



## A Short Guide to Modern Mapping Systems for Managing Woodlands

*A Geographic Information System (GIS) is a powerful mapping system many professional foresters use to maintain clients' management portfolios. Woodland owners can make use of the record-keeping, map-creation, and management-planning capabilities using this system. Woodland map information stored in digital format allows for easy retrieval, updates, and map printouts. This guide explains: 1) the basics of computerized mapping systems like GIS and 2) the benefits GIS can provide woodland owners.*

### Introduction

Complex GIS software has been around for more than 35 years. Only recently, however, has it become easier to use and less expensive. Since the 1990s, natural resource students routinely learn the proper use of GIS as part of their formal education. As a result, many forest consultants now offer GIS as part of their services. Woodland owners do not have to spend time or money learning GIS to reap its many benefits. It is important to know how the system works and what it can do for you so you can discuss your needs with a GIS professional as they develop and organize woodland data for your planning objectives.

### Computerized Mapping Basics - How GIS Works

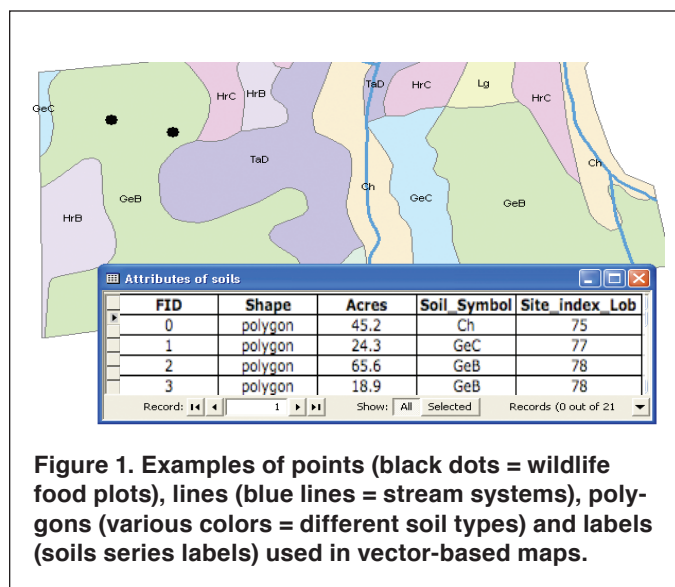
GIS mapping software stores, analyzes, and displays information about your woodlands.

Features of your landscape such as timber stands, soils, and streams are stored and drawn as map “layers.” Think of layers as sheets of see-through plastic that you can draw on. One layer may have only roads, another could have streams. Forest stands, wildlife areas, soils, and home sites may each have their own layer. You can turn layers on and off to aid your ability to visualize and plan. Most GISs store data in two different structures: “vector” and “raster.” Each structure has its own benefits.

#### **Vector Data (points, lines, and polygons)**

**Vector** data stores map features in *points*, *lines*, and *areas (polygons)*. Figure 1 shows land features represented in three data layers:

- wildlife food plots as points
- streams as lines
- soil types as areas.



**Figure 1. Examples of points (black dots = wildlife food plots), lines (blue lines = stream systems), polygons (various colors = different soil types) and labels (soils series labels) used in vector-based maps.**

### Vector Data: (database tables)

Every GIS vector map also has a database table associated with it. Figure 1 shows the database table associated with the soils map data (streams and wildlife food plots not shown here). Database tables store the descriptive information about each map feature in the layer (for example, in Figure 1, every soil area in the soil layer). The table columns in Figure 1 are *attributes* and can be considered information you want to know about your map features. In the soils map above, this information may include:

Information you want to know	Attribute name
What is the soil series?	Soil_Symbol
What are the areas of each soil shown?	Acres
What is the expected site index (or productivity) of loblolly pine for that soil?	Site_Index_Lob

This information is required to make proper management decisions about your woodland. Each soil feature in the map has its own row in the table and its own unique set of answers for each attribute. These are termed *attribute values*. The attribute values for the first polygon in the list are Acres=45.2, Soil\_Symbol = *Ch*, and Site\_Index\_Lob = 75 (interpreted as “75 feet tall in 50 years”).

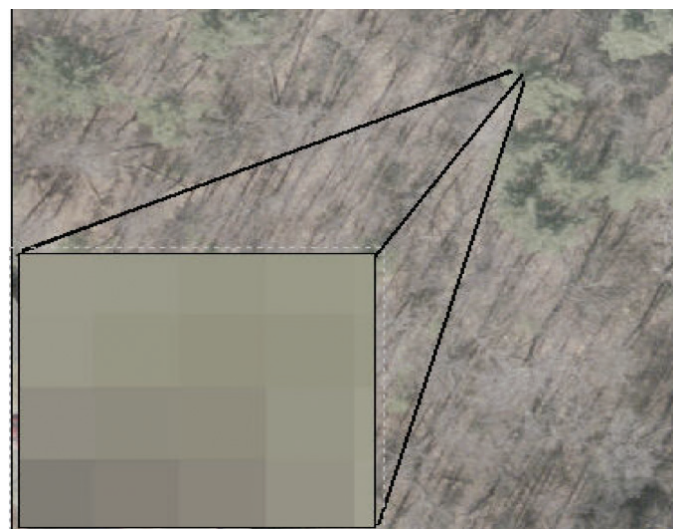
The attribute values allow for separation of the soil features. For instance, the map could be made to color all soils with site index ≤ 77 less red and all those with

### Vector Data – what you should have and where to get it

Important vector data for your woodland includes:

- ♦ pre-existing data (mostly from public agencies)
  - many are accessible from your county mapping office
    - parcel boundaries
    - soils
    - streams
    - roads
- ♦ new data created for your property
  - created by a professional forester, other resource professional, or landowner
    - timber stands and/or management units
    - harvest units
    - hiking trails
    - landings, skid trails
    - aesthetic areas
    - structures
    - new roads.....etc

site index >77 green. As it happens, the above map’s (Figure 1) coloring is based on the Soil\_Symbol attribute – a different color for each soil series. Notice how the *Chewlaca* series (*Ch*) is associated with streams (the blue lines in Figure 1). It is a powerful thing to be able to color your map based on attribute values, allowing you



**Figure 2. Digital aerial image of a white pine and hardwood forest during leaf-off period. The magnified area (lower left) reveals this is simply a raster image with each pixel colored differently.**



## DEFINITIONS

**Map Feature:** the elements on a map. Each soil polygon, stream section, road, section, timber stand, etc. on a map is a map feature.

**Map Layer:** map features of similar type (point, line, or area) that are stored in their own unique files. All wildlife food plot areas, streams, and roads on your property are all stored as separate map layers. These layers can be turned on and off as needed.

**Vector Data:** A common data structure used in GIS where the map features are represented as points, lines, and areas.

**Raster Data:** A common data structure used in GIS that stores data in a grid format. Two common types are raster image and raster grid data (see below).

**Raster Image:** Raster data of images such as aerial photography and topographic maps. This data is typically viewed as a backdrop and is not normally used for raster analysis techniques.

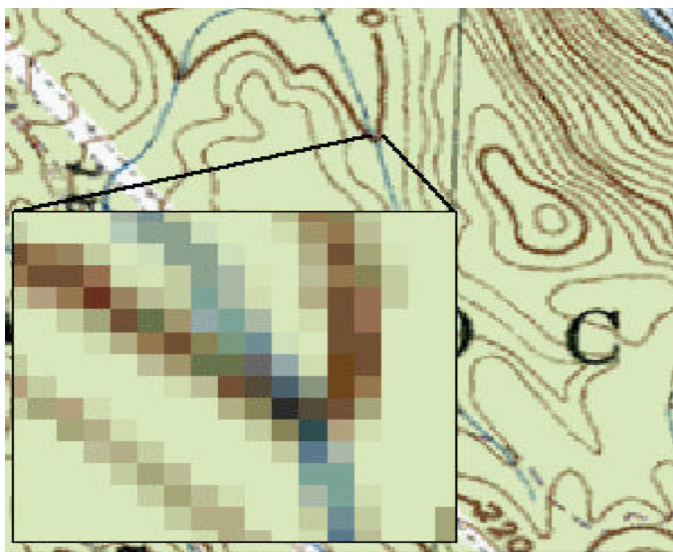
**Raster Grid:** Data stored in a gridded format, but each cell has information such as elevation and air quality. This data can be used for raster analysis techniques.

**Geographic Information System:** A computer application that uses map features and tabular (in a database table) information about those features. This allows for storage, analysis, and display of the map and tabular information.

**GIS Table:** The tabular information that helps describe features of a GIS map layer. Examples are: for a road layer, the tabular information might be “number of lanes” with possible answers “1” through “8” and “surface material,” with possible answers “asphalt,” “gravel,” or “dirt.”

**Map Query:** Answers questions using the map or database table. Examples are: “select all wildlife areas within ½ mile from all roads,” or “select all forest stands where the “species” = “northern red oak” and “age” > “50.”

to recognize interesting associations, relationships, and trends on your property. Later in this document, you'll see how storing attribute data allows important analysis of your map data.



**Figure 3. Digital USGS Topographic Map.** The magnified area (lower left) reveals this is simply a raster image with each pixel colored differently.

### *Raster Data – images and grids*

Simply put, raster data is stored and displayed in a grid like your TV or computer screen. Each of the millions of cells in the grid are colored, composing a digital image. Common raster images used in forestry are digital aerial photography or digital USGS topographic maps as seen (Figures 2 and 3). These often serve as a backdrop in which to better understand vector data. The information gained by having raster images is enormous; one picture is worth a thousand words!

There is another raster format referred to as a *raster grid* that applies measurement data for every raster cell. One common raster grid used by natural resource managers is the digital elevation model (DEM) that applies elevation to each cell, thus creating three-dimensional data. Slope, aspect, and other physical features of the landscape can be viewed using DEM data. A good example of a three-dimensional data structure is Google Earth's “Terrain View.”

### *Raster Vs. Vector Data—Which Is Better? Both Are Great?*

The pros and cons of vector and raster data are given below in Table 1 (see Table 1 on p. 4). Digital raster products such as photography and topographic maps

Table 1 Benefits and possible problems associated with two common GIS data formats, vector and raster.

Data format	Benefits	Possible Issues
Vector	Easy to create and edit changes	It omits information—only shows what map-maker thinks is important. For instance, small but important trails may be left off the map showing only larger ones
	Can be captured with GPS	
	Small data files	
	Can be very accurate (survey accuracy)	
	Easy to calculate areas / distances	
Raster	Shows real world—aerial photography—does not lose information	Cannot edit readily
		Does not show survey boundaries, etc.
	Shows lay of the land—topographic images	Could have too much information
		Only as current as latest flight

give you the big picture of your woodlands. Sometimes you need to see boundaries and other features not found on digital imagery such as property boundaries, timber stands, soil type boundaries, and points of interest. For this, vector data works very well. Vector data is much

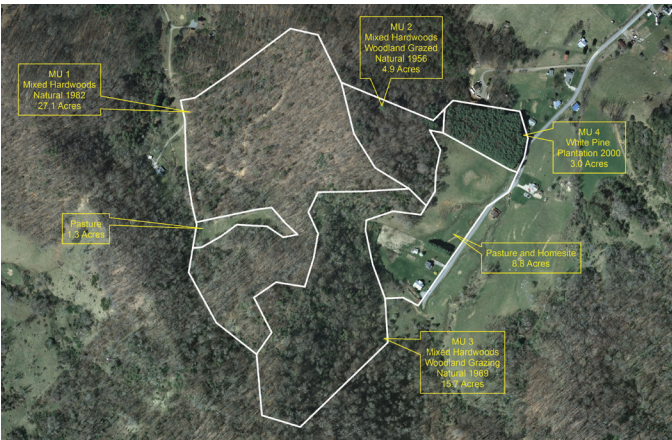


Figure 4a. Basic aerial photo (raster image) with management units (vector data).

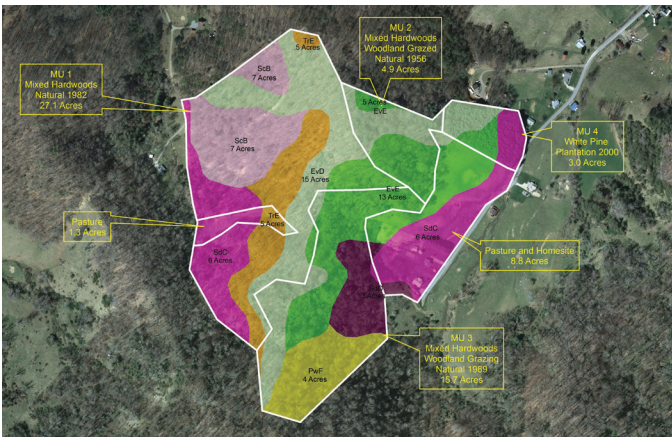


Figure 4b. Basic aerial (raster image) and soils (vector) with management units (vector).

easier to edit when updating your maps. For instance, newly leased hunting or firewood-cutting areas are quickly added to the map using vector data.

So which is better? Well, of course, you maximize your benefits by using vector and raster layers together. Forest consultants utilizing GIS will use different layer combinations that help you gain a better visual understanding of your property, which enhances your informed management decisions. Figures 4a through 4c show various combinations of vector and raster data that make planning maps much easier.

How can GIS benefit woodland owners?

There are numerous reasons why your woodland assets should be stored in GIS format.

• **Digital data stores more easily than traditional map data.** Lots of data can be stored in a small space. Numerous copies can be made of the data and kept in safe storage.

• **Digital data is easy to update.** Any new changes to maps or to the database can be quickly added while still

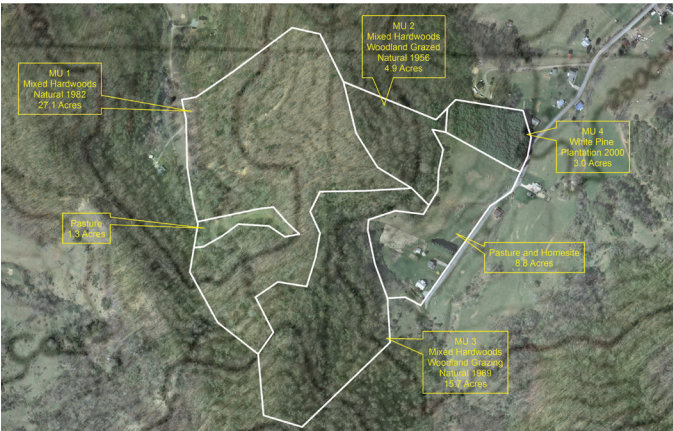


Figure 4c. Basic aerial image (raster) and topography (raster, made 50 percent transparent) with management units (vector).



### Raster Data – what you should have and where to get it

Important raster image data for your woodlands include:

- ◊ digital aerial photography (Figure 2)
  - may be accessed from your county mapping office or NC One Map (see box)
    - updates every 3–7 years
  - taken during leaf off allowing you to see:
    - structures
    - ground
    - hardwoods vs softwoods
- ◊ digital topographic maps (Figure 3)
  - may be accessed at your county mapping office or through the NC Department of Transportation (see box)
    - updates every 10–20 years
  - identifies:
    - topographic features
    - streams, lakes, roads, cemeteries, many other features

keeping the older versions. This allows your legacy to be recorded for posterity.

• **Custom maps are easy to generate.** Print maps or tables of any scale for any portion of the property. Include as many different layers as needed to make the map useful.

• **Data is becoming easier to share.** Free applications such as Google Earth allow you to share your map data with family and friends without having to mail them paper maps. Consider saving your map in a Google Earth format (called “.kml”) and emailing it to a family member. They can then open the map in Google Earth and the data will automatically be placed where it belongs in the landscape. You can do this with any vector layer.

• **Easier planning, “what-if” scenarios?** Road placement, site development, trail locations, timber harvests, wildlife food plot placement, and other data can be assessed visually and deleted without any changes to the original data sets.

More sophisticated analysis techniques using map data layers that will help you analyze and plan are given in the next section. The five reasons listed above make using GIS an attractive alternative to paper maps.

### GIS Analysis – Making Full Use of the Power: Queries, Buffers, and Site Selection

GIS generates quick maps that are stored digitally. But equally important is the ability to analyze map data and

develop new information for planning purposes. While there are dozens (maybe hundreds) of standard GIS analysis techniques, a few classic examples are “queries,” “buffers,” and “site selection.”

#### Map Queries

GIS not only stores map data, but it has the ability to store information about every feature in a database table. Refer back to Figure 1, which shows a portion of the database table that is associated with the soil series layer (“Attributes of soils”). Every horizontal row in the table has information for one soil polygon drawn on the map. The top row is associated with the tan polygon in the center of the map (with the “Ch” label). According to the database table, this polygon has:

- **Acres = 45.2**
- **Soil\_Symbol = Ch** (Chewlaca Soil Series)
- **Site\_Index\_Lob = 75** (has a site index of 75 for loblolly pine)

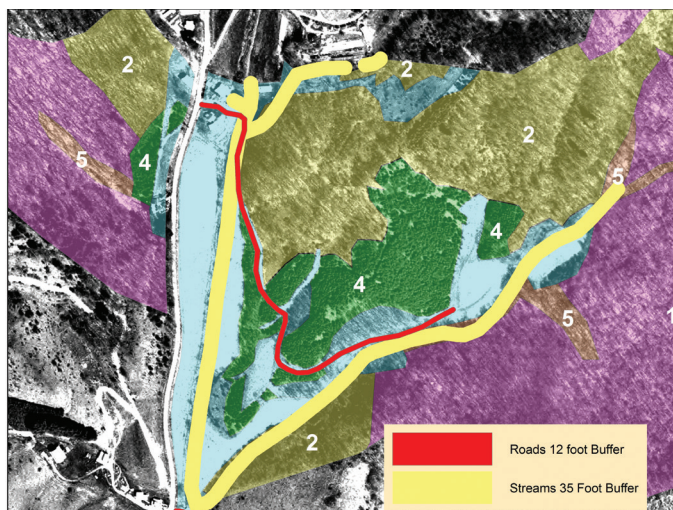
The soil layer’s table contains data describing each polygon in the soil layer. All other layers in this map (wildlife plots and streams) have similar tables. These contain important data for their respective features (such as fertilization records for the wildlife plots).

The link between map and table allows for queries regarding your property. In the soil map example, you might query:

“show me all soils that **Soil\_Symbol = GeB** and **Acres > 50**”

### What are coordinate systems?

All spatial data formats (raster and vector) use some form of coordinate system to locate data features on earth. This allows for accurate distance and area measurements to be calculated. Common coordinate systems such as Latitude/Longitude (Lat/Long), Universal Transverse Mercator (UTM), State Plane Coordinates (SPC), and many others have been developed over the years based on the portion of the world covered and the intended use of the coordinates. Most GISs are capable of overlaying data from these numerous sources. GPS data are also stored in real-world coordinates making it easy to load data from a GPS unit directly onto a GIS. It is important that the person using the GIS be familiar with the various coordinate formats and how to get the GIS to recognize them for proper overlay.



**Figure 5.** Results of a 12-foot radius (24-foot total) road buffer (red) and a 35-foot radius (70-foot total) stream buffer (yellow) for SMZs. These areas can be deducted from the timber stands for a correct estimate of acreage.

Such a query would select Polygon 2 (FID = 2) in Figure 1.

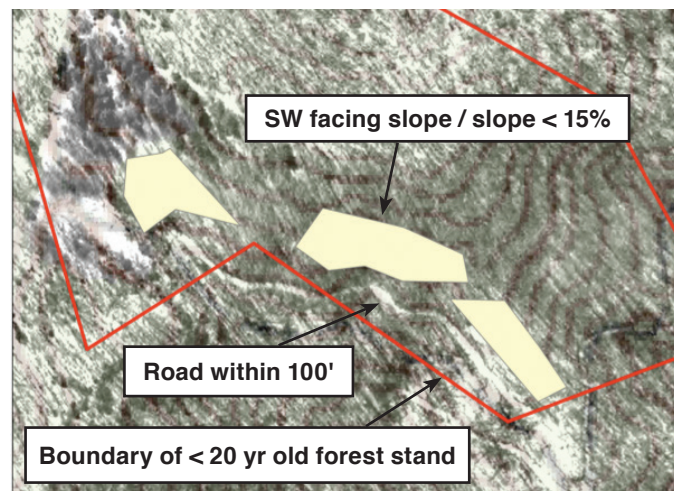
Another example: for a forest tract in the mountains, you could query the GIS database to find all the white pine stands more than 60 years old and larger than 5 acres. Queries are powerful ways to get answers about your woodlands once you make the database.

### Buffers

Good stewards protect their water resources. Statewide Best Management Practices (BMPs) and regional River Basin Rules in North Carolina require streamside management zones (SMZs). These areas are often excluded from the total harvestable areas. Road areas should also be excluded from the total forested area. GIS offers buffer techniques to build areas around each line feature (such as a stream or road) to any width. Buffer areas can then be deducted from timber production areas, giving

### NC OneMap—Public Access for State and County Data Layers

NC OneMap is the geographic data repository supporting North Carolina data users. Numerous partners throughout North Carolina, including local, state, and federal government agencies, the private sector, and academia, routinely contribute new data that may be downloaded and used by anyone. NC OneMap is an evolving initiative directed by the NC Geographic Information Coordinating Council. (Accessed from [www.nconemap.com](http://www.nconemap.com))



**Figure 6.** Results of a site selection for wildlife food plots (in yellow). Topographic map lines are overlaid on aerial photography to give the lay of the land. Each wildlife plot selected is greater than 2 acres. Note: The grainy look is due to the topographic map overlay and set to 50% transparent in order to see the topography and aerial photography layers together.

correct woodland acreages. Figure 5 shows the results of road and stream buffer removals from the acreage.

### Site Selection

Matching management activities with the most suitable site is crucial for proper woodland management. With GIS, factors that fit specific criteria can be used to locate the best sites for activities. For example, below are some requirements necessary for a wildlife food plot in the mountains:

- Food plots need to be located on:
  - south-southwest facing slopes
  - slopes less than 15%
  - woodland stands less than 20 years old
  - woodland stands within 100 feet of existing roads
  - selected areas must be greater than 2 acres

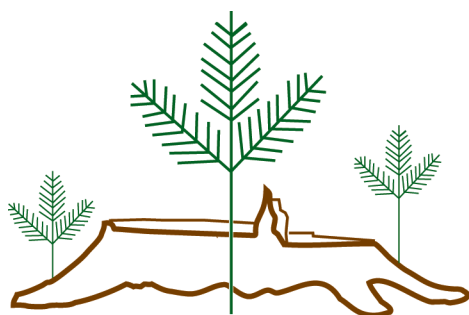
Figure 6 shows the results of the site selection process using those criteria. Requirements 1 and 2 listed above, aspect (the direction a slope faces) and slope steepness are identified using a DEM (raster grid). The woodland stands database was queried to find polygons meeting the age requirement (3). Buffers built around roads were used to solve the distance requirement (4). Finally, when all possible areas fitting the first four requirements were identified (the yellow polygons, Figure 6), a query was performed to find those larger than 2 acres, requirement 5. Virtually limitless combinations can be performed to select sites for woodland objective requirements, from finding ideal salamander habitat to locating the best sites for logging decks and roads.

**Summary**

The world is changing; information is not static. Your woodland property is a valuable asset and it is worth taking the time to have it documented correctly. GIS serves not only as a tool to develop excellent working maps, but also as a way to plan for the future and show what you have done in the past. It would be in your and your heirs' best interest to take advantage of GIS. Start by speaking with a forester who understands how to assist you with mapping your woodland using GIS.

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