USING TAMM TO PROJECT STATE LEVEL
RESOURCE AND MARKET CONDITIONS

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ABSTRACT

The USDA Forest Service has used the Timber Assessment Market Model (TAMM) to project regional forest resource and market conditions since 1980. These projections have been of limited use to state policy makers as the supply regions encompass aggregate, multi-state regions. However, the recent production of a PC version of TAMM provides an opportunity for local analysts to incorporate state level projections into the spatial, multi-market framework of TAMM.

This paper describes a methodology for adding an additional supply region to TAMM and provides results for the state of Florida using the 1993 RPA assessment update as a base case. This project also provided an opportunity to review and, in some cases, modify several routines within TAMM where exogenous inputs appeared to restrict the operation of the economic model.

INTRODUCTION

Recent timber supply restrictions in the western United States have lead to increased commodity prices in both product and stumpage markets. Theory suggests that such rises in commodity prices will encourage producers to increase output, and land previously considered marginal for commercial timberland will be brought into production. It would also be expected that lower quality timber will be used in production processes. These market changes within the forest industries could significantly benefit the economies of particular areas of the world. Recent

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studies (Perez-Garcia 1993, Sedjo and Lyon 1990, and Haynes et al. 1995) show that one of the regions likely to experience the largest gains is the U.S. South.

The pressures placed on the southern resource bring a new set of decisions for policy makers in southern states. Environmental restrictions in the form of Best Management Practices, and harvesting restrictions as a result of endangered species legislation, have recently reduced the area of timberland available to meet the projected increase in demand. The state or private policy maker therefore needs to have tools at his or her disposal which can project the effects of outside influences on state timber supply, while also considering local resource issues.

Comprehensive analysis at the state level requires the use of economic models which include the state in a multi-regional, spatial framework, take into consideration vertical markets, and make appropriate consideration of changing technologies. Such a framework is provided by the timber supply models used by the USDA Forest Service in their projections of future market and resource conditions under the mandate of the Rangeland Renewable Resource Planning Act (RPA) of 1974. RPA projections of timber resources are determined through the use of a combination of timber supply models. The Timber Assessment Market Model (TAMM) (Adams and Haynes 1980) is an econometric model of the demand and supply of sawtimber in the U.S. and Canada. Projections for the pulp and paper sector are made using the North American Pulp and Paper model (NAPAP; Ince 1994) which is run iteratively with TAMM. Both models are linked to the Aggregate Timberland Assessment System (ATLAS; Mills and Kincaid 1992) which is a growth and yield model. Results are reported for nine U.S. supply regions and three Canadian regions. Florida is part of the Southeastern supply region which also includes the states of Georgia, North Carolina, South Carolina and Virginia.

The primary objective of this project is to add Florida as an additional supply region to TAMM and produce base case results. The study also provides an opportunity for analysts in the U.S. South to become familiar with the assumptions and behavior of TAMM.

**METHODS**

A PC version of TAMM was supplied by the University of Montana. The version supplied gave base case results as published in the 1993 RPA Timber Assessment Update (Haynes et al. 1995). To add the additional supply region to TAMM, the Southeastern supply region used must be disaggregated into two new supply regions; the state of Florida and an aggregation of the other four states of the Southeast - Virginia, North Carolina, South Carolina and Georgia. This region will be referred to here as the "balance of the Southeast". In disaggregating data, attempts were made to use the same data sources as those used in TAMM. Where more contemporary data was available, such as recently completed inventory surveys in some states, the new data was used². Emphasis was placed on disaggregating all data used such that the sub-regional data summed to the aggregate level used in TAMM.

²Although the most recent forest survey in Florida was completed in 1994, data was not available for this study and the previous survey results (1987) were used.
Changing ATLAS input data

ATLAS requires three types of input files: inventory files contain the starting acreages and volumes; management files contain growth, yield, management alternatives and area change parameters; and harvest files aggregate forest types into fiber types (hardwood and softwood) as well as establish reporting parameters. To produce results for Florida it is necessary to replace the existing Southeastern inventory and management files with two new files of each type; one for the state of Florida and the other for the balance of the Southeast. The existing harvest file must also be modified to incorporate the additional region.

**Inventory files.** New inventory files were constructed using Forest Inventory and Analysis (FIA) data for the five states of the Southeast. The only data requirement which could not be directly obtained from FIA data were management intensities (MI's). ATLAS relies on the provision of MI's to apply a specific yield table to a stand. These can be shifted over time to represent changing technologies. To include this data into the study it was assumed that a given ownership, forest type and site quality in a sub-regional area would have the same initial proportions by area of each MI as the same land type at the regional level.

**Management files.** The most significant changes to management files included area changes, softwood fractions and growth and yield information. ATLAS allows changes in total acres within management units to simulate shifts in forest ownership, timberland gains or losses from land use changes, or long term forest type transitions. Assumptions regarding area changes in the South used in the 1993 update were based on Alig et al. (1990). However, the only publication which has the detail required at the state level is the South's Fourth Forest (SFF) (USDA Forest Service 1988). Forecast data in the SFF has been updated using most recent forest inventory data as a base where available, and continuing the SFF's forecast trends (i.e., percentage increases or decreases).

Inventory data read by ATLAS is made up of aggregate volumes that contain both softwood and hardwood. However, inventory input to TAMM requires both a softwood and hardwood quantity which are determined through the use of softwood fractions. Softwood fractions were calculated for the two new regions based on current fractions from the FIA data. In cases where a particular age class did not exist in a region during the last survey, the fraction used for the Southeast in TAMM was used as a default.

Analysis of FIA data shows yields per acre to be consistently lower in the state of Florida than the balance of the Southeast for all forest types. These differences must be reflected in the disaggregation to avoid showing unrealistically high growth in Florida. ATLAS uses a yield curve for each ownership, site quality and management intensity to act as a volume trajectory guide curve which, used along with a relative density change equation and average stocking proportions, forms the basis of growth and yield projections for a given region (Mills and Kincaid 1992). New yields curves were generated by shifting the TAMM yield curve to reflect the relative sub-regional yields. This shift was made on the basis of differences shown in the most recent FIA data.

**Harvest files.** Aside from the addition of an extra region to the harvest unit file, two additional changes were made. First, the harvest file used with TAMM uses an additional data field not required in stand alone versions of ATLAS. The additional field requires input of softwood proportions of the initial inventory for each region by fiber type (softwood or
hardwood) and ownership (Forest Industry or Other Private). This information can be readily extracted from FIA data.

The second change involves the treatment of Bottomland Hardwood forest types in Florida. This forest type includes softwood species such as Baldcypress (Taxodium distichum) and Pondcypress (Taxodium distichum var. mamans). In contrast to other areas of the Southeast, the southern regions of Florida contain a large percentage of these softwood species, much of which is in the Other Private ownership category. These species are commercially valuable and harvesting in these forest types in Florida appears to be motivated by the extraction of softwood rather than hardwood as is the case in other states. Consequently, although Bottomland Hardwoods are treated as a hardwood fiber type in TAMM, it has been changed to a softwood forest type for the Florida region of this study.

Supply equations

Although direct econometric estimation of new product and stumpage supply equations was initially attempted for the new regions, the quality and availability of data lead to unsatisfactory results. Several of the data series required by the supply equations could only be indirectly estimated, and the derived data does not appear to adequately describe the short term trends in prices or production that are important for accurate econometric estimation at a sub-regional level.

An alternative approach is to rely only on the mean values of the available data and consider the TAMM supply equation for the Southeast as the horizontal sum of sub-regional supply functions. Southeastern regional coefficients can be broken down into sub-regional components by assuming the same supply elasticities at both regional and sub-regional levels.

Changes to the base structure of TAMM

In the course of this project areas were identified where some improvements to the basic model could be made. Although some of these changes are beyond the scope of this project, more straightforward changes have been implemented. These include changes to:

- capacity change routines
- distribution of projected southern pulpwood supplies from NAPAP
- the treatment of land leased by Forest Industry
- stumpage supply intercept shifts.

Capacity change. TAMM seeks to establish long term equilibrium conditions by expanding and contracting capacity within final product markets. The method currently used to calculate annual capacity changes was found to be limited and dependent on exogenously determined limits and expansion and contraction factors. An alternative, simpler, more theoretically consistent procedure was developed for the Southeastern regions in this study based on the relationship between historical profit margins and capacity change in the Southeast.

Distribution of projected southern pulpwood supplies. Volume, price, and trade of pulpwood are provided by NAPAP. TAMM provides projections of sawtimber prices, growing stock inventory, and residue volumes to NAPAP which returns projections of pulpwood consumption by roundwood and residue categories to TAMM in an iterative process. NAPAP is a spatial market model which considers three U.S. regions - North, South, and West. The southern region is a combination of the Southeastern and South Central regions of TAMM. Data is passed
between the two models by distributing the NAPAP projections between the two TAMMM southern regions based on the continuation of past trends.

This method of allocating roundwood supply between regions is incongruent with the detail that has gone into the regional analyses of the sawtimber sector. The econometrically estimated sawtimber supply relationships at the regional level use inventory as an independent variable. The inventory level for the region will be dependent on the amount of roundwood harvested for pulpwood in previous years. Over the fifty year projection period the current method of allocation could result in vast over or underestimates of inventory.

An alternative routine used in this project utilizes a relationship between pulpwood production in Florida, relative inventories and aggregate southern pulpwood production. This routine was used for softwood pulpwood roundwood and possibly also has applications for hardwood and residue markets.

**Timberland leased by Forest Industry.** TAMMM uses two broad categories of private timberland ownership -- Forest Industry and Other Private. However, the distinction is clouded in the southeastern U.S., and particularly in the states of Florida and Georgia, where large tracts of land are leased by Forest Industry from Other Private owners. These leases are usually long term (i.e., at least one rotation) and the intensity of management on this land is usually the same as that on Forest Industry ownerships. In recognition of this, publications specifically dealing with southern regions of the U.S. (e.g., USDA Forest Service 1988) incorporate lease holdings into Forest Industry ownership categories. However, inventory data used in TAMMM and published in national publications (e.g., Haynes et al. 1995) include this leased land as Other Private.

As stumpage supply functions are estimated separately for each ownership group, these differences become significant, and consequently lease holdings have been included in the Forest Industry category for this study. This change will allow for management objectives on leased land to be more closely aligned with those on Forest Industry land and will also assist in making direct comparisons with other southern studies.

**Stumpage supply intercept shifts.** In the version of TAMMM supplied for this study, exogenous data was included which has the effect of shifting the Southeast region softwood sawtimber stumpage supply curves. The magnitude of this shift varies annually, but the effect in each period is a shift inward in the stumpage supply curve, resulting in increased stumpage prices and reduced harvest quantities. The purpose of the shift is to restrict harvest levels which can reach unrealistically high levels during the projection period (Personal communication, Dr. Darius Adams 1994).

Initially the Florida model was run without these shifts. However, forecast removals for Other Private owners were unreasonably high and the percentage shifts have been retained for this ownership. Forest Industry results still appeared reasonable without the shifts and they have been removed for this study.
RESULTS

Although TAMM generates projections for both softwood and hardwood solidwood product and stumpage markets, the results presented will be restricted to softwood markets.

Product markets

Lumber. Projected prices and production volumes in Florida's lumber markets are presented in figure 1. The trends shown are the result of changing relative costs between regions at stumpage and product market levels. The sharp increases in softwood lumber prices shown in the early part of this decade can be largely attributed to reductions in public harvest in the Pacific Northwest region. As a result of the importance of this region as a lumber producer, lumber prices are projected to increase in all regions over the period 1991 to 1997. Consequent increases in profit margins in Florida lead to capacity expansion and increased production over the next two decades.

Plywood. Projected softwood plywood prices and production are shown in figure 2. While stumpage prices in Florida are driven upward by an increasing demand for lumber, the demand for plywood is dampened by the production of less expensive, substitute products such as oriented strand board (OSB) and waferboard. Because of the potential for substitution by these cheaper products, the rate of increase in plywood prices is less than that for lumber and sawtimber stumpage. Margins consequently stay below the level at which pure profits are available to producers, and capacity declines over the projection period.

Sawtimber stumpage markets

Figures 3 and 4 show projected roundwood sawtimber removals and inventories, respectively. In the first decade of the projection harvests follow similar trends for both groups of owners. After the year 2000, Forest Industry inventories continue to increase as existing plantations mature, natural pine is converted to higher yielding plantations, and replanting with improved stock leads to greater yields from existing plantation lands. At the same time, area change forecasts show an increase in timberland area for Forest Industry ownerships. In contrast, Other Private inventories decline as increases in management intensity do not offset increased harvests and loss of area to urbanization and Forest Industry.

The response of Forest Industry removals is as expected -- increasing removals until both prices and inventory stabilize around 2020. However, interpretation of the results for Other Private owners is difficult because of the effect of exogenously entered constraints on harvests in the form of stumpage supply intercept shifts. Without these shifts the model will maintain the level of harvest at rates which are unsustainable and cause inventory to decline sharply.

Figure 5 illustrates projected sawtimber stumpage prices. Increases over the next two decades are a response to the increasing demand for sawtimber, as capacity for lumber production expands in response to increasing product prices. By 2020, private inventories in the West are beginning to mature, and stumpage prices, along with lumber prices, decline slightly. An increasing
dependence on Florida's resource for non-sawtimber commodities drives inventories down and prices up towards the end of the projection period.

**Figure 1:** Projected softwood lumber production and prices in Florida, 1990-2040.

**Figure 2:** Projected softwood plywood production and prices in Florida, 1990-2040.

**Figure 3:** Projected softwood sawtimber removals in Florida by ownership, 1990-2040.

**Figure 4:** Projected softwood growing stock inventories in Florida by ownership, 1990-2040.
SUMMARY AND CONCLUSIONS

State level resource and market conditions have been forecast within the spatial equilibrium, multi-market framework of the models used by the USDA Forest Service. Results show that recent timber supply restrictions in the western U.S. will influence Florida's future timber supply situation. The Pacific Northwest has historically been an important source of lumber in both global and national markets. Reductions in timber supply in this region due to environmental concerns result in increasing lumber prices nationally, and immediate increases in western stumpage prices. The model shows capacity moving out of the West and into southern states, including Florida, where lumber production is projected to almost double from 1990 to 2010. As capacity increases, stumpage prices rise and the rate of expansion in lumber processing activity declines. In plywood markets, rising stumpage prices and substitution from other panel products are expected to result in reductions in production over the projection period.

While inventories on Other Private lands decline due to losses of timberland area to both Forest Industry and urban development, Forest Industry inventories increase as natural stands are converted to higher yielding plantations, new lands are acquired, and improvements in technology result in higher yields from existing plantations. The resource is consequently able to sustain a 60 percent increase in growing stock removals over the next 50 years.

Models of timber supply must simplify and abstract from the complex interactions of a number of markets over long periods of time, with various biological constraints. The modeling process must be considered dynamic, but at the same time both public and private policy makers need to make well informed decisions which will impact the welfare of future generations. The current system of models used by the USDA Forest Service incorporate many of the qualities necessary to make such decisions. The models also include some exogenous adjustments which appear
necessary to keep results within reasonable limits. But these adjustments also tend to restrict the economic interpretation of results. It is imperative that decision makers understand the assumptions which are key to influencing model results before implementing policy based on the use of these tools.

LITERATURE CITED


