AN ECONOMETRIC STUDY OF PRIVATE LAND MANAGEMENT IN GEORGIA[1]

Karen J. Lee and Brian C. Murray[2]

Abstract.--An econometric model is developed for private timberland management to be used in the projection of forest resource supplies. A restricted profit function is used to develop output supply and input derived demand equations for nonindustrial and industrial owners. The estimation indicated limited price response and significant inventory response. Continuing research will examine alternative ownership objectives and policy effects on private land management.[3]

INTRODUCTION

Projections from a recent USDA assessment of forest resource supplies indicate that additional domestic timber production will be increasingly concentrated on private timberlands in the South (USDA Forest Service 1990). Increased production from southern forests can be achieved either through increases in timberland and/or through increased management intensity on existing timberland. The objective of this paper is to develop an econometric model of the management activities of private timberland owners. This model will be designed for ultimate use in the projection of forest resource supplies.

The USDA Forest Service employs a number of econometric models, each representing a different geographic region, in the projections for the RPA assessment (Adams and Haynes 1980, 1986; Alig and others 1984). Of these models, only the Southern Area Model (SAM) explicitly considers the effect of different management activities on forest type transition (figure 1). The current technique used to project timberland management in SAM is developed from a basic accounting of three broad management activities in one ten-year period: harvesting, no disturbance, and other activity.

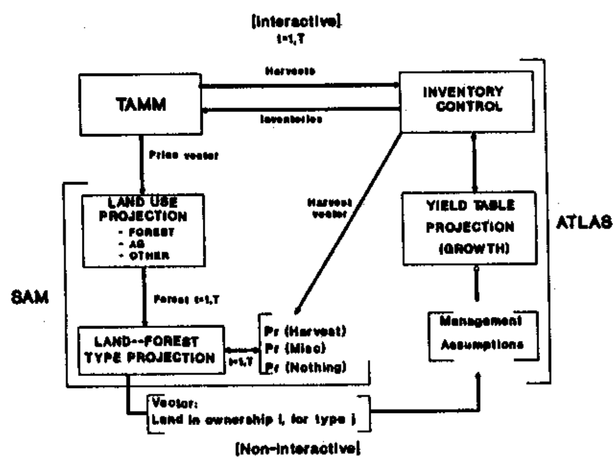

Figure 1.--TAMM/ATLAS/SAM forest resource projection system.

1/Paper presented at the annual meeting of the Southern Forest Economic Workers, Monroe, LA, March 28-30, 1990.

2/Economist, Southeastern Forest Experiment Station, USDA Forest Service, Research Triangle Park, NC 27709; Forester, Southeastern Forest Experiment Station, USDA Forest Service, Research Triangle Park, NC 27709.

3/The authors acknowledge the assistance of Raymond Sheffield, FIA, USDA Forest Service, Asheville, NC; Diane Riggsbee, USDA Forest Service, RTP, NC; and useful review comments by Thomas Holmes, Robert Abt, and Keville Larson.

A discrete probability distribution is derived for all ownerships and forest types in the model. This approach assigns intertemporal transition probabilities, but the effect is not associated with any systematic structure. For instance, planting rates are only loosely associated with economic factors that may change through time (e.g., rising stumpage prices). Our goal in developing a model of private timberland management is to improve upon this methodology.

Management activities for timber production have been examined for both forest industry (FI) and nonindustrial (NI) forest owners. Binkley (1981), Boyd (1984), Hyberg and Holthausen (1989) and Royer (1987) have examined the effects of various economic factors on the management decisions of NI owners. Owners were found to be responsive to government programs and treatment costs, and less responsive to prices (Alig and others 1990). A recent study by Wear and Newman (1989) examined regeneration and harvesting decisions of FI owners, finding a positive response to stumpage prices in the South.

This study addresses only private timberland, which accounts for 90 percent of the timberland in the South (USDA Forest Service 1988). We examine management activities on land that has remained in forest; we are not looking at land use change decisions. The land use change decisions of FI and NI ownerships were addressed by Alig (1986) and Alig and others (1988). As a pilot case for our methodology, we use data for pine forest types in Georgia. The next section outlines the development of a theoretical model, followed by a discussion of the data. We then discuss the preliminary econometric estimation and the results. We conclude by describing additional research needed in this ongoing project.

MODEL DEVELOPMENT

The model used in this analysis assumes that private landowners manage their land to maximize profits. While there are limitations with this type of model (e.g., see Cubbage and Haynes 1988) it provides a useful first step in our analysis of landowner behavior. The specific question here is to determine the effects of economic factors on the timberland management decisions of private landowners. While we would like to examine all types of management, time and data constraints restrict the focus to two management activities: final harvesting (clearcutting) and artificial regeneration (planting). Because the ultimate use of the models developed here is for projection of acres by management on different forest types, we begin by estimating final harvest and regeneration equations for pine types, including pine plantations and natural pine, in Georgia.

Assuming that landowners maximize profits, the long run aggregate profit function can be modeled:

$$\max_{Q,R,L} Z_F = \sum_{t=0} \left[P_t Q_t(R_t, L_t, GS_t) - P_{R_t} R_t - P_{L_t} L_t \right] (1+r)^{-t} \quad (1)$$

$$\text{subject to: } GS_{t+1} = GS_t + g(R_t, GS_t, L_t) - Q_t$$

P = stumpage price	P_R = input cost
Q = quantity harvested	R = regeneration
L = land	GS = growing stock
P_L = price of land	$g(\cdot)$ = growth function
t = time period	r = discount rate

In this model, all factors of production -- land, growing stock and regeneration -- are variable and their use depends on the associated prices and on the production function. The constraint in (1) ensures that harvesting, regeneration and growth in one period are accounted for in future periods. This model is based on Wear and Newman (1989).

Comparative statics results for this model imply that increased harvest results from increased stumpage price and decreased input costs. An increase in any one input use will occur if that cost goes down or if the output price increases. The effects of one input cost on the other input usage cannot be determined because of the possible opposing impacts of output and substitution effects.

Because we only have data at two points in time (or two cross sections), we did not attempt to model the long run production process, but instead used a short run profit function as our decision model (2). As noted above, we are focusing on the intensive, rather than extensive, management of land for forest products.

$$\max_{Q,R} Z_{SR} = PQ(R;GS,L) - P_R R \quad (2)$$

This is a single period model, based on the long run model, except that both growing stock and land are fixed. Regeneration effort is the only variable input.

The decision variables in a primal profit function are the amount of output to produce and the amount of inputs to use (2). Assuming that a landowner is using the optimal level of inputs and producing the optimal level of output, it is possible to model this same problem from a different, or dual, perspective (3). This will allow us to model profit as a function of the prices of the inputs and outputs, and the levels of the fixed factors.

$$R_\Pi = f(P, P_R; GS, L) \quad (3)$$

Use of the dual profit function also allows us to apply the envelope theorem, Hotelling's Lemma in this case, to the model to derive the optimal output supply (4) and input derived demand equations (5). Because we are interested in land management, we use harvested acres as the output and regenerated acres as the input.

$$A_H = Q^*(P, P_R; GS, L) \quad (4)$$

$$A_R = R^*(P, P_R; GS, L) \quad (5)$$

Use of acres in the output supply equation is possible by assuming a constant yield per acre of output. Because Q = acres * yield/acre, a constant yield/acre for all harvested acres will allow Q to be expressed as a function of acres harvested only (A_H). For the input, the actual inputs are site preparation, planting, and seedlings used, a mix of both capital and labor inputs. We assume a constant level of these inputs per acre for all regenerated acres. This allows regeneration to be expressed as a function of acres planted (A_R). Given that we are using data for pine forest types only, in a relatively homogeneous area, we feel that this assumption is not too restrictive. Extending this model to other forest types will present a more complicated, but not insurmountable problem. This model can also be easily extended to other harvesting methods and to other silvicultural treatments.

DATA AND ESTIMATION

A listing of the variables used in the estimation and a description is shown in table 1. One of the reasons we chose Georgia as our test case was because the Sixth Forest Inventory and Analysis (FIA) survey had just been completed. FIA data are collected through periodic surveys and have been made available at the county level for the two most recent survey periods (Sheffield and Knight 1984, Thompson 1989). Private landowners are active in timber markets in all parts of the state. While there has been little change in total private ownership between the 1982 survey and the 1988 survey, there has been a shift from industrial and farmer ownerships to other individual and corporate ownerships (figure 2).

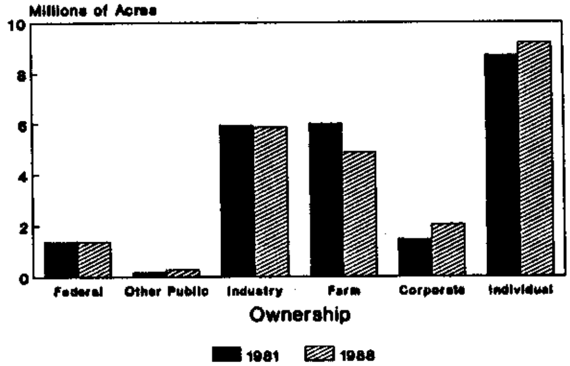

Figure 2.--Timberland ownership in Georgia.

In Georgia, the timberland owned by FI is concentrated near the coast and somewhat in the piedmont (figure 3). Primarily, however, this land is concentrated near the larger mills. This

Table 1.--Description of variables used in the estimation

Variable	Description and Source
PLANT	Timberland acres, previously in pine, that were planted to pine in a county over the survey period. Annual average by ownership. FIA.
HARVEST	Timberland acres, previously in pine, that were harvested in a county over the survey period. Annual average by ownership. FIA.
PRICE	Stumpage price based on a period average of Timber Mart South prices for the regions of Georgia. Sawtimber was used for NI, pulpwood for FI.
COST	Cost of medium site preparation and planting based on Forestry Incentives Program and Forest Farmer data.
SWGS	Total softwood growing stock in pine types in a county at the beginning of the survey period by ownership. FIA.
HWGS	Total hardwood growing stock in pine types in a county at the beginning of the survey period by ownership. FIA.
LAND	Total acres in pine forest types in a county at the beginning of the survey period by ownership. FIA.
YEAR	Dummy variable used to account for survey period differences.

is important in our study because the price data we used delineated only three regions in Georgia. While prices more distant from a mill should be lower, that will not be reflected by applying a regional price to the county level.

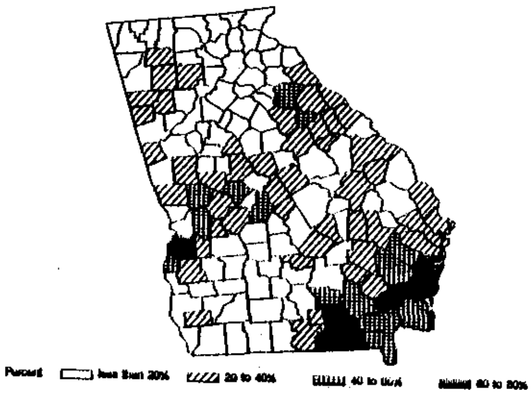

Figure 3.--Percent of timberland owned by forest industry in Georgia, 1988.

The FIA data also indicate significant increases in NI management between the two surveys. One possible explanation is the presence of a state program to encourage reforestation. After the 1982 FIA survey, which portrayed a gloomy future for the forest resource in Georgia, the state began an intensive campaign to encourage reforestation, particularly by NI owners. Regeneration did increase dramatically between the two survey periods (figure 4). However, all other activities also increased, and from this type of data, it is difficult to tell if the increase is due to economic factors or to other factors.

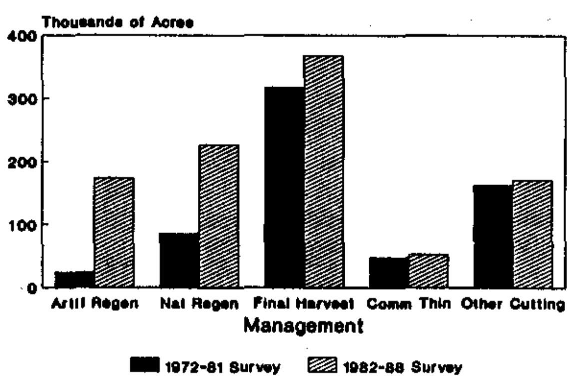

Figure 4.--Nonindustrial forest management in Georgia.

Another change between the 1972-81 and 1982-1988 surveys was the passage of the federal Reforestation Tax Credit. Beginning in 1981, landowners were allowed to amortize and claim tax credit for reforestation expenses up to $10,000 (Siegel and Hickman 1988). We therefore included a dummy variable for year to account for the tax credit and reforestation policies that may have affected reforestation by private owners during the second survey period.

The equations to be estimated from the above model are linear equations, where weighted least squares was used to account for differences in county size. Given that we are examining a single period decision where regeneration, growing stock, and land are inputs to the production process, we would expect that, as the cost of planting increases, the acres harvested and acres planted would decrease in both NI and FI ownerships. The effects of output price on the harvesting decisions of private owners are expected to be positive. The price effect on planting is also expected to be positive. In our model, regeneration is considered an input to production in the current period, implying that an increase in the output price should result in increased input use, i.e., an increase in planted acres.

The effects of SWGS and LAND on harvesting by both NI and FI are expected to be positive as more LAND and SWGS are available for production. Previous studies have shown positive effects of growing stock, or inventory, on output (Adams and Haynes 1980, Daniels and Hyde 1986, Newman 1987). The effects of SWGS on the planting decision cannot be specified because of the conflicting impacts of the output and substitution effects. With increased SWGS, higher harvesting is expected, and with higher harvesting, we expect increased planting (the output effect). Yet, because both planting and SWGS are inputs into production, it is possible that they may be substitutes, resulting in a negative relationship (the substitution effect). These effects, and the design of the model, preclude us from hypothesizing the sign of the coefficients for SWGS or LAND in the planting equations.

The effects of HWGS on planting and harvesting are particularly obscure. Additional HWGS may be expected to reduce the acres harvested because hardwoods are usually less valuable, have a longer rotation, and may be harvested by a method other than final harvesting. In NI ownerships, this could also imply some amenity value of HWGS, resulting in less harvesting. This would then have a negative effect on planting through the output effect. The substitution effect in this case could be positive. More HWGS could lead to more planting, implying that in a fixed land base, more HWGS means a less productive land base, leading to increased planting inputs on the remaining land base. As with SWGS, it is not possible to determine the sign of the HWGS coefficient in either the NI or FI planting equations.

RESULTS

The results obtained from the estimations indicate that these types of models can provide a more analytical basis for projections of management activities on existing timberland acres (table 2). The R-squared values for the harvesting equations were higher than those for the planting equations, and the values for the industrial equations were higher than those for the nonindustrial. The variables had the expected signs with the exception of the cost variable in the NI planting equation. This could be due to our use of the non-subsidized costs of planting in the equation when much of private reforestation is subsidized.

Price and Cost Response

Neither ownership shows a dramatic price or cost response. Given the geographically limited price data, these results were not surprising. Because of the high correlation (.97) between the sawtimber and pulpwood prices, which would have introduced multicollinearity problems, we used only one output price in each equation. We chose to use sawtimber for NI and pulpwood for FI based on the best performance in the model. The output price effect on both NI and FI planting was significant at the .05 level. The cost coefficient was not significant in any of the equations.

The limited price response in the FI harvesting equation could be a result of forest industry providing a regulated forest, generating output supply and input demand at fixed levels according to the amount of LAND and growing stock in any county. There could also be other strategic reasons, reflected by economic variables which we have not included in the model. The lack of price and cost response on harvesting by NI owners can be explained through data limitations as well as through a possible utility response. Both of these aspects of private land management behavior will be examined in the second sweep of our analysis. The output price elasticities in both NI and FI harvesting equations are

Table 2.--Estimation results for pine types in Georgia

	Dependent Variables			
Independent Variables	NI PLANT	NI HARVEST	FI PLANT	FI HARVEST
INTERCEPT	-30151/ (-3.4)*	-1660 (-.98)	2375 (.96)	1916 (.75)
PRICE	7.6 (3.7)* [2.3]	5.0 (1.3) [.31]	40.1 (2.0)* [.61]	32.7 (1.6) [.37]
COST	.69 (0.6) [.54]	-2.9 (-1.4) [-.47]	-1.7 (-.50) [-.49]	-2.2 (-.60) [-.36]
SWGS	.003 (2.8)*	.012 (5.7)*	.04 (12.3)*	.05 (14.8)*
HWGS	-.02 (-5.4)*	-.04 (-5.2)*	.002 (-.10)	.005 (.28)
LAND	.01 (4.1)*	.02 (7.4)*	.002 (.85)	.002 (.95)
YEAR	30.3 (3.3)*	20.1 (1.2)	-29.6 (-1.2)	-22.5 (-.9)
R^2	.29	.58	.62	.70
n	532	532	434	434

1/Coefficient
(t-value)
[elasticity]
* = significant at .05 level.
n = number of observations

comparable to those in Adams and Haynes (1980) and Daniels and Hyde (1986).

Growing Stock Response

FI and NI planting and harvesting equations show strong positive responses to softwood growing stock indicating that higher inventory levels result in higher harvesting and planting. Hardwood growing stock was also included, although it was not significant in the FI equations. The negative effect of HWGS on NI planting and harvesting is significant in both equations. The reasons why hardwood growing stock would have a negative effect on both planting and harvesting are discussed above.

Land Response

Increased land area is significant and positive in the NI equations, but not in the industrial equations. This implies that an increase in pine acreage in NI ownership will result in more harvesting and planting, even without an increase in SWGS on nonindustrial lands.

Year Response

The coefficient for the year dummy variable is significant in only the NI planting equation, indicating a significant difference between the survey periods. In spite of the large increase in NI harvesting between the Fifth and Sixth Surveys (figure 4), that difference can be attributed to economic factors already included in the model. The year variable was not significant in either the FI harvesting or planting equations, indicating that there were no significant changes that were not already accounted for in the model.

CONCLUSIONS AND ADDITIONAL RESEARCH

This study constitutes an initial effort to define and test an economic system underlying aggregate levels of forest management. Although we believe our approach can lead to improved projections of land management, we realize that our model can be enhanced in both specification and scale.

We made conventional assumptions about perfect competition in the timber markets, where all agents are price-taking profit-maximizers. Industry owners responded primarily to inventory variables, while NI responded to inventory and land. Rather than conclude that FI owners act irrationally due to their lack of price response in harvesting, we suggest that imperfections in the stumpage market may cause industry owners to procure land and manage according to internal costs, rather than market prices for stumpage. Future research would benefit from testing a model of optimal input use and land procurement in response to strategic considerations of the firm.

Specification of the NI models may be improved by examining the utility maximizing objective. This would involve including nonmarket variables such as income and population as possible factors affecting NI land management. Further analysis of hardwood growing stock in these models is also warranted. In addition, the current model has not considered the effects of government subsidies or other policies on NI forest production.

There are a number of ways in which our approach could be expanded to be more useful to the resource assessment process. First, the model should be extended to the regional level, and ultimately to the national level. Also, a more comprehensive array of alternative management activities is available from the survey data, including commercial and precommercial thinning and natural regeneration. Unfortunately, the costs associated with these activities are difficult to estimate, except at broad levels of aggregation. The development of data recovery techniques may help in deriving costs for these activities, based upon market data of related activities, or, engineering analysis and factor costing.

These models represent an important step toward using existing data for the projection of private timberland management. Limitations in the data will continue to restrict the modeling, but this analysis has provided promising results for future research. Several improvements can be made in both the modeling and estimation, and we hope to address these issues and improvements in our continuing analysis.

LITERATURE CITED

Adams, Darius M.; Haynes, Richard W. 1980. The 1980 softwood timber assessment market model: structure, projections, and policy simulations. Forest Science Monograph 22. 64 pp.

Adams, Darius M.; Haynes, Richard W. 1986. Development of the timber assessment market model system for long-range planning by the United States Forest Service. In: Plochmann, Richard, div. coord. Proceedings of the 18th IUFRO World Congress; 1986 September 7-21; Ljubljana, Yugoslavia. Yugoslavia IUFRO World Conference Organizing Committee; 158-169.

Alig, Ralph J. 1986. Econometric analysis of the factors influencing forest acreage trends in the Southeast. Forest Science 32(1):119-134.

Alig, Ralph J.; Lee, Karen J.; Moulton, Robert J. 1990. Likelihood of timber management on nonindustrial private forests: evidence from research studies. Gen. Tech. Rep. SE-60. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 17 pp.

Alig, Ralph J.; Lewis, Bernard J.; Morris, Paul A. 1984. Aggregate timber supply analyses. Gen. Tech. Rep. RM-106. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 49 pp.

Alig, Ralph J.; White, Fred C.; Murray, Brian C. 1988. Economic factors influencing land use changes in the South Central United States. USDA Forest Service Research Paper SE-272. Southeastern Forest Experiment Station, Asheville, NC. 23 pp.

Binkley, Clark S. 1981. Timber supply from nonindustrial forests. Bull. 92. New Haven, CT: School of Forestry and Environmental Studies, Yale University. 97 pp.

Boyd, Roy. 1984. Government support of nonindustrial production: the case of private forests. Southern Journal of Economics 51:89-107.

Cubbage, Frederick W.; Haynes, Richard. 1988. Evaluation of the effectiveness of market responses to timber scarcity problems. Mark. Res. Rep. 1149. Washington, DC: U.S. Department of Agriculture, Forest Service. 87 pp.

Daniels, B.; Hyde, W.H. 1986. Demand and supply for North Carolina's timber. Forest Ecology and Management 14(2):59-67.

Hyberg, Bengt T.; Holthausen, Duncan M. 1989. The behavior of nonindustrial private forest landowners. Canadian Journal of Forest Research 19:1014-1023.

Newman, David H. 1987. An econometric analysis of the southern softwood stumpage market: 1950-1980. Forest Science 33(4):932-945.

Royer, Jack P. 1987. Determinants of reforestation behavior among southern landowners. Forest Science 33(3):654-667.

Sheffield, Raymond M.; Knight, Herbert A. 1984. Georgia's forests. Resour. Bull. SE-73. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 92 pp.

Siegel, William C.; Hickman, Clifford A. 1988. Taxes and the Southern forest. pp. 101-120. In: Proceedings of the Policy and Program Conference on "The South's Fourth Forest: Alternatives for the Future." 1987 March 18-19; Atlanta, GA. Miscellaneous Publication No. 1463. Washington, DC: U.S. Department of Agriculture, Forest Service.

Thompson, Michael T. 1989. Forest statistics for Georgia, 1989. Resour. Bill. SE-109. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 68 pp.

U.S. Department of Agriculture, Forest Service. 1988. The South's fourth forest: alternatives for the future. Res. Rep. 24. Washington, DC: U.S. Department of Agriculture, Forest Service. 512 pp.

U.S. Department of Agriculture, Forest Service. [in press]. An analysis of the timber situation in the United States: 1989-2040. Gen. Tech. Rep. (in press). Ft. Collins, CO: U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Wear, David N.; Newman, David H. 1989. The structure of southern industrial roundwood supply. In: Potter, Rich, ed. Proceedings of the 1989 southern forest economics workers meeting, 1989 March 1-3; San Antonio, TX. pp. 99-106.