DPSupply: A NEW APPROACH TO TIMBER INVENTORY PROJECTION IN THE SOUTHEAST

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ABSTRACT

Timber inventory projection is essential to the development of long-term timber supply studies. The DPSupply Model demonstrates a new way to simulate regional timber supply and inventory changes over time. The model first gives the optimal harvest decision rule for each year based on estimates of net present value, and then the actual harvest will be determined by a combination of harvest decision rules, market demand and the previous period's inventory. This paper describes the general structure of the DPSupply model, and the approach is demonstrated using 1990 FIA inventory data to project future inventories for southeast Alabama. The impact of new policies for establishing streamside management zones (SMZs) on the timber supply situation is also analyzed using the model.

INTRODUCTION

Inventory projection is essential to the development of long-term timber supply studies. Since forest surveys are conducted only every eight to ten years, the task facing researchers is to develop mechanisms for describing changes in the forest inventory base that result from removals during the period since the last survey, and to project growth and harvests for some period into the future. For this reason, researchers more oriented to local and regional problems have focused their efforts on identifying trends in timber growth, harvest and inventory levels. In the South, several regional timber market models have been developed during the recent decade including SPATS (Brooks, 1987), GRITS (Cubbage and Harris, 1991) and SERTS (Abt, 1993).

SPATS and GRITS are only concerned with the growth and harvest aspects of the projection problem and ignore market factors such as stumpage price and the discount rate which may affect the supply behavior of individual forest owners and will in turn influence inventory levels over time. In the SERTS model (the SouthEastern Regional Timber Supply), stumpage supply is a function of stumpage price and inventory in the beginning period, while demand is modeled as a function of price and forest
products production levels. The user has to enter price elasticities and an estimate of inventory elasticity to determine the sensitivity of these factors. Growth and harvest decisions for each of these models are age-class based.

The research reported in this paper used dynamic programming to project changes in forest inventories over time. The model developed identifies the optimal path of annual harvests and inventories over time based on net present value estimates for existing inventories and potential future inventories. The significance of this model is that it links the biological and economic variables together to describe forest inventory changes over time. The harvest decision is made based on stumpage values, and it provides a global optimum result for the projection period. Such a result will give decision makers a clearer picture of possible future harvests and inventories and aid the investment planning process.

This paper describes the general structure of the DPSupply model. The approach is demonstrated using 1990 FIA inventory data to project the future inventory of southeast Alabama. The impact of establishing streamside management zones (SMZs) along forested streams in the region is also analyzed to provide an example of the model’s po for the southeast Alabama.

THE DPSUPPLY MODEL

The principle assumption of this model is that forest owners manage their forest in order to maximize net present value (subject to assumptions regarding how they discount future returns). Then the general recursive equation for the dynamic model can be expressed as:

\[ V_t = \max \{ \Pi_t (P_t, o_t, s_t, d_t, u_t, k_t) + \beta V_{t+1} (P_{t+1}, o_{t+1}, s_{t+1}, d_{t+1}, u_{t+1}) \} \]

where 
- \( k_t \) --- cut decision at time \( t \);
- \( o_t \) --- ownership at time \( t \);
- \( s_t \) --- forest type at time \( t \);
- \( d_t \) --- dbh class at time \( t \);
- \( u_t \) --- volume per acre at time \( t \);
- \( P_t \) --- timber product price per cubic foot at time \( t \).

An array of variables for potential inclusion in this program were carefully examined. We initially considered owner, site index, stocking, dbh class, volume class, and type class. We determined that owner and site index are not significant variables when modeling growth at the survey unit level. Stocking has some effect, but volume and dbh class can be combined to achieve the same effect. Although keeping owner class as a variable did not improve our growth modeling, we kept it in the DP to distinguish decisions made by different ownership groups. Finally, five state variables were selected including: (1) forest type, (2) diameter class (DBH), (3) volume per acre, and (4) timber price per cubic foot. The decision variable, defined in the model as \( k \), indicates if the forest is clear-cut (or not) or thinned based on a net present value calculation.
APPLICATION

The model is demonstrated for southeast Alabama using FIA inventory data from 1982 and 1990 and Timber-Mart South data for Alabama. The total timberland in southeast Alabama was 5,907,594 acres (11,400 acres of non-stocked land are excluded), of which 97% (5,728,136 acres) were owned by industry or private individuals in 1990. For this project, public timberland was excluded because of the small proportion of forest land owned by that owner class. Although the assumptions can be relaxed in future studies and the program can be easily modified and customized, the major assumptions made for our current research include: (1) timberland area does not change over time; (2) forest types and ownership classes do not change over time.

The 1990 FIA data were used to develop DBH and volume growth models. The plot numbers were checked for both the 1982 and 1990 inventories. Only the plots in both the 1982 and 1990 surveys were used to estimate the model. Basically, the DBH and volume models are both stand models. There are separate DBH projection models for current DBH<5.0" and DBH>=5.0", and the models for volume per acre projections are restricted to considering only state variable combinations where DBH>=5.0". We assume that volume per acre is zero when mean DBH<5.0". Separate growth models were constructed for each forest type.

Stumpage prices used in the DP model are from "Timber-Mart South" (1977-1993). The price function was obtained based on the following assumptions: (1) price per cubic foot for DBH classes less than 5" is zero; (2) for DBH classes greater than 5", price functions were developed for each forest type and include DBH as a variable; (3) prices are normalized according to the price of pine sawtimber at the highest dbh class.

Cost estimates for forest management for this DP model are based on costs reported in Forest Farmer (Belli et al., 1992). Common costs are excluded from the value function, since they will not affect the harvest decision. The model was simulated for 45 years at real discount rate of 7%.

Data on forest area and volume contained in streamside management zones (SMZs) for southeast Alabama were developed by Wu (1994) who used GIS/remote sensing techniques and FIA data for the region to compute the SMZ areas volumes. The harvest level estimates were based on severance tax reports and FIA data. The DPSupply Model was used to project harvests and inventory changes from 1990 to 2005. One scenario was evaluated for this demonstration: harvest levels were kept constant after 1994 at the 1994 harvest level. Two conditions were examined for this scenario: 1) a regional inventory situation without streamside management zones (no SMZs) and 2) a situation where 15 meter SMZs are established along all forested streams (with SMZs).

RESULTS

The results of the projections using the DPSupply model are presented in Figures 2 and 3. Figure
2 shows that, without the impact of SMZs, softwood and hardwood inventories remain stable until 1999 with some slight fluctuations. After that point, softwood inventory will begin to increase and hardwood inventory will start to drop. Softwood inventories increase by 7.8% and the hardwood inventories decrease by 10.3% while total inventory (softwood and hardwood combined) from 1990 to 2005 will decrease about 2.1%. With the SMZ volumes withdrawn from the inventory base (Figure 3), softwood inventories will decline by 3.9% during 1990 to 2005 compared with a 7.8% inventory increase without the impact of the SMZ withdrawals. Hardwood inventories decrease sharply after year 2000 with a total decrease of 13.5% over the 1990 to 2005 period. Total inventory is projected to decrease by 5% with the SMZ’s in place, compared with the 2.1% decrease without the SMZ’s.
CONCLUSIONS

The DPSupply Model demonstrates a new way to simulate regional timber supply and inventory changes over time. The model first provides an optimal harvest decision rule for each year based on estimates of net present value, then the actual harvest level is determined by a combination of harvest decision rule, market demand, and the previous period inventory. The advantages of this new model are fourfold: (1) it links economic and biological variables together to determine the removal decision; (2) the decision to offer for harvest for a particular combination of owner class, type, DBH and volume/acre is made based on stumpage values, the stand with the highest value will actually be cut first, (3) a distribution of the inventory over diameter classes can be provided by the model, and (4) the model is flexible and can allow for various approaches to forecasting future markets and recognizing new constraints on availability.

REFERENCES


