LONG-TERM SUSTAINABILITY ANALYSIS OF WOOD SUPPLY IN GEORGIA - PRELIMINARY APPROACH

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Abstract

Described is an initial state of a new cooperative study at the School of Forest Resources, University of Georgia, in analysis of long-term wood supply in Georgia. The answers sought pertain to various questions about sustainability of current wood supply in the context of the available literature, unpublished research on intensive plantation management, growth and yield dynamics, and the reality of political and regulatory conditions. At the current state the analysis is based on basic inventory summaries founded on the databases provided by the USDA Forest Service Forest Inventory Analysis unit. Even this simplified preliminary approach to the analysis is far more comprehensive than any previously done work in the region. We present here the preliminary results and identify the directions and resources for futures improvements.

Keywords: Long-term sustainable forest management, maximum allowable cut, intensive forest management

Background

One of the most vital questions asked by society today is whether or not our natural resources are utilized on a sustainable basis. No reliable answer to this question can be produced from simple comparisons of current growth rates and levels of removals because 1) the growth of forests does not follow linear trends and 2) all growing stock recorded is not recorded in the forest inventory due to minimum recording size. To answer resource sustainability questions, one needs to conduct a more complex analysis involving proper modeling of changes over time that are nonlinear in nature. This includes using explicit assumptions concerning regeneration dynamics, specifying assumptions regarding future land use changes, and taking into account supply and demand of forest products.

With the growing concern of societies about the welfare of natural resources, even private landowners face the possibility of drastic regulatory constraints for the sake of preservation, sustainability, and stewardship. At the same time, some of the concerns about sustainability are the result of uncertainty about future developments rather than conclusions from existing data or conclusive information. Through this project we want to provide a scientific basis for realistic analyses of the long-term considerations of sustainability of natural resources in Georgia.

Georgia, located in the southeastern United States, is the third fastest growing state in the Union. Forest production is Georgia's highest valued agricultural commodity and one in which it leads the nation. With over 72 percent of forest cover, Georgia has 23.6 million acres in commercial forest, more than any other state. Approximately 630,000 private landowners own over two-thirds of

Georgia's forests. Georgia's forest industry generates 177,000 jobs of which 75,000 are employed directly with the remaining jobs in industries supporting forest products manufacturing. The annual economic impact of the forest sector in Georgia exceeds $21 billion contribution to the state economy through both domestic and foreign markets. The direct value of harvested forest products to the state's economy in 1996 was $1.22 billion.

Since 1993, Georgia has led the United States in the number of trees planted. In 1996-1997 over a quarter billion trees were planted in Georgia on almost a half million acres. In 1991, 2.6 million Georgians over 16 years old participated in some form of wildlife recreational activity, including fishing, hunting and other non-consumptive wildlife activities. The impact of this recreation in Georgia was $1.1 billion. The growth of trees in Georgia is very rapid compared to other parts of the country. Expected rotation ages on presently managed plantations are approximately 20-30 years, for fiber and solid products, respectively.

Increased forest management intensity, demand for forest products, population growth, and development have led to very rapid changes in the forest landscape of Georgia in recent years. Land uses are changing, with increased land area being taken out of forest production for development. Forest management has intensified in recent years to produce increased yields from the commercial landbase (Daniels, 1999). With such unprecedented demands there is a need to understand the long-term sustainability of the state's forests. Are the current land use trends sustainable? Can increased productivity of intensively managed forestland sustain the demand for forest products amid a shrinking landbase? Can Georgia meet the forest resource needs and values of the present without compromising the similar capability of future generations? (Helms 1998).

With the rapid changes in the status and conditions of forests in Georgia and throughout the South, there is a need for more frequent inventory surveys and improved analysis of long-term trends. The state's forest industry and its economy depend on accurate fiber supply assessments and the ability to predict the changes in available inventory and their uncertainties. It is important also to monitor changes in land use, urbanization, fuel loading, balance of growth to harvest and various catastrophic events. Recent efforts toward a more accurate and timely inventory have involved a reorganization of the Forest Inventory Analysis (FIA) inventory methods and the implementation of the Southern Annual Forest Inventory System (SAFIS), reflecting the importance of accurate and timely inventory updates for the forest industry and southern state economies.

US Inventory Systems

The U.S. Forest Service was authorized to conduct the national forest survey by the McSweeney-McNary Forest Research Act of 1928 that called for "a determination of the present and potential productivity of forest land therein (the United States)". Since then, the Forest Inventory Analysis (FIA) section of the U.S. Forest Service has provided the inventory service across the United States. The first national forest survey began in 1930. Until recently, the FIA inventories have been carried out on approximately 10 year cycles in the southeast to 20 or more years in other parts of the USA. However, as a matter of reality, many inventories in the southeast have taken some 15 years to complete.

In the southeast part of the United States the first forest survey was implemented in the 1930's. Currently, this region is being inventoried for the seventh time. The applied sampling units (the basic unit of measurement on the ground) have been changing over time. These included fixed area plots and point sampling with variable area plots of different basal area factors for trees greater than 5.0 inches dbh with fixed area plots for trees smaller than 5 inches in dbh (Frayer and Furnival 1999).

The main emphasis in past inventories was placed on providing current estimates of the forest resources rather than on providing estimates of growth and other changes over time. The sampling design of the FIA plots was a combination of systematic and random sampling (Chojnacky 1998). Specifically, the plots have been selected from a random selection of points on a systematic grid. Site productivity is described in terms of site class and site index based on arbitrarily selected site-representative dominant tree height measurement.

Measurements recorded under the FIA program were very extensive, labor intensive and covered the collection of various detailed information that could be desirable by different interest groups. Some examples of gathered records include information on den trees and cavities, wildlife cover and habitat types, recreation information and profiles of understory vegetation. On a typical day, a two-person crew could establish and measure one plot and complete land classification. Thus, most of the effort was assigned to obtaining diverse ecological, environmental and other non-mensurational data and only a small portion of time was used for measuring trees.

Objectives

Our short-term objectives are to illustrate a proof of concept for running statewide simulations based on the FIA data and to conduct preliminary visibility analysis based on simplified assumptions and criteria of forest management. The long-term objectives are to:

1. conduct spatially explicit detailed simulations under various assumptions and regulatory constraints;
2. identify major factors impacting the long term wood supply in Georgia;
3. conduct sensitivity analysis on simulations with respect to the assumptions and forest management practices;
4. estimate the impact of various forest management practices and policy scenarios on future states of the forest resources in Georgia; and
5. estimate the impact of various regulatory constraints on the wood supply in Georgia.

Data

The data were acquired from plot level FIA database (Hansen *et al*. 1992) and imported to the model. All non-forest records were deleted. Then species groups were defined. We defined only 3 groups (natural softwoods, planted softwoods and hardwoods) using "current forest type" (TYPCUR) and "stand origin" (STORCUR) variables.

The minimum data requirements for our simulations include: area, species group, site index and age (or year of establishment). This data is available directly from the database. All other values are automatically filled in from the yield tables as the program starts a scenario. We used the following FIA variables:

Options variable	Description	FIA variable(s)	Using of FIA values
Area	Area of the polygon	EXPACR	Directly
SPG	Species group	TYPCUR & STORCUR	see description
SIC	Site index (base age 50)	SI and SI AGE	Directly
Age	Average age	STDAGE	Directly

After analysis of distribution of site indices – 5 site index classes were defined (very low, low, medium, high and very high for site indices from 50 to 99):

Class limits	Area [mill. acres]	Description	Definition (code)	Yield table SIC
0 – 55	1.3	Very low	VLOW	50
56 – 65	4.2	Low	LOW	60
66 – 75	11.4	Medium	MED	70
76 – 85	5.3	High	HIGH	80
86 – 999	2.1	Very high	VHIG	90

Methods

We wanted to run 200-year simulations for Georgia with the same harvesting level as currently used in Georgia, (i.e., 1,476.7 Mill cubic feet per annum) according to results of the latest FIA data (Thompson 1998). To accomplish this task we needed to make assumptions about the following definitions:

1. appropriate simulation tool,
2. simplified representation of the species growing in Georgia,
3. definition of management regimes,
4. maturity criteria for different species groups, and
5. harvesting priorities.

Approach to Landscape Simulation

With the long-term objectives in mind we set out to research tools that were capable of landscape level simulations. After extensive research on Forest Estate Models we have selected OPTIONS from DR Systems Inc., 1615 Bowen Road, Nanaimo, B.C., as the most comprehensive and spatially explicit forest estate model. OPTIONS can be used to examine different forest management scenarios for land areas including financial, industrial and policy decisions and sustainability analysis. The simulator is based on forecasting information for individual polygons. Each piece of information is processed annually, record by record. It is a simulator (without optimization) with GIS functionality.

The fact that OPTIONS software does not do any optimization could be considered a limitation. However, we considered such a scenario to be appropriate for our study, because it is impossible to optimize harvesting levels among 630,000 independent landowners who own most of the Georgia's forestland. We assumed that even though many timber companies in Georgia do optimize the forest management on their properties and apply optimized harvest scheduling, a prudent approach to the simulation of forest inventory for an entire state such as Georgia was not to use any optimization. We realize that this will likely result in an appreciable bias underestimating the growth potential in Georgia. However, we feel that in these types of studies it is better to be conservative rather than aggressive.

OPTIONS program keeps topology for polygons from up to 25 GIS layers. This information can be used with an external GIS system through links to individual basic polygons. Because it keeps polygon topology – it is possible to define combinations of constraints and targets for every spatial layer. GIS layers can be switched on and off – according to goals of the simulation. For each basic polygon the simulator does all defined silvicultural treatments (regeneration, PCT, fertilization etc.) excluding commercial harvesting (thinning and final harvesting), which are treated as the last treatments.

The model starts with the current inventory data and simulates changes over time according to the defined rules and provided yield tables. Even though OPTIONS is a landscape simulator with very complex capability it also has very low minimum data requirements. Basic simulations in OPTIONS can be run using only information about area, species groups, site index, age or year of establishment, and some basic assumptions on yield tables. When needed, OPTIONS can make use of information about basal area, height, diameter, stocking, volume, year of thinning, current management regime, future management regime, stand activity constraints, various GIS constraints, and many other variables. For this reason we found OPTIONS particularly suitable for our study and decided to start the simulations using crude data summaries and only basic assumptions without giving up the perspective of increasing the complexity of our analysis to the highest desirable levels in the foreseeable future.

Species groups and Yield tables

Three species groups and two yield tables were created:

1. For softwoods – yield tables for planted loblolly pine (Harrison and Borders 1996) were used with adjustment factors of
    a. 0.9 for natural stands; and
    b. 1.3 for planted stands.
2. For hardwoods – because of lack of good yield tables for hardwood species - we used the tables for upland oaks by Gingrich (1971) with adjustment factor 1.0.

Management regimes

Three management regimes were defined for all species groups:

1. Regime #1 was management of natural softwood stands with natural regeneration and one time thinning at the age of 20 years.
2. Regime #2 was management of planted softwood stands with artificial regeneration, one thinning at age of 14-16 and one fertilization at age of 15-17 (1 year after thinning).
3. Regime #3 was management of hardwood stands with natural regeneration and no additional treatments.

Then we made the following assumptions on transition of different cover types following harvests:

1. 10% of natural softwoods will remain natural;
2. 90% of natural softwoods will be converted into planted stands;

3. 100% of planted stands will remain planted;
4. 50% of hardwoods will be converted to planted coniferous; and
5. 50% of hardwoods will remain natural.

The above assumptions were programmed into OPTIONS as the following regime allocation table:

Species group	Current regime	% of allocation	Future regime
NSOF	1	10	1
NSOF	1	90	2
PSOF	2	100	2
HWDS	3	50	2
HWDS	3	50	3

Maturity criteria

The maturity criteria are specified in order to define when a stand becomes available for final harvesting. We selected the maturity criteria using arbitrary ages for each of the species groups and site index classes. The following table summarized the assumed maturity criteria:

SPG code	VLOW	LOW	MED	HIGH	VHIG
NSOF	40	35	35	35	30
PSOF	30	25	25	25	20
HWDS	50	45	45	45	40

Harvesting priorities

The following harvesting priority was assumed:

1. over-mature stands should be cut first,
2. second growth should be cut next, and
3. thinning should be performed as the last priority.

The species priority in harvesting was as following:

1. planted softwoods,
2. natural softwoods, and
3. hardwoods.

Results

The results of the simulations (Fig. 1 and 2) suggest that, at the specified harvesting level, the volume available for harvesting, which is the volume represented by stands at ages older than the harvesting age, would be decreasing during the first half century (Fig. 1 top). After that, the volume available for harvesting would remain more or less constant for the remaining period of the simulations.

The sources of annual timber harvest (Fig. 1 middle) includes reports on total available annual timber harvest (divided into different sources of wood as: thinning, second-growth and over-mature stands), comparison of total cut with volume available for cutting and analysis of annual cutting by sources. This figure suggests that the cut level is well below the potential of the wood supply.

The graph illustrating source of annual harvesting in terms of cut (Fig. 1 bottom) suggests that the level of harvesting has been maintained by a small margin and that a relatively small increase in harvesting level could cause a downfall in wood supply.

Fig. 2 illustrates how the averages within different age classes of (from top down) i) total area, ii) total volume, iii) volume per acre, and iv) average diameter, were changing over time within the simulation framework. One of the notable messages coming out of this figure is that both average diameter and volume per acre in older age classes decreased over time. This suggests a negative bias in the applied yield tables, which resulted

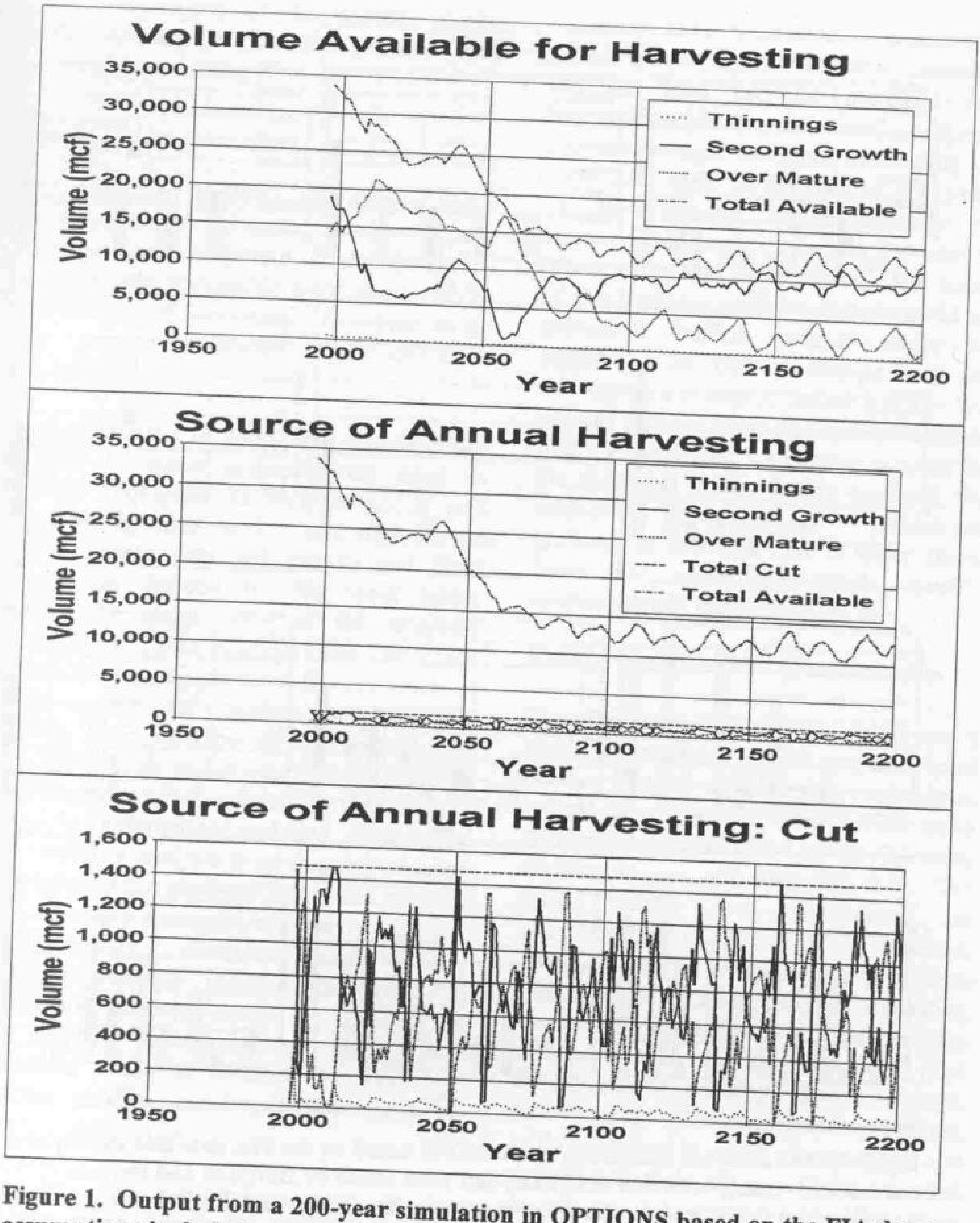

Figure 1. Output from a 200-year simulation in OPTIONS based on the FIA data; assumptions included current harvesting rate and land base, and yield tables by Harrison and Borders (1996) and Gingrich (1971) with a conservative assumption of 30% higher yield of intensively managed pine plantations. Top flat-line on the bottom graph illustrates the sustainable harvest level at the given assumptions.

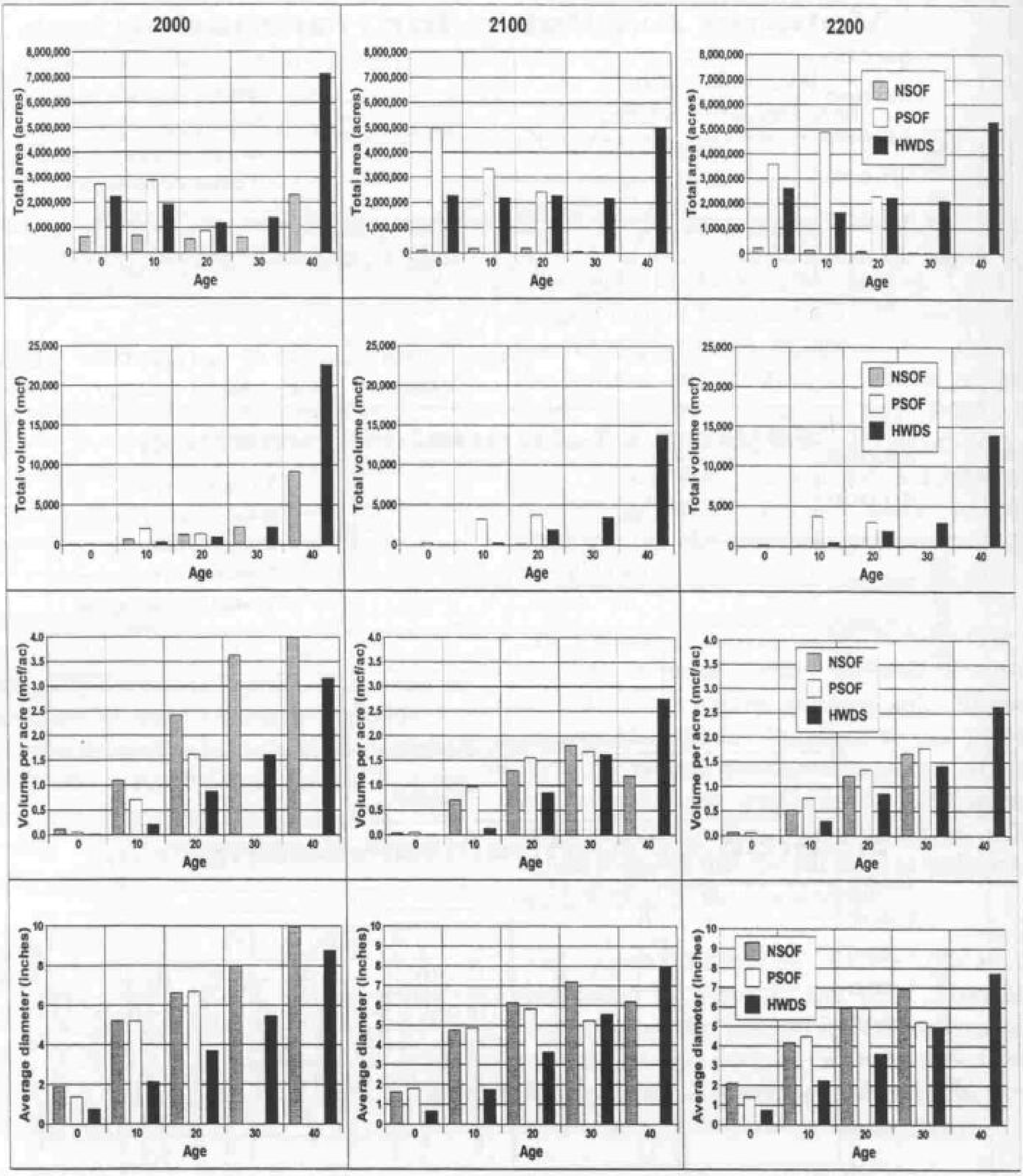

Figure 2. The 200-year simulation in OPTIONS based on the FIA data and assumptions of current harvesting rates and land base, and yield tables by Harrison and Borders (1996) and Gingrich (1971) with a conservative assumption of 30% higher yields for intensively managed pine plantations. Rows from top down illustrate average values by age classes of: i) area of Georgia forests; ii) total volume; iii) volume per acre; and iv) diameters; (the decreasing over time diameter and volume/ac suggest underestimation of growth rates).

in underestimation of the growth of the stands, simulated within the framework of the simulation assumptions.

Discussion

This simplified analysis of Georgia forest management and harvesting scenarios based on current practices and public inventory data suggest a sustainable wood supply at the current level of harvesting. However, in no way are these results final or even conclusive.

In consideration of long-term sustainability analysis of forest resources we need to consider biological as well as social and economic information. In this analysis the FIA inventory data and growth and yield information defined by the yield tables formed the major body of the technical information. This analysis was concerned primarily with biophysical factors, such as forest management practices, rates of timber growth, and definition of the inventory in terms of species and productivity. This was our first approximation based on dramatically simplified assumptions and data. Meaningful sustainability analysis is an ongoing process. The information obtained from such analysis is in no way a guarantee of what will happen in the future. However, such analysis provides valuable insights into potential impacts of different factors and actions on the potential level of wood supply, and therefore, it can be invaluable in decision-making process on issues dependent on future wood supply.

The data and assumptions used in this analysis were drastically simplified. We have observed a negative bias in prediction of future growth and yield. A small negative bias in estimation of the growing stock of wood also results from the fact that the FIA inventory does not record trees smaller then six inches in diameter. On the other hand, we likely have a positive bias in assuming that all land can be managed and harvested, while it is reasonable to expect that there might be some constraints on some land uses. It is expected that some of the forested landbase will be compromised in the future for the sake of urbanization and other uses. Also, some of the landbase may be compromised as protective buffers, which might be significant as carbon storage but not relevant as a source of timber supply. We need to address many additional factors in future simulations. We need to account for the shrinking timber supply landbase, for intensive management plantations growing in Georgia two to three times faster than unmanaged stands, specific species growth characteristics, etc.

Future directions and related studies

The next stage of this study will use a spatially explicit analysis on a subplot level. Instead of statewide summaries individual polygons of various cover types will be constructed based on the FIA data, satellite images, and state GIS data. The future efforts will concentrate on increasing the resolution of the analysis, including the use of spatially explicit data with adjacency rules, and incorporating spatial information from various available GIS data and satellite images. The definitions of existing species groups, cover types, and management regimes, will be defined in much greater detail and growth and yield tables will be extended to all species groups and silviculture treatments. We will target the analysis to consider such regulatory constraints as introduction of riparian zones, maximum area harvesting limits, and adjacency and green-up constraints. The study of long-term wood supply in Georgia will also be conducted in conjunction with the study of wood quality and its spatial distribution in the context of the Georgia's biogeographical regions and climate patterns. Finally, we will conduct marginal error analysis according to the principles discussed by Cieszewski *et al.* (1996), along with various sensitivity analysis demonstrating how much the final solutions are dependent on deviations from the original assumptions.

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