lines, or polygons and has one set of attributes associated with each feature. Raster data is a continuous area broken into a regular grid of cells, each cell having a value (attribute) associated with it. For example, a soil grid might have the soil type found at each cell location. The main difference between vector and raster data is that vectors are feature-oriented and rasters are landscape-oriented. Discrete data, such as a structure, is better suited to a vector format, while continuous data, such as slope, is better suited to a raster format.

Spatial data is usually separated into layers. A layer represents a group of features with a common set of attributes. For instance, roads, trails, soils, and terrain aspect are all possible data layers. In some cases, seemingly different features can be combined into one layer if the attributes are general enough. For example, roads and trails can be combined into a single layer called transportation, with an attribute describing whether the feature is a road or a trail.

Obtaining Data

Although obtaining data has always been, and remains the single largest roadblock to developing successful GIS applications, the tools available for collecting data are more numerous and easier to use than ever before. Some of the more popular methods for cultural landscape data collection include the following:

- Global Positioning Systems (GPS). This involves the use of hand-held receivers that receive signals from satellites to determine the user's location on the ground. (See *Landscape Lines 11: Global Positioning Systems*.)
- Map scanning. Scanners have become a quick and efficient method for entering data from old maps and are much faster than hand-digitizing on a digitizing table, although sometimes the latter method must still be used. (See Figures 3 and 4.) A scanned image is converted from a raster format to a line format through vectoring software.
- Digital orthophotography. This is aerial imagery in which all the distortion due to terrain, camera angle, etc., is removed so that it is essentially a photo map. Many software packages allow "heads up" digitizing on a computer monitor with the digital orthophoto image displayed as a backdrop.

In the next few years the development of very detailed satellite imagery may become a useful source of data for cultural landscape management.

Storing Data

All georeferenced data must be stored in a coordinate system and datum. Furthermore, to use two or more data sets together, they must be stored in the same coordinate system and datum. There are many coordinate systems available, including latitude/longitude and state plane, but the one most commonly employed within the NPS is the Universal Transverse Mercator (UTM) system. This coordinate system is based on a series of Transverse

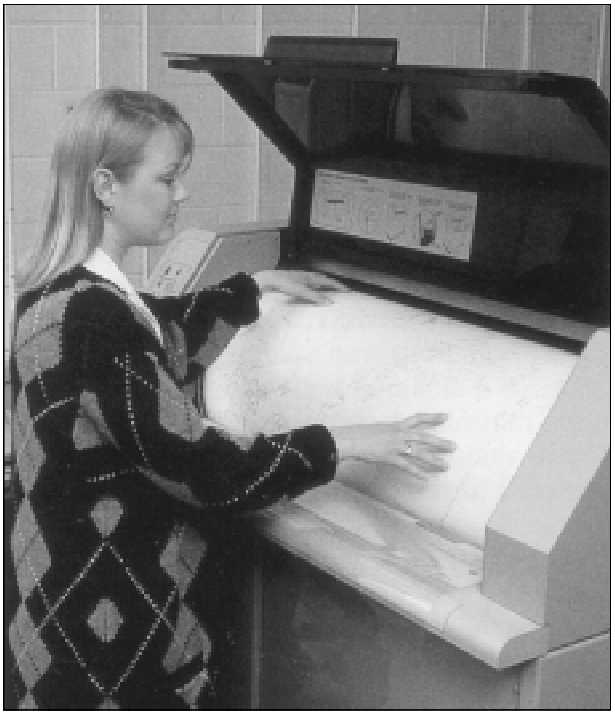

Figure 3. A large scanning device converts map information to digital form. (USGS, 1995)

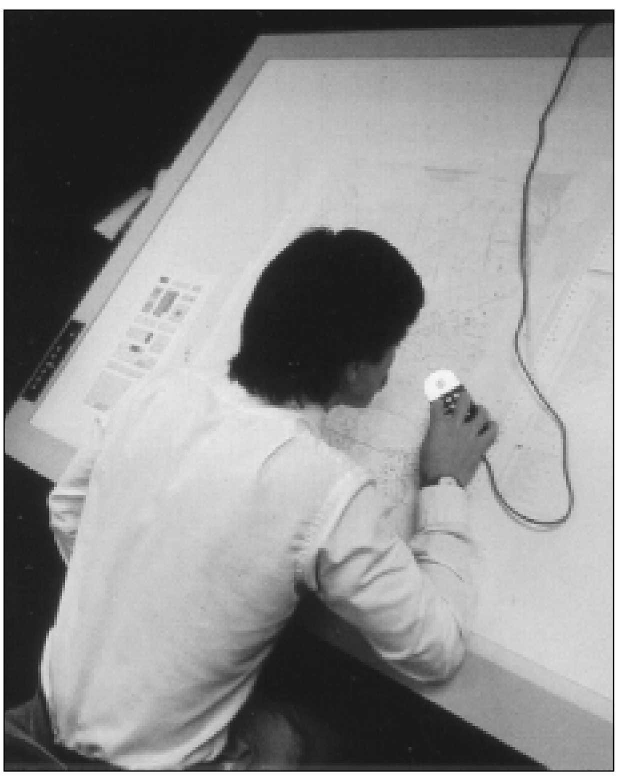

Figure 4. Digitizing converts map information to digital form using a hand-held mouse. (USGS, 1995)

Mercator projections, each one having its own set of parameters that control how the spatial coordinates are displayed. There are 60 zones encircling the earth corresponding to these projections, each zone being six degrees of longitude in width. Since each zone has its own Transverse Mercator projection and set of associated parameters, all data to be used together must be stored in the same UTM zone.

There are two datums in widespread use around the agency: North American Datum of 1927 (NAD27) and North American Datum of 1983 (NAD83). The latter is a more accurate description of the earth's surface and NPS guidelines recommend that data should be placed in this datum whenever possible. However, since many agencies still use NAD27, there is often the practical consideration of converting large amounts of data obtained from other sources to NAD83. Again, the most important concern is that all data to be used together be in the same datum.

Resolution, Accuracy, and Scale

Other issues pertaining to data include resolution, accuracy, and scale. Although these terms are not synonymous, they are often used interchangeably, sometimes leading to confusion. Resolution refers to the degree of precision in a data set; that is, how finely described the data is. In a raster data set, resolution is the same as the cell size. In a vector data set, resolution can be thought of in terms of how closely the shape points in a line or polygon are spaced. (For a straight line, no more than two points are needed to describe it precisely.)

Accuracy describes how close a feature in a data set is to its real location on the ground. This is easier to do with vector data than with raster data. Because raster data is not feature-based, it is often difficult to discern errors in spatial accuracy from errors in attribute accuracy unless the entire grid has been shifted, or rotated from its true location.

Finally, scale is a nearly meaningless term when applied to digital data storage. Digital data is essentially scaleless until it is displayed, and even then its display scale can be easily changed. When performing spatial analysis or creating cartographic output, the most important considerations are the resolution and accuracy of the data. Data presented at too low a resolution will appear crude and blocky when displayed at a large scale. Since cultural landscape management often deals with small areas displayed at large scales, it is often necessary to have very high resolution data.

A good source for information about the suitability of a data set for a particular need is the layer's metadata. Metadata is information about data. It should include such things as the source of the data, estimated accuracy, and time from which the data was collected. Metadata can be stored in many forms, ranging from a simple text file for an entire data layer to complex attribute fields describing each feature in a layer.

Hardware and Software

When the NPS began heavily promoting the use of GIS in the mid-1980s, there were few powerful software packages available for personal computers (PCs). Consequently, most parks turned to workstation computers running the UNIX operating system. Early GIS software included GRASS, a package developed by the United States Army Corps of Engineers, but most of these systems are now running Arc/Info, a proprietary package from the Environmental Systems Research Institute, Inc. (ESRI). The last few years have seen the rise of GIS software for PCs, primarily ArcView, another product from ESRI. Desktop GIS is seen by many in the agency as the best way to get non-GIS specialists actively involved in using spatial data for analysis and mapping. Many opportunities exist for cultural resource managers to receive training for desktop GIS. Contact a regional or cluster GIS coordinator for information.

Where to Go For Assistance

Within the NPS there are many sources for obtaining further technical assistance related to GIS. Many parks have staff who are knowledgeable in the use of GIS and who can respond to inquiries. Many regions and clusters have field technical support centers that provide GIS services. In addition, there are regional and cluster GIS coordinators throughout the NPS who can provide technical guidance and direct individuals to appropriate resources. Their names and phone numbers, along with other agency-related GIS information, are available on the NPS GIS world wide web site (www.nps.gov). For general program information, the national GIS coordinator can be reached at 303-969-2964. The national GIS program office also has a cooperative agreement with North Carolina State University to provide consultation and training services. Finally, the NPS Cultural Resource GIS (CRGIS) Facility of the Heritage Preservation Services Program in Washington provides GIS training and data collection service.

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