Using FIA and GIS Data to Estimate Areas and Volumes of Potential Stream Management Zones and Road Beautifying Buffers

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Abstract.—Georgia Stream Management Zones (SMZ) are voluntary and have an unknown extent and impact. We use FIA data, Landsat TM imagery, and GAP and other GIS data to estimate the acreages and volumes of these buffers. We use stream data classified into trout, perennial, and intermittent, combined with DEM files containing elevation values, to assess buffers with widths consistent with Best Management Practice rules. Our results suggest that SMZs in Georgia occupy about 3.6 percent of the forested area and contain about 4 percent of its volume. Assuming 100-foot buffers, the area would be more than 7.5 percent and the volume 8.4 percent.

As the country becomes more populated, urban expansion will leave fewer acres available for production forestry. We will also face greater demand for clean water and other nontimber forest benefits, which will also reduce the number of acres available for production forestry. At the same time, demand for various wood products from our forests will increase. Thus, we will have less land from which more wood products will be required (Wear and Greis 2002). This could mean that the standing timber supply may not meet demand. Since policymakers and business leaders make decisions that affect our forests, we need tools to evaluate the potential effects that their decisions will have on this resource. For example, we might wish to know how environmental constraints (such as mandatory SMZs of various sizes along streams and rivers) would affect the inventory of merchantable trees or business decisions such as the location of pulp or sawmills in particular locations within the State.

Riparian / Stream Management Zones

The Stream Management Zone (SMZ) is a mandated protection zone around a stream, lake, or other water body meant to protect factors such as water quality and fish habitat. The SMZ consists mostly of riparian habitat area—the area directly adjacent to a waterway that includes the bank vegetation and a strip of forest.

The most important function of riparian zones is maintaining water quality. They buffer rivers from adjacent pollution sources by filtering sediments, absorbing nutrients, and stabilizing stream banks. Riparian zones also provide habitat for wetland animals and plants, and travel routes for others. They provide habitat and food for stream organisms, and, by shading streams, moderate ambient temperature (Welsch 1991).

Stream management zones were mandated by Federal water quality legislation (“Clean Water Act”) to minimize or prevent nonpoint sources of water pollution (NPSP). In 1976 the U.S. Environmental Protection Agency recommended using Best Management Practices (BMPs) as a primary method for controlling NPSP. The State of Georgia chose a nonregulatory system of voluntary compliance. The Georgia Forestry Commission issued the current “Georgia’s Best Management Practices For Forestry” manual in 1999.

Nowadays we are facing the possibility of mandatory BMPs for all forested areas. Changes in BMPs are also possible to meet the demands of some environmentalists to make required buffers around streams wider and forest management inside of them more restricted (Wenger 1999). Currently, for perennial streams BMPs recommend leaving evenly distributed 50 square feet of basal area per acre or at least 50 percent of the canopy cover after a harvest. For trout streams, an additional no-harvest zone around the stream’s bank must be created. For intermittent streams, requirements include leaving 25 square feet of basal area per acre or at least 25 percent of

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canopy cover after a harvest (GFC 1999). The extent of these potential harvesting limitations is not yet known.

Although many studies on riparian / stream management zones in the South exist (e.g., Wenger 1999), literature on their extent, assessment, and statistics is scarce. Cubbage and Woodman (1993) estimated harvesting area losses and costs by management classes using hypothetical "Forest Management Units" (FMUs) based on data from the FIA inventory for Georgia. They estimated forested area in stream management zones to range from 4.8 percent of total forest area (based on recommendations from BMPs of 1989), through 5.3 percent with buffers 35 to 100 feet wide, depending on slope to 7.09 percent for primary SMZs 300 ft wide. Beyond this study, some limited statistics are available from small-scale assessments and experiments, including ecological, biochemical, physiological, socioeconomical, and hydrological issues (e.g., Coweeta Long Term Ecological Research). However, these studies use mostly simplified assumptions (area of the buffer is calculated as a product of the stream length and the buffer width) and don't provide more detailed statistics.

Specific Objectives

We analyzed various Georgia data by relating spatially the FIA data to Landsat TM imagery and other GIS data to estimate the acreages and volumes of the protective zones and to assess potential impacts of implementing these zones in Georgia. Our specific objectives were to:

1. Develop an extended spatially explicit database with the FIA inventory information, water resources, and road developments in Georgia, plus hypothetical information on areas potentially classified as SMZs and road buffers.
2. Use the above database to evaluate the effects of regulations on timber harvests at various distances from roads and water resources in the State.

Data

In our study we used several sources of data. Administrative boundaries, roads, rivers, and elevation data (Digital Elevation Model – DEM) were downloaded from the Georgia GIS Data Clearinghouse located at (www.gis.state.ga.us/Clearinghouse/clearinghouse.html). The Georgia GIS Data Clearinghouse provides access to Geographic Information Systems (GIS) resources of Georgia for use by government, academia, and the private sector, mostly free of charge.

Information about natural land cover types comes from Georgia GAP Analysis Program data and was obtained from the Internet (http://narsal.ecology.uga.edu/gap/gap_landcover.html). Coordinated under the National Gap Analysis Program of the USGS Biological Resources Division, GAP is a nationwide biological diversity assessment and planning program. It assesses the conservation status of native vertebrate species and natural land cover types throughout the U.S., and facilitates the application of this information to land management activities. The GAP data set distinguishes 18 general land cover types, including three forest cover types (deciduous, evergreen, and mixed), forested wetlands that can be also classified as deciduous forests, and clearcut/sparse areas, derived from 1998 Landsat TM imagery by a series of unsupervised classifications. In addition, several ancillary data sources were incorporated, including roads, power lines, and the National Wetlands Inventory data. Delineation of additional subclasses of vegetation is still in progress. We used this data set to stratify Landsat TM imagery (16 scenes of Georgia collected in 1999 and 2000) data into three forest types (evergreen, deciduous, and mixed) and other nonforest types, to mask out some water bodies and roads, and to determine the initial cover type inside stream and road buffers.

Trout streams were identified using a "Trout Streams of Georgia" data set from NARSAL, Institute of Ecology, College of Environment and Design.

Methods and Assumptions

First, data on streams were classified into trout, perennial, and intermittent. Trout streams are those suitable for trout (potentially carrying trout). Perennial streams flow in a well-defined channel throughout most of the year under normal weather con-

Table 1.—*Buffer widths according to Georgia's current BMPs*

Stream type	Slope	Buffer width
Trout	All	**[ft]**
		100
Perennial	Slight (<20%)	40
	Moderate (21-40%)	70
	Steep (>40%)	100
Intermittent	Slight (<20%)	20
	Moderate (21-40%)	35
	Steep (>40%)	50

ditions. Intermittent streams flow in a well-defined channel during wet seasons but not for the entire year. Classified streams were masked out with assumed widths. In addition to data from the Georgia GIS Clearinghouse, we added water bodies extracted from GAP (recognized on satellite images as water bodies).

DEM data sets contain elevation values that were converted to slopes expressed in percent. The slope data set was reclassified according to BMP recommendations as slight (0-20 percent), moderate (21-40 percent), and steep (>40 percent) slope using ArcView software. Having classified the streams and derived slopes, we could finally create buffers around streams using widths from the water body shown in table 1. Buffers were stored in the GIS software (ArcView and ArcInfo) as a separate information layer. Transportation class (roads) was extracted from GAP data and combined with GIS Clearinghouse data. We assumed primary and secondary buffers (40 and 100 feet) that were processed similarly to streams. Resulting buffered streams and roads were intersected with the GAP land cover information layer.

The next step included the use of GAP data to stratify Landsat imagery into broad cover type classes. The stratified Landsat data were classified using the Euclidian distance approach developed by the USDA Forest Service (Ruefenacht *et al.* 2002). Classification for each forest cover type class was performed separately. Resulting polygons got FIA data assigned and were intersected with buffered streams and roads. It allowed calculating more detailed statistics, than using first step based only on the GAP data set analysis.

Results

The first results are based on GAP data only. As a result, we obtained area characteristics by GAP cover types. We also combined areas with volume data. For each of the broad forest cover types we calculated average volume per area using the FIA database (Hansen *et al.* 1992, Miles *et al.* 2001) and multiplied it by the number of acres in a given class. Areas and volumes were compared with the latest results of the FIA program (Thompson 1998) and presented in table 2. Stream buffers established according to Georgia's BMPs occupy about 872,500 acres, which makes up 3.57 percent of total forested area of the State. Assuming all buffers to be 100 feet wide, we came up with over 7.5 percent of forested area. Forests in the determined buffers contain 3.96 and 8.39 percent of total inventoried volume, depending on buffer width. Results for the scenario based on BMPs are smaller than numbers coming from studies by Cubbage and Woodman (4.8 and 5.3 percent), although the authors of the cited study assumed different buffer widths and a completely different (aspatial) approach. The area of the buffers in "primary SMZ zones" (7.09 percent) corresponds to our results from the scenario assuming all buffers are 100 feet wide. Shares of various cover types from our study are comparable to corresponding management class shares from the cited study (see Cubbage and Woodman 1993).

The next step of the research will be done on classified Landsat TM data with spatially distributed FIA attributes. Due to their computational requirements, these analyses are unfinished.

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Table 2.—*Summary statistics of stream buffers in the State of Georgia based on GAP data and FIA summaries*

		Stream buffers according to BMPs		Stream buffers 100 ft wide	
		Volume		Area	
GAP code	**Code volume description**	**Area [acres (%)]**	**[mill.ft^3 (%)]**	**[acres (%)]**	**[mill.ft^3 (%)]**
7	Beaches/dunes	918		2,139	
18	Transportation	38,291		83,332	
20	Utility swaths	3,448		7,736	
22	Low-intensity urban	16,433		37,775	
24	High-intensity urban	4,728		11,712	
31	**Clearcut/sparse**	**46,212 (0.19)**		**107,089 (0.44)**	
33	Quarries/strip mines	1,083		2,705	
35	Rock outcrop	22		42	
41	**Deciduous forest**	**301,191 (1.23)**	**539 (1.60)**	**576,466 (2.36)**	**1032 (3.07)**
42	**Evergreen forest**	**186,259 (0.76)**	**234 (0.70)**	**435,920 (1.79)**	**548 (1.63)**
43	**Mixed forests**	**84.157 (0.34)**	**106 (0.32)**	**156,078 (0.64)**	**197 (0.58)**
73	Golf courses	1,168		2,696	
80	Pasture	61,188		123,100	
83	Row crop	27,608		72,940	
91	**Forested wetland**	**253,915 (1.04)**	**455 (1.35)**	**584,716 (2.40)**	**1,046 (3.11)**
92	Coastal marsh	14,557		35,432	
93	Nonforested wetland	5,003		8,697	
	Total Forests	**871,734 (3.57)**	**1334 (3.96)**	**1,860,268 (7.62)**	**2,824 (8.39)**

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