EXPLORING PRODUCT SUPPLY ACROSS AGE CLASSES AND FOREST TYPES

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ABSTRACT

Timber suply modeling has evolved from examining inventory sustainability based on growth/drain relationships to sophisticated inventory and supply models. These analyses have consistently recognized regional, ownership (public/private), and species group (hardwood/softwood) differences. Recognition of product differences is fundamental to market analysis which traditionally focus on sawtimber and pulpwood. This paper explores the link between product demand and distribution of harvest across forest types and age classes through a simple econometric analysis of US Forest Service FIA tree level data for the state of Georgia. Harvest by owner-forest type-age class was found to be correlated with inventory. Some price response, and a limited response to expected prices was also found, although a much more detailed analysis of expected prices is needed to draw any firm conclusions about the role of price expectations in harvesting. There was support, at least for short term modeling, for using a constant harvest proportion of inventory but limited evidence that oldest stands are harvested first.

INTRODUCTION

Inventory models, including those linked to market models, use various *ad hoc* assumptions to allocate harvest across management types and age classes. For example, ATLAS (Mills and Kincaid, 1991) can be configured to use fixed proportions or to harvest oldest age class first. In contrast, the GRITS model (Cubbage et al. 1992) assumes that future harvest across both age classes and forest types is identical to the current distribution. The SERTS model (Abt et al. 1993) allows the user to allocate harvest based on starting harvest proportions, current inventory proportions, current growth proportions, or some combination of these. However, an economic perspective of harvesting behavior would imply that harvest across age classes and types would reflect current and future prices as well as available inventory. In this paper, we examine several of these assumptions using tree level FIA survey data for Georgia.

We tested several common assumptions regarding harvest distribution across age classes and management types. The four hypotheses we examined include 1) are oldest stands harvested first? 2) is harvest as a proportion of inventory stable over time? 3) is harvest in an age class-forest type related to the amount of inventory available? and 4) is harvest by age class and forest type also related to price? The next section of this paper discusses the data and methods we used to test these hypotheses, followed by the results and conclusions.

DATA AND METHODS

For this analysis we used data from the Sixth Forest Inventory and Analysis survey of Georgia. We analyzed private timber supply behavior on both forest industry and nonindustrial private forest (NIPF) lands. The data was separated by owner and by basic management type (forest type) as shown in Figure 1. Inventory and harvest data were subset into 5-year age classes using the FIA assigned stand age. Inventory volume is the beginning of period volume (either 1981 or 1982, depending on the location), while harvest is an annual volume using the FIA estimates of year harvested.

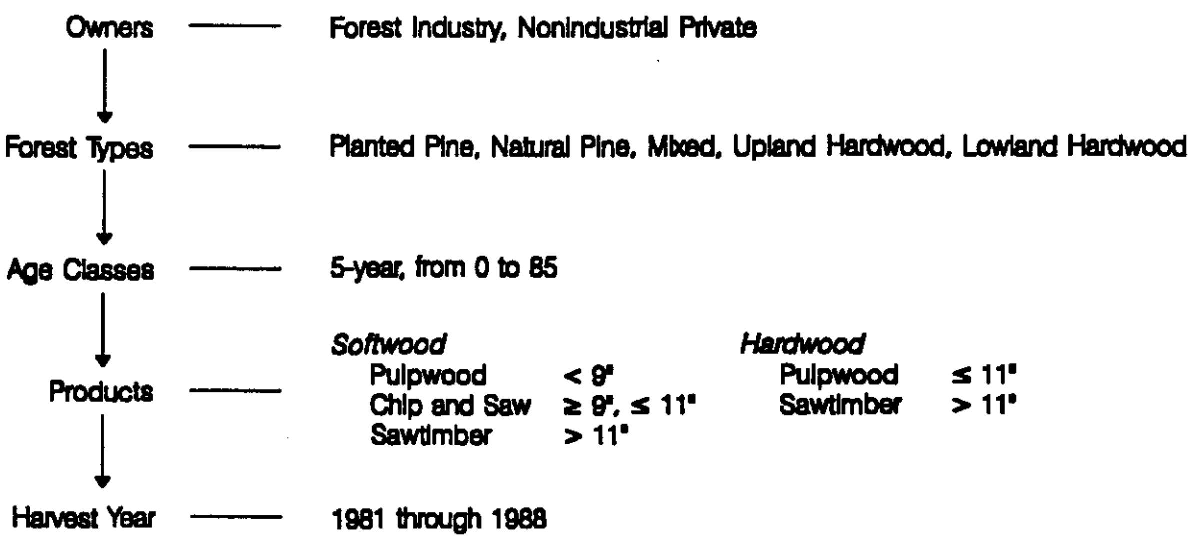

Figure 1. Data structure and merchantability standards used in this analysis

The inventory and harvest for each age class and forest type was further divided into product classes using the diameter distribution from the survey data. Figure 1 also shows the merchantability standards assumed in this analysis. Prices for all harvested volume were calculated using the product volumes and the Timber Mart South product prices for each harvest year. This resulted in a single weighted price for each age class-forest type-owner harvest volume.

We use linear regressions and chi-square independence tests to examine our four hypotheses. The chi-square tests of independence are used to determine if the proportion of inventory harvested by age has changed over time and if the harvest and inventory are drawn from the same underlying distribution. Although these tests have very low power, we combine them with the regressions to address the various hypotheses.

RESULTS

Are oldest stands harvested first?

There is not really much mystery here--the answer is no, at least at the aggregate level. This can be clearly seen in the current data. Unless we assume some type of benevolent social planner and/or identical landowners and land, an individual decision to harvest that owners oldest stands will not translate into an aggregate 'harvest oldest first'. The question is whether or not the current aggregate harvest patterns are consistent with the models where the aggregate of the oldest stands is harvested first. Our conclusion is that they are not.

The data are summarized in figures 2 through 6. Figure 2 shows the age class distribution of both harvest and beginning inventory, indicating that the peak in harvest (at about age 25) does not coincide with the peak in inventory (age 40). Figure 3 shows this distribution by owner, and it appears that harvest and inventory are more closely related on industry than on NIPF lands. Figure 4 shows this same information for planted and natural pine. Clearly, a large part of the discrepancy between harvest and inventory volumes is occurring in natural pine stands. Figures 5 and 6 show the product harvest by age class for both softwoods and hardwoods. As expected, the age distributions of these product harvests are different, although more so in softwoods than in hardwoods.

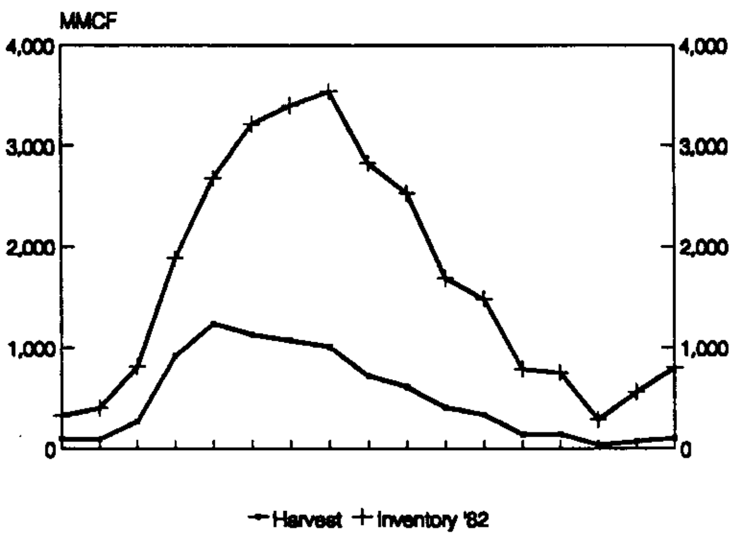

Figure 2. Age class distribution of harvest and beginning inventory for Georgia

The model we used regressed harvest by age as a

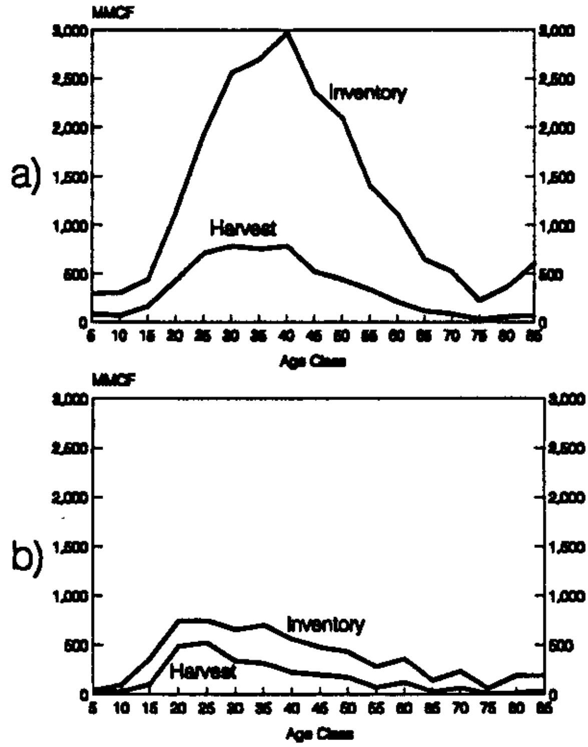

Figure 3. Age class distribution by owner: a) nonindustrial private, b) forest industry

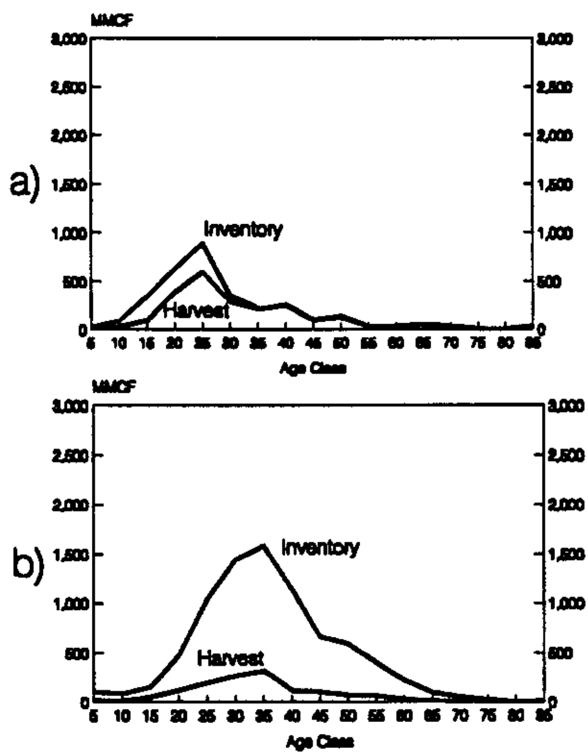

Figure 4. Age class distribution by management type: a) planted pine, b) natural pine

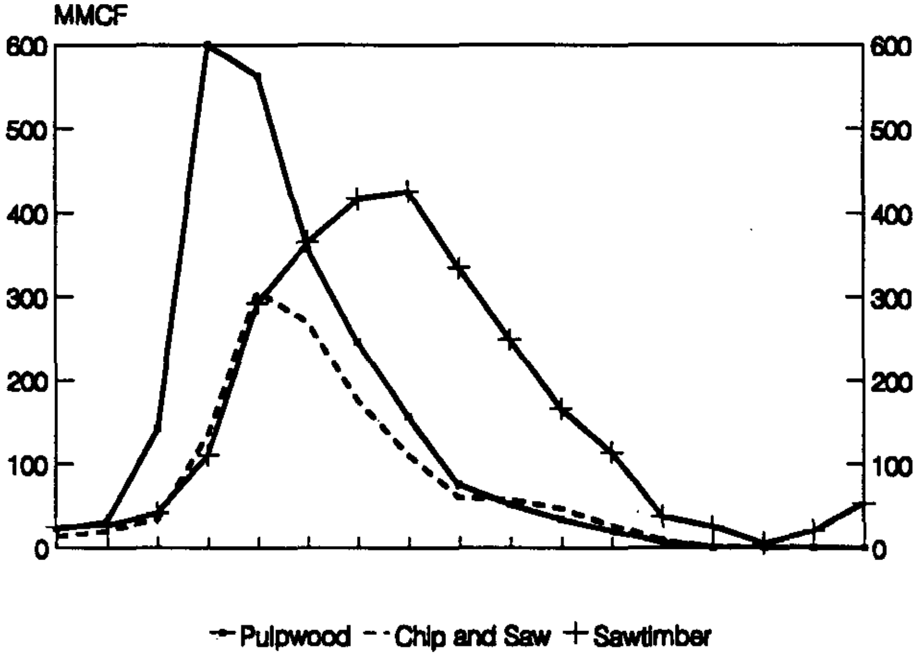

Figure 5. Product harvest by age class for Georgia's softwoods

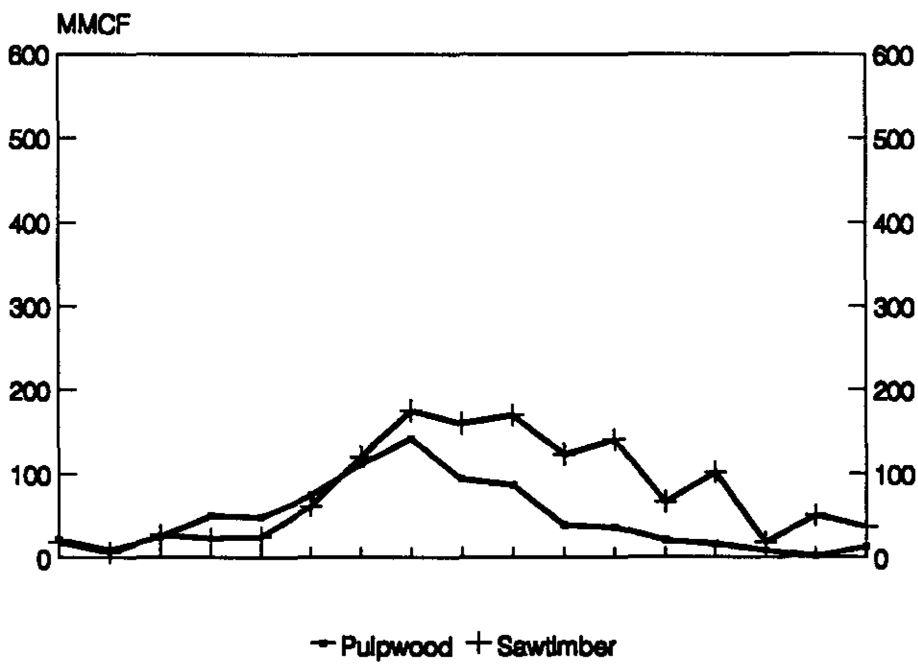

Figure 6. Product harvest by age class for Georgia's hardwoods

proportion of total harvest on the stand age. If the oldest stands are being harvested first, then we would expect the proportion to increase with age. These results, shown in table 1, indicate that the planted pine types for both owners do exhibit this relationship. However, industry natural pine and lowland hardwoods have a negative coefficient indicating a decreasing proportion of total harvest coming from older age classes. This does not provide conclusive evidence either way, but is one more piece of information to refute the use of oldest first in aggregate supply models.

Table 1. Harvest by age as a proportion of total harvest as a function of age.
Model tested: Harvest by age / Total harvest = f (Age)

	Planted Pine	Natural Pine	Mixed Oak-Pine	Upland Hardwood	Lowland Hardwood
Forest Industry	.01 (7.2)**	-.007 (-2.6)**	.004 (1.3)	-.0009 (-.30)	-.004 (-2.9)**
NIPF	.010 (7.5)**	.0003 (.61)	-.0006 (-1.4)	-.000003 (-.06)	-.0009 (-1.7)

** significant at .05

Is harvest as a proportion of inventory stable over time?

Using the FIA estimated date of harvest and the beginning inventory (1982) the chi-square test of independence was rejected for both owners, all forest types. While this is a low power test covering only a few years of data (1981-1989), this result lends support to models which use a constant harvest proportion of inventory for short term inventory projections.

A second test of this hypothesis involved a regression of harvest proportion of inventory on year harvested. In industry hardwood types, upland and lowland, the coefficients on year were significant, implying that an increasing proportion of inventory is being harvested over time (table 2). None of the other industry types nor any of the NIPF forest types showed any significant differences over time. These results are qualified by the short time series of data available and our use of the 1982 inventory volumes for all harvest years. For longer time periods we would expect both the inventory and harvest distributions to change over time and the data does not allow us to draw any meaningful conclusions for long term projections.

Is harvest in an age class-forest type related to the amount of inventory available?

At a more aggregate level, this has been shown to be true, even though the theoretical basis for such a model is hard to pin down (Binkley, 1987). However, when modeling long term inventory changes resulting from harvests and growth, it is necessary to assume that harvest by age class and forest type responds to changed in inventory as well. Our results indicate that harvest is positively correlated with inventory by owner, age class and forest type in all cases except industry lowland hardwoods (see table 3).

Table 2. Harvest proportion of inventory as a function of year harvested..
Model tested: Harvest / Inventory = f(Year harvested)

	Planted Pine	Natural Pine	Mixed Oak-Pine	Upland Hardwood	Lowland Hardwood
Forest Industry	.020 (1.4)	.028 (1.36)	.033 (1.25)	.082 (3.2)**	.044 (2.7)**
NIPF	.015 (1.11)	.0005 (.11)	.0015 (.36)	.0014 (.34)	.005 (1.06)

** significant at .05

Table 3. Harvest as a function of available inventory.
Model tested: Log (Harvest) = f (Log (Inventory))

	Planted Pine	Natural Pine	Mixed Oak-Pine	Upland Hardwood	Lowland Hardwood
Forest Industry	.363 (5.20)**	.464 (3.48)**	.772 (4.05)**	.597 (4.89)**	.167 (1.04)
NIPF	.453 (5.67)**	.496 (6.86)**	.779 (7.17)**	.409 (6.94)**	.342 (3.63)**

** significant at .05

A chi-square test of independence between harvesting and inventory was rejected for all forest type-owner combinations, lending support to the hypothesis that harvest and inventory have roughly the dame distribution across age classes.

Is harvest by age class and forest type also related to price?

It is normal in economic theory to expect a positive supply response to increasing price, but price has not been found to universally lead to increased harvest in aggregate timber supply models. The first model tested below has harvest volume as a function of current price and inventory. The results are in table 4. The planted pine harvests for both owners are positively correlated with price, as is the harvest from other NIPF forest types. The other pine and hardwood types for industry do not have any significant correlation between harvest and price.

A second model incorporates a measure of price expectations. The price expectations term is simply the per unit value of the next older age class. There are problems with this when there is not harvest from the next older age class from which to derive this 'expectation' and thus the price for the next oldest available age class was used as the expected price. The model reported in table 5 regresses harvest on the ratio of expected price to current price and on inventory. We expect a negative correlation between this ratio and current harvest, reflecting the opportunity cost of harvesting stands before they have reached their maximum value. For NIPF owners, pine types, and all types for industry owners, the price ratio coefficients are insignificant. Only the mixed, and upland and lowland hardwood price ratios have the expected response.

Table 4. Harvest by age as a function of price and inventory.
Model tested: Harvest by age = f (price, inventory)

		Planted Pine	Natural Pine	Mixed Oak-Pine	Upland Hardwood	Lowland Hardwood
Forest Industry	Price	.59 (5.6)**	.0009 (.004)	.313 (1.52)	.178 (1.03)	.024 (.11)
	Inventory	.36 (5.8)**	.463 (3.41)**	.654 (3.2)**	.577 (4.6)**	.164 (1.01)
NIPF	Price	.534 (.47)**	..219 (2.3)**	.212 (2.5)**	.345 (4.8)**	.288 (3.5)**
	Inventory	.347 (4.5)**	.486 (6.8)**	.744 (6.9)**	.397 (7.04)**	.281 (3.0)**

** significant at .05

Table 5. Harvest by age as a function of a price ratio and inventory.
Model tested: Harvest by age = f (expected price / current price, inventory)

		Planted Pine	Natural Pine	Mixed Oak-Pine	Upland Hardwood	Lowland Hardwood
Forest Industry	Exp.Prc/ Curr.Prc.	-.101 (-.86)	.233 (1.3)	-.268 (-1.1)	-.033 (-.22)	.036 (.22)
	Inventory	.366 (5.23)**	.468 (3.5)**	.747 (3.9)**	.602 (4.8)**	.167 (1.03)
NIPF	Exp.Prc/ Curr.Prc.	-.04 (-.39)	-.11 (-1.55)	-.213 (-3.2)**	-.243 (-4.2)**	-.176 (-2.6)**
	Inventory	.45 (5.6)**	.486 (6.8)**	.752 (7.1)**	.404 (7.11)**	.347 (3.7)**

** significant at .05

We also ran this particular regression using all owners and forest types, and the results are consistent with our hypothesis, with a negative and significant response to the price ratio and a positive and significant response to inventory. However, this contrasts with the above table, and implies a stronger response in forest industry and NIPF pine types than is present in the less aggregate models. Clearly, caution should be used when assuming that aggregate results apply to individual owners or forest types.

CONCLUSIONS

These results lend some support to the assumptions behind current modeling and projection frameworks. Specifically, we found that harvest by owner-forest type-age class is correlated with inventory, similarly to aggregate models. We also found some price response, and a limited response to expected prices, although a much more detailed analysis of expected prices is needed to draw any firm conclusions about the role of price expectations in harvesting. There was support, at least for short term modeling, for using a constant harvest proportion of inventory, but we found little evidence of harvesting oldest stands first.

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