DEVELOPMENT OF A REGIONAL
TIMBER SUPPLY MODEL FOR GEORGIA

by

Frederick Cubbage, Dale Hogg, Thomas Harris, Jr., and Joseph Burgess

Abstract.—A regional timber supply model was developed to forecast softwood and hardwood supplies at state and substate levels, and applied to Georgia as a case study. The model is usable on a microcomputer. Data are entered in a spreadsheet template and forecasts are made using a Pascal program. Projections made for Georgia indicate that softwood supplies will decrease substantially in many important substate areas given current growth and harvest levels and hardwood supplies will increase.

Future timber supplies are a continual concern of the forestry community. Fears of timber shortages prompted most of the federal forestry laws and policies, including setting aside the national forests, creation of the U.S. Forest Service, and promotion of private forestry programs. Accordingly, efforts to predict future timber supplies have occurred continually for decades. This paper summarizes efforts we have made to develop a timber supply model for state and substate level forecasting, with an application to Georgia.

LITERATURE

Many other timber supply models have been developed, but few, if any, met our needs for supply forecasts at a substate level. Early U.S. Forest Service timber supply modeling efforts used the Timber Resource Analysis System (TRAS) to project volume through time (Larson and Goforth 1970). In the 1980's, TRAS has been replaced by an econometric timber supply/demand/price model termed Tamm (Timber Assessment Market Model), which is coupled with the TRIM (Timber Resource Inventory Model) inventory projection model. Tamm is an econometric spatial model of North American softwood lumber, plywood, and stumpage markets, which is designed to


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provide long-range projections of price, consumption, and production trends (Adams and Haynes 1980).

TRIM is an area yield table projection model, that projects timber supplies based on specific stand types land areas and yields. TRIM is a series of four linked computer programs that were developed for a mainframe and have been adopted to run on an IBM or IBM-compatible personal computer (Tedd et al. 1987). TRIM requires plot-level data on initial inventories, areas, growth, and removals. It also requires data on yields and management treatments for the model, as well as stand organization and removals.

In the recent southern timber study—called the South’s Fourth Forest (U.S.D.A. Forest Service 1987)—TAMM and TRIM were used to project regional timber supplies for the South for various years from 1990 to 2030. The results from these projections were then disaggregated into state-level data via the State Allocation of Regional Inventory Model (SARIM), developed by Robert Abt (1987) at the University of Florida. SARIM is an accounting model that disaggregates trends at the regional level so timber area, growth, removal, and inventories could be obtained for each state.

In addition to the Forest Service’s continual timber supply modeling efforts, several state models of timber supplies have been developed. Several recent econometric models of state timber supplies have been developed, including in North Carolina (Daniels and Hyde 1986) and in Montana (Jackson 1983). These models develop equations for timber supply and demand based on historical data on prices, inventory, and consumption.

Besides the recent work on econometric supply and demand curve estimation, some forest economists have also tried to estimate theoretical timber supply curves that would project how much timber would be supplied at various levels of timber prices. Robinson et al. (1978) developed the GASPPLY (Georgia Timber Supply) method of estimating the amount of timber that economically rational landowners would provide as their rates of return increased. Increasing returns would elicit increased timber production by owners in the state. Hotvedt and Thomas (1986) adopted this method to estimate a theoretical supply curve for Louisiana.

In the last few years, there have been several more applied state timber supply models developed as well. In Minnesota, Rose and others (Pelkkä et al. 1987, Hoganson 1987) have developed integrated inventory, growth, removal, and harvest scheduling models in order to forecast timber supplies on a state or substate basis. In Georgia, Fortson and Shackelford (1986) developed a model to forecast pine timber supply for Georgia from 1987 to 2017. Currently, Robert Abt and others are using TRIM to project timber supplies for Florida, and for the southern two forest survey units in Georgia as well. All of these modeling efforts are attempts to accurately predict actual amounts of timber growth, removals, and inventory in their respective areas.

These prior modeling efforts were considered when developing a model to project timber supplies in Georgia. For many reasons, it seemed that developing a resource-based supply model, exclusive of explicit economic considerations, would be desirable. The TAMM/TRIM models have led to
widely accepted methods of analyzing national timber trends, but have not been as useful for state-level projections yet. The possibility of using TRIM in this study was investigated, but a workable, inexpensive model could not be obtained when this study was initiated. Only a very large, cumbersome, and expensive mainframe version was available at that time. A cheaper microcomputer version has since been released, which is currently being used in the Florida research project.

The state-level econometric estimates of supply and demand for timber, while seemingly more elegant, also rely on unquestionably bad data. National econometric models, while far from perfect, at least have a large amount of data to work with. State models usually are based on timber supply (survey) estimates of three or four points, as well as on very shaky Department of Commerce estimates of production, and dubious average factors to convert usage into stumpage supplies. Lastly, these models at the state level have not actually been used in predicting future timber supplies, perhaps due to validation problems. They do provide one piece of useful information, namely that timber supply and demand are very insensitive to price. This at least suggests that supply models that do not include price may not be as flawed as rudimentary economics might suggest.

The preceding considerations led us to develop a new model that could forecast future timber supplies at the state level in a simple, yet believable manner. Basically, this involved taking the existing inventory, area, growth, and removal rates, applying them to current stands, factoring possible land area or forest type changes, and making projections into the future. In principal, this is somewhat similar to the efforts that were performed concurrently in Minnesota (Hoganson 1987) and by a colleague at Georgia (Fortson and Shackelford 1986). The specifics of the approaches varied somewhat in all cases, however. For the results in Georgia, the differences in the approaches and results between the southern timber study, the study by Fortson, and our current study will be noted later in this paper.

**OBJECTIVES**

The review of other models presages our objectives for development of a state-level timber supply forecasting model. We desired to develop a model that could:

1) forecast timber supplies accurately;

2) forecast supplies at the state, survey unit, and subsurvey unit level;

3) be used on a microcomputer;

4) use existing or easily obtained forest survey data; and

5) be used easily by persons not familiar with computer programming or with manipulating large data set files.

In brief, we were trying to develop a simple, easy-to-use, accurate timber supply forecasting model that could quickly analyze different supply
scenarios at a substate level. This was not necessarily designed to be a higher-tech model, but rather a more easily used and understood model. As part of projecting timber supplies at a substate level, we divided Georgia into many regions, including the basic five survey units and subdivisions of three of these units (Figure 1). Survey units were subdivided on the basis of factors that would be likely to affect local supply, including mill locations, transportation, and demographics.

 METHODS

All methods of forecasting timber supplies require similar input data, including timberland area, timber volumes, timber growth, and timber removals. Most models incorporate detailed information on each of these factors. Timberland area changes may be tracked by ownership class or management type. Initial volumes may be broken down into product classes, diameter classes, or age classes. Growth may include mortality and ingrowth, or they may be modeled separately. Growth and removals may also consider owner class, management type, product class, age class, diameter, and other factors.

In our research, we developed two methods to forecast timber supplies. Both were designed to use easily obtained forest survey data and to run on a microcomputer with 640K RAM or less. One method was developed that projects supplies by ownership class and species group, based on current survey data. In the second method, forecasts are made by management type, species group, and age class.

Both methods used tables generated by the Southeastern Forest Experiment Station, Forest Inventory and Analysis Work Unit (1984) for basic data. These included the following 1982 forest survey data for each relevant region in Georgia:

1) commercial timberland area in acres,
2) volume of all growing stock in cubic feet,
3) net annual growth of growing stock in cubic feet per year, and
4) annual removals of growing stock in cubic feet per year.

These data were obtained for each relevant owner, management type, species group, or age class category.

Commercial timberland area was obtained for each region identified. Growing stock consisted of all volume in the stem of trees 5 inches dbh and greater, up to a 4 inch top. Net annual growth consisted of the net average growth over the last survey unit period, adjusted to equal an estimate of the last year's growth (current annual increment). Growth was obtained by age class, which could then be used like an empirical yield table. Annual removals consisted of average removals over the last survey period, also adjusted to estimate last year's removals. Removals for Georgia were only available in total for all age classes, but we wanted to take out volume across all age classes, as is done in practice. Thus we
Figure 1. Regional Timber Supply Areas Modeled in Georgia
proportioned total removals among all age classes based on such survey information available for other recent southeastern state forest surveys.

The data obtained were then entered into a Lotus 1-2-3 spreadsheet by region and other relevant category. The Lotus spreadsheets were used to calculate removal to growth and inventory to removal ratios for all owner/species group and management type/age class/species group combinations. These provided some insights about possible supply trends by themselves. They also provided the basic inputs for use in a Pascal program that was developed to forecast timber supplies for each of the models.

Supply projection methods for each of the two differed significantly. Ownership/species model basic input data included softwood and hardwood species groups and four land ownership classes — industry, farmer, other private, and public. The ownership/species model was essentially a linear projection of past trends. If growth exceeded removals, inventory would increase over time unless substantial land area losses occurred, and vice versa.

The management/age class model is essentially a stand growth projection model that forecasts supplies based on the cumulative structure of the stands in a unit and the relevant growth, removal, and land area changes. Management/age class inputs included five forest management types (pine plantation, natural pine, oak-pine, bottomland hardwoods, and upland hardwoods), which each were divided into softwood and hardwood species groups, and up to seven 10-year age class categories. In this management type/age class model, volumes were "grown" through the various age classes over time in order to project future inventory. Each area/species/age class/management type category had unique growth and removal rates, which were then applied to the initial inventory in that category. Volumes and areas removed from inventory were returned to the 0 to 10 age class to grow through time again.

Since all good (or bad) models must have an acronym for simplicity and easy recognition, we have named these two supply projection methods. Both will be referred to as the_Georgia _Regional Timber Supply models (GRITS). The ownership/species model will be called GRITS/OS; management type/age class model GRITS/MA.

RESULTS

The results from this research project may be divided into three parts. The first portion concerns the merits and success of the timber supply forecasting techniques employed. The second component of this study addressed some interesting analyses that can be made based on the ratio analyses of inventory, growth, removals for the various regions, without even making any forecasts, but will not be discussed here. The third area of results includes the findings of the actual forecasts made. Specifically, do the timber supply models suggest cause for concern or for comfort about future supplies, and how do they compare with other studies? Due to space limitations, we will be brief in our discussion of these results here.
GRITS Modeling Approach

While those of us who developed the model are biased, the Georgia Timber Supply Model seems to have many merits. First, the model is simple, understandable, easy to use, and intuitively logical. This certainly represents somewhat of a breakthrough in timber supply modeling. The national timber supply models are extremely complex and cryptic, and although they run on a microcomputer, it is not easy. Understanding the inputs, processes, and outputs of GRITS is also simple. For GRITS/OS, applying removal to growth ratios and area changes to base-level inventories is simple to understand. Even GRITS/MA, which is essentially a stand table projection method, seems intuitive, albeit somewhat more complex. The removal of timber from all age classes, as was done in GRITS/MA, also seems logical. This is the way forests are harvested or cleared, and this is reflected in the forest survey data collected in South Carolina, North Carolina, and Virginia. Again, this fact is not explicitly incorporated in other models. Keeping the model simple enough to use on a microcomputer with 640K of RAM memory and the use of spreadsheet software is also an improvement over existing models.

Second, the models can forecast timber supplies on a regional basis for any geographic area desired. State average areas and inventories are simply not that important to forest products firms making decisions about major mill openings or expansions. Mills draw timber from a limited geographic region, and need to have supply information on a similar basis. The GRITS models can be used easily to analyze timber situations on almost any geographic area, based on Forest Inventory Retrieval special runs that can be obtained from the Southeastern Forest Experiment Station. This is a great help for both policy analysis and for practical wood procurement analyses. Even the regional ratio analyses alone will provide considerably more information than prior state-wide timber supply estimates. Actually forecasting these regional supplies will be a great improvement.

Lastly, the flexibility of the model to analyze a wide variety of possible timber situations is an advantage. The program includes automatic area change and removal rate change menus that can be invoked to model changes from the base data. Additionally, since the basic data are contained on a Lotus spreadsheet, one can simply manually change these inputs to determine how they would affect supply. Alternately, the basic model results could be altered as add-on after forecasts are made, by adding incremental acres or volumes that users feel cannot be easily accounted for using fixed percentage changes. Similarly, the model could be used to analyze the effect of adding processing capacity (i.e. a pulp mill) on removals and supply, or of closing a plant. Changes in species used by mills could also be incorporated.

The preceding merits of the Georgia Regional Timber Supply Model indicate that it has achieved the objectives intended. However, there is considerable room for improvement. Like all prototype models, its development has been rather evolutionary, and the contribution of many individuals to the programming of the model has led to some inconsistencies. Several components of the model could be improved in future versions. These include model internal consistency, handling of non-managed stands, and growth and removals computation methods. While the
model can forecast supplies well, the demand side (how much timber will be removed in the future) needs better quantification. The model also needs to be made more generalizable to cases with different numbers of areas.

Supply Forecasts

This section compares the forecasts made with GRITS/OS and GRITS/MA with those made in the recent southern timber study (U.S. Forest Service 1987) and the study made by Fortson and Shackelford (1986) in Georgia.

Methodology.—Several supply forecast scenarios were run with both GRITS/OS and GRITS/MA. The basic scenario examined projects current trends into the future as they have occurred historically. Growth and removals were assumed to occur at the rates reported in the 1982 Georgia forest survey. Land area changes by ownership, species group, and stand management class were assumed to occur at the rates experienced from 1972 to 1982, as reported by Sheffield and Knight (1984) and Knight and McClure (1974).

The approaches among the other supply models differed considerably. The southern timber study was an econometric (TAMM)/inventory (TRIM) model that predicted supply trends for the South and divided them among the states using SARIM. TRIM grew trees according to various yield tables, and also advanced stands towards fully stocked using an approach to normality equation. It changed areas among ownership classes according to a separate econometric land area model developed by Alig (1985). Harvested volumes in TRIM were generally removed from the oldest age classes first, except for a small amount of volume removed in thinnings. The amount of volumes to be harvested were determined by the equilibrium amounts determined in TAMM.

Fortson and Shackelford's model used research-based yield tables for pine plantations and empirical yield tables for other pines; it did not model hardwoods. Harvest levels in their model were set based on predetermined harvest ages. All pine plantations were harvested at age 25, and all natural pine stands were harvested at age 40. Since many stands in the state exceeded these criteria at the starting point of 1982, those stands were all liquidated and regenerated at that date, which did result in large amount of "lost" volume that would not be used by a processing facility. Fortson and Shackelford also assumed that lands could change management type after harvest, usually degenerating from a greater component of pine to a lesser component, especially for nonindustrial private forest landowners.

Comparative Forecasts.—Table 1 summarizes the results of these different forecast methods—GRITS, the southern timber study, and Fortson—for softwood species in the state of Georgia as a whole. All of these models could use different input assumptions that would vary these results; the ones reported here are just the ones for the base-level scenarios.

The differences in the results among the different projection methods are striking, perhaps indicating the folly of even trying to forecast timber supplies. First, let's compare the two Georgia Regional Timber Supply projection methods. The model for projecting by ownership class and
<table>
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<th>Year</th>
<th>Southern Timber Study (Softwoods)</th>
<th>Fortson and Shackelford (Pine)</th>
<th>GRITS/OS (Pine)</th>
<th>GRITS/MA (Softwoods)</th>
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¹/ Sheffield and Knight 1984
species group generally forecast continually increasing total softwood inventory in the state, although some regions that were overcutting in 1982 were forecast to have inventory decreases. However, since growth slightly exceeded removals and not that much forest land area was being lost, total inventory did increase significantly.

The Georgia Regional Timber Supply model projections by management type, species group, and age class, however, showed moderately declining softwood inventories in the state. It also showed that some areas being overcut in 1982 might be more productive in subsequent years. However, much of the crucial Southeast and Southwest Survey Units would face permanently reduced timber supplies. Of the two models, one should place more faith in the results forecast by GRITS/MA, since it does take stand age class structure and growth rates into account.

The results from the model by Fortson and Shackelford also showed substantial pine inventory declines, and even greater pine harvest level declines. Their report did not focus on pine inventory, but rather on allowable harvest. Nevertheless, they provided tables from which one could calculate total state supplies. They started with a curiously large amount of pine volume, but liquidated almost 3 billion cubic feet of this in the first year. Total volumes in their model continued to decline thereafter until 2012, although they were still as much as those in the GRITS/MA model in most cases, perhaps indicating adequate inventory. Their model, however, only allowed harvests to occur at age 25 for pine plantations and 40 for natural stands. This, coupled with the liquidation of a large amount of timber in 1982, created an unbalanced age structure and a reduction of "allowable cut" of almost 50% in the years beyond 2005. It should be noted that there still would be adequate inventory in their model for current removal levels if the strict harvest age class assumptions were relaxed.

The supply forecasts from the southern timber study tracked those of the Georgia Regional Timber Supply management type/age class model relatively closely. The two models were vaguely similar in construct, since they both were based on stand growth projection methods to forecast inventory. The southern study was considerably more involved in many of its linkages to prices, demand, and regional competition, however. Nevertheless, the similarity of the results between the two models generates more confidence in both the models.

Of the two GRITS models, the projections by management type and age class seem most reliable. Thus only their substate level forecasts will be discussed here. Given the current age structure of forest stands in Georgia and the growth rates of removals by age class, the GRITS/MA model suggests that state timber inventories will decrease continually for about two decades (until the year 2005) and then begin a gradual rise after that (Table 2). However, inventories would never reach the levels recorded in 1982, even with the additional 400,000 acres of CRP plantations that were included in the model. This does not mean that the state would run out of timber, but prices probably would increase. Present harvest levels could be sustained on a state-wide basis, but any increase in removals from the 1982 levels (or decreases in growth) could have substantial adverse impacts.
## Table 2. Georgia Regional Timber Supply Total Softwood Inventory Projections for the Management Type/Age Class Model, 1982-2015

<table>
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Note: Total volume in cubic feet (000,000)
Georgia Regional Forecasts.—The regional distribution of timber supplies forecast using the GRITS/MA model should cause particular concern to the Georgia forestry sector. Inventories are forecast to drop appreciably in several important subsurvey unit areas of the state. The coast subunit of the Southeast Survey Unit (1) is projected to lose over almost two-thirds of its inventory by the year 1995, dropping from 1163 million cubic feet in 1982 to 349 million cubic feet in 1995. After this drop, slight increases do occur, mostly due to added pine plantation increases. The northern subunit of Unit 1 inventory also declines by about two-thirds, losing over 1.2 billion cubic feet of volume from the 1982 base of 1.9 billion. The southern subunit inventory does increase considerably, rising from 2044 million cubic feet in 1982 to 3303 cubic feet in 2015. But the overall inventory levels in the Southeast Survey Unit do drop significantly throughout the period. The Southwest Survey Unit also has a substantial projected softwood inventory decrease, from 2129 million cubic feet in 1982 to 1575 million cubic feet in 2015.

In the Central Survey Unit, projections indicate that volumes will increase substantially in the western part of the survey unit, and decrease substantially in the eastern part. These results are probably due to a preponderance of young stands in the west (which will have large volumes in the future, but low growth rates now), and old stands in the east (which have high current growth rates but low growth for many years after being harvested).

Projected GRITS/MA forecasts for softwood timber supplies in the North Central Survey Unit are also bleak. Inventories are projected to decline by over one-half in the western part of the survey unit. Additionally, they are expected to remain stable at best in the Atlanta metro area, and decline in the eastern part of the survey unit as well. Even the North Survey Unit is only projected to have stable softwood timber supplies in the future.

The GRITS/MA projections for hardwood timber supplies do project substantial increases in state hardwood supplies, although much less than the ownership/species model. Hardwood timber supplies are projected to increase about 3 billion cubic feet by 2015, to 16.65 billion cubic feet of total hardwood inventory. Hardwood supplies are forecast to increase modestly in the Southwest and Central Survey Units, and actually decrease slightly in the Southeast Unit. Hardwood inventory is still likely to increase substantially in the North Central and Central Survey Units. No subsurvey units appear to be facing imminent hardwood shortages.

CONCLUSIONS

The Georgia Regional Timber Supply Model represents a prototype version that can be used to project timber supplies in a state and its subregions. Two versions of the model have been developed—one to project by ownership class and species type and one by management type, age class, and species group. Both of the models are operational and easy to use on a microcomputer once the initial data are entered. Both can forecast supplies based on existing inventory, growth, removal, and land area changes. They can also perform sensitivity analyses to evaluate the impact of changes in removals or land area.
While ease of use is desirable, reliability of forecasts is of course more important. Of the two versions of the Georgia Regional Timber Supply Model, it seems clear that the projections by species group, management type, and age class are more accurate than those of the ownership class/species group model. One should account for age class distributions in a supply model. The ownership/species model may be useful for identifying ownership sectors and regions with large adverse or favorable drain to growth ratios. But its use as an accurate forecasting tool seems limited to very short-term projection periods. Several model enhancements to GRITS/MA have also been identified.

We will soon be able to assess the accuracy of all of the timber supply models for Georgia. The forest survey crews are currently working in the state and should have results within a couple of years. These will be similar enough to be compared to the 1982-based survey projections, which will indeed be interesting. Preliminary tallies of the Southwest Forest Survey unit suggests that the GRITS/MA forecast of 1988 volumes was within one percent of actual inventory, which bodes well.

The implications of the projections also bear mentioning. At the very least, they indicate that softwood timber supplies in Georgia appear to be only adequate to sustain the level of harvests experienced in the late 1970s and early 1980s. If softwood removals increased substantially, and demand remained the same, one could expect substantial decreases in inventory, and eventually a shortage of timber available without substantial real price increases. These prospects seem to be worse in the southern areas of the state where most primary processing facilities are located. Additionally, if the 1982 data represented a low point in removals (they were measured during a business recession) or if timber growth has reduced significantly (as has been suggested), Georgia may indeed be facing its first recorded reduction in softwood volumes in this century. Prospects of timber shortages might not materialize for several reasons. Perhaps removals were measured at a high point, and growth has remained stable—this would increase softwood supplies. Industry may perhaps shift to increased reliance on hardwoods, especially for pulp, paper, and composite boards. Improved regeneration of cutover forest land and planting of agricultural land, especially under the CRP program, may augment supplies.

LITERATURE CITED


