

MAPPING AND INVENTORY OF
FOREST ROADS WITH
GLOBAL POSITIONING SYSTEMS

Mark M. Milligan
President
GeoTech Systems
Tallahassee, Florida

Richard W. Davis
Vice President
GeoTech Systems
Tallahassee, FL

ABSTRACT

The forest industry constantly faces inventory demands for the purposes of managing timber resources. Foresters also get involved with the inventory of other natural, environmental and cultural resources on a periodic basis. Other than timber resources and land value, road infrastructure (roads, bridges, culverts, etc.) is by far the most valuable asset managed by forest managers and landowners. However, when it comes to managing these resources, information is often lacking or very poor. This can result in misallocation of resources and resulting inefficiencies.

The use of Global Positioning Systems provide foresters with the ability to map and inventory forest roads, bridges, culverts, low-water-crossings, gates, etc. Not only can accurate maps be produced with accurate positions and lengths of roads and segments, but attribute data can easily be tagged with each mapped feature. These attributes contain information such as road classification, surface type, width, condition, elevation with respect to grade, road name and others. Likewise, similar attributes and their values can be collected for the other feature types. This information can then be used in a Geographic Information System (GIS) to query the collected data for the purposes of managing these resources. For example, a map could easily be produced in minutes displaying all culverts that need replacement, or all roads in poor condition.

Two such inventories are presented in this paper. Both were conducted for the Florida Division of Forestry on Lake Talquin and Blackwater River State Forests. Both instances illustrate the underestimation that forest managers can make when it comes to road infrastructure. For example, for Lake Talquin State Forest the miles of roads were estimated at more than 50% below what was actually mapped. Even more telling, the number of crossings (bridges, culverts, washouts, etc.) were underestimated by more than 500%. Final numbers for Blackwater will be available by the conference, but appear to be similarly underestimated. These findings suggest that forest managers should at least investigate the possibility of conducting such an inventory.

INTRODUCTION

As the forest industry continues to go through a period of drastic ownership changes and more companies merge, the need for forest inventory information is at an all-time high. These inventories are vital to forest managers and financial experts in order to evaluate income potential and place values on these assets. A well-designed, properly-constructed and maintained road system has a positive effect on lowering logging costs, which, subsequently, raises stumpage values. However, not all roads are created equal.

Just as foresters must collect, process and analyze timber and bare land values, it is becoming more apparent for the need to address forest roads. In particular, the whole infrastructure and how it affects forest management. The use of Global Positioning Systems (GPS) affords the manager the ability to easily map and record multiple attribute (i.e. Condition, Width) and value (i.e. Fair, 12 feet) information for all roads, bridges, culverts, low water crossings, etc. Integration with Geographic Information Systems (GIS) allows the processing and evaluation of these inventories to assist the manager in determining the adequacies, and inadequacies, of the road system.

Most forest roads are constructed to access timber, but often support many other purposes. Roads in forested areas allow access for the application of scientifically based practices designed to maintain or enhance the health of forest ecosystems. Roads provide access for recreation, rural travel, fighting forest fires, and controlling pests and diseases. Roads also provide people with access to commodities, such as timber, oil, natural gas, minerals, livestock grazing, and special forest products. A well-maintained network of roads is an asset for good forest management and the ability to meet management objectives (SAF 1999).

The Florida Division of Forestry (DOF) manages approximately 800,000 acres of state forestlands as the primary agency responsible. There is a growing demand to open these lands to a higher degree of use than in the past. Timber, wildlife, recreation and environmental management activities, in their totality, are introducing increased levels of vehicular use of the forest road network. Problems in managing these volumes and usage demands have necessitated the need for a comprehensive road network inventory. GeoTech Systems, of Tallahassee, Florida has been the successful bidder on both projects.

This paper will discuss the findings of these inventories for the DOF. These projects underscore the lack of accurate information at hand for forest managers regarding their road networks and point to the need to conduct such inventories on forestlands.

METHODS

General

Lake Talquin State Forest (LTSF) and Blackwater River State Forest (BRSF) are approximately 16,400 acres and 190,000 acres, respectively. Both are located in the heavily-wooded portions of north Florida. LTSF is located in Leon and Gadsden counties, while BRSF covers Okaloosa and Santa Rosa counties. The majority of the LTSF inventory was conducted in the spring of 1999 and the few remaining portions were completed in the spring of 2000, while the BRSF inventory was conducted through the summer of 2000.

Equipment

Both projects were specified to be measured with professional-grade mapping GPS equipment. The LTSF job specified a 1-5 meter grade machine, while the BRSF project called for a sub-meter system. Figure 1 illustrates the quality of these two systems for this type of work.



Figure 1. The first set of road features was collected with a 1-5 meter GPS system. With editing, the road features were acceptable. However, notice the gaps between segments and some of the inaccuracies (inconsistencies) showing up in the horizontal line.



The second set of features was collected with a sub-meter system. No editing was needed. Notice the lack of any gap between the road segments and the consistency of the line.

Because the quality of the sub-meter data is so high, and since editing is kept to a minimum, it was decided by DOF personnel to specify these units when conducting such inventories.

A four-wheel drive jeep was primarily used to perform the inventory on LTSF. Based upon the limitations encountered with such a vehicle, the consultants decided to

employ All-Terrain-Vehicles (ATV's) for the BRSF project. It was decided that the flexibility and accessibility of these machines were required to achieve the efficiencies needed to undertake such a large task.

Collection Process

In both cases it was fortunate that the DOF had some existing maps on-hand. These were used to plan data collection activities, areas of assignment and to help keep up on the day's progress.

Roads (lines) were collected at 3-second intervals. All points were collected using a 20-second interval. The data collected were differentially corrected through post-processing, with the closest available public base stations, to achieve the best accuracy possible. Table 1 summarizes the data that was collected for both projects.

Table 1. List of Features and Attributes for the Lake Talquin and Blackwater River State Forest Road Inventory Projects

Lake Talquin State Forest					Blackwater River State Forest			
Number	Feature	Type	Attribute		Number	Feature	Type	Attribute
1	Roads	Line	Classification Name/Number Surface Type Surface Condition Lanes Elevation/Grade Signs		1	Roads	Line	Classification Name/Number Surface Type Surface Condition Lanes Width Elevation/Grade
2	Culvert	Point	Crossing Shape Type Number Diameter Length Condition Posted					Wetland Approach Signs <i>Average Slope</i> <i>Maximum Slope</i> <i>Erodibility Factor</i> <i>Avg. Stream App. Slope</i> <i>Max. Stream App. Slope</i>
3	Bridge	Point	Crossing Type Weight Limit Condition Posted		2	Closed Roads	Line	Blocked Stabilized Traffic Successfully
4	Washout	Point	Condition Improvement		3	Culverts	Point	Crossing Shape Type Number Diameter Length Approach Distance Leaving Distance Conditions Posted Adequate
5	Low Water Xing	Point	Crossing Surface Material Condition					
6	Log Decks	Point	Stable Planted/Seeded					

Table 1 Continued

	4 Equ. Culverts	Point	Angle Shape Type Number Diameter Length Condition Posted Adequate
	5 Bridge	Point	Crossing Type Weight Limit Condition Posted Elevation HWM Approach Distance Leaving Distance
	6 Low Water Xing	Point	Angle Crossing Surface Material Condition Angle Approach Distance Leaving Distance Daming Effect
	7 Barriers	Point	Type Condition Trespass No Vehicle Sign Locked Safety Device
	8 Washouts	Point	Size Classification Passable By Improvement
	9 Gullies	Point	Size

It is evident from the above table that the BRSF inventory was quite more complicated and involved. Beside the fact that more features and even more attributes were included, the BRSF project called for average and maximum slopes as well as erodibility factors to be collected for each road segment. It was obvious that these attributes were going to be difficult, at best, to attain in the field.

In order to address this issue, it was decided to utilize existing GPS and GIS data to populate these data fields. Soils coverages were acquired in order to attain the erodibility (K) factor. A GIS contractor wrote a script in ArcView that uses weighted averages for each road segment as it passes through different soil types, to derive an average K factor. To derive slope values, another contractor wrote a program, also utilizing a weighted average approach, to calculate these values by the heights (only possible with a sub-meter GPS unit) given through the GPS. Testing of this data proved to be quite accurate and efficient.

RESULTS

Up to the date of this publication, all of LTSF is completed, while 60% of BRSF is done. The results from these inventories indicate that there are approximately 89 acres per mile of road on LTSF, while there is approximately 110 acres per mile on BRSF. Points per mile were 1.12 for LTSF and 2.5 for BRSF.

A total of 184 miles and 207 points were collected on LTSF. For BRSF, at least similar results are expected based on the rates encountered thus far.

CONCLUSIONS

Underestimation

In both cases, estimates from forest managers concerning road mileage and, particularly, number of crossings (bridges, culverts, low water crossings) and other points, were well below that of actual values. The numbers from LTSF indicate that roads were underestimated by more than 50%, while the number of points were by more than 500%.

For both LTSF and BRSF, the final and preliminary numbers certainly suggest that, lacking a current road inventory, managers are subject to gross underestimates of actual road network assets. This could be due to the fact that, traditionally, foresters are not trained nor expected to estimate these resources like those for timber or other natural resources. In any case, more information will have to be gathered in order to positively conclude whether this is an isolated event, or if this is more indicative of the industry as a whole.

The Case To Conduct a Road Network Inventory

As a wise forester once said, "How can you manage something if you don't know what you have?" This is a very true statement, and one that is certainly applicable to this situation. If a road network is not properly laid out, nor properly maintained, this will ultimately lead to longer skid distances (Tufts and others 1988). Many studies have documented the effect of skid distances and different logging systems on logging costs (Kellogg and Bettinger 1994). Therefore, longer skid distances lead to higher logging costs, and thus lower stumpage prices.

There is also the need to assess a proper maintenance budget for any given forest. Factors such as slope, soils, local markets and wetlands will help determine the proper placement, density and maintenance of the road network.

Timber access is a major issue to companies and organizations managing these resources. Traditionally, weather dictates timber access. However, with careful planning and maintenance, timber may be accessed when desired or when silviculturally and economically beneficial to the landowner.

Environmental Considerations

Roads represent an environmental challenge. Drainage from roads and their associated features can cause erosion and reduce water quality. Roads can help the spread of forest diseases, exotic plants and other pests, and fragment wildlife habitat (Gorte 1997, Johnson et al. 1995). These issues must be addressed in managing any forest road infrastructure.

With the recent EPA Total Maximum Daily Load (TMDL) rules, it remains to be seen how this will affect the forest industry. Even though forestry was specifically removed from the requirement for federal permitting, states will still be required to develop plans to reduce pollution in more than 20,000 lakes, streams and bays that EPA claims do not now meet minimum federal water quality standards. If this ruling stands, then individual states may look at forestry, and specifically forest roads, as a target for regulation. An up-to-date road inventory would certainly go a long way towards addressing this possibly wide-ranging and far-reaching rule.

LITERATURE CITED

- Gorte, R.W., 1997. "Forest roads: Construction and Financing." CRS Report for Congress. Congressional Research Service. Washington, DC.
- Johnson, K. N. et al., 1995. "Forest Health and Timber Harvest on National Forests in the Blue Mountains of Oregon: A Report to Governor Kitzhaber." Salem, Oregon.
- Kellogg, L. D.; Bettinger, P., 1994. "Thinning Productivity and Cost for a Mechanized Cut-to-Length System in the Northwest Pacific Coast Region of the USA." Journal of Forest Engineering 5(2):43-54.
- Society of American Foresters, 1999. "Roads in Forests". Position Statement on National Forest Road Policy. Bethesda, MD
- Tufts, R. A.; Stokes, B. J.; Lanford, B. L., 1998. "Productivity of Grapple Skidders in Southern Pine." Forest Products Journal 38(10):24-30.