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Impact of In-Woods Product Merchandizing on Profitable Logging Opportunities in Southern Upland Hardwood Forests

Dennis M. May, Chris B. LeDoux, John B. Tansey,
and Richard Widmann

SUMMARY

Procedures developed to assess available timber supplies from upland hardwood forest statistics reported by the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) units, were modified to demonstrate the impact of three in-woods product-merchandizing options on profitable logging opportunities in upland hardwood forests in 14 Southern States. Product-merchandizing options ranged from harvesting a single, lower valued product to harvesting multiple, higher valued products. Under the specific assumptions and conditions of the demonstration, two-fifths of the South's reported upland hardwood forest, containing about three-fifths of the reported inventory, was estimated to be profitable to log. Multiproduct harvesting was generally shown to increase profitable logging opportunities and profit margins. However, in specific situations defined by product prices, market locations, and stand characteristics, merchandizing options harvesting fewer and lower valued products were shown to be most profitable, demonstrating that multiproduct harvesting cannot always be assumed to be an optimal merchandizing alternative.

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INTRODUCTION

Southern upland hardwood forests have traditionally supplied a large portion of the wood requirements for the hardwood lumber and other solid wood-product industries. More recently, these same forests have been supplying an increasing share of the wood-fiber needs of both domestic and foreign pulp and paper industries. As harvesting pressure mounts, assessments of timber supplies available from these once overlooked forests will become increasingly more important.

Forest inventory statistics reported by the U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) units, do provide estimates of the wood volume existing in southern upland hardwood forests. However, much of this reported volume is unavailable for harvest simply because it cannot be profitably logged and delivered to market. Therefore, determining the amount of the reported inventory that is profitable to log is one key component in estimating timber availability and is one objective of this report. The other objective is to demonstrate how in-woods product merchandizing can affect profitable logging opportunities because it has been shown to offer opportunities for increasing logging profitability through higher harvest revenues, increased logging system productivity, improved wood utilization, and protection against mill-imposed product quotas (Baumgras and LeDoux 1988).

FOREST INVENTORY DATA

Each of the four eastern FIA units periodically gathers forest inventory data from a series of sample plots located across each State in its jurisdiction. Reported inventory statistics for southern upland hardwood forests were compiled from the latest inventories of sample plots occurring on upland hardwood forests (FIA oak-hickory and maple-beech-birch forest type groups) in 14 Southern States (fig. 1). This task was greatly simplified by using the Eastwide Database (Hansen and others 1992), which was designed to minimize differences in sampling designs and inventory data between the four eastern FIA units. Inherent in the reported inventory is a discounting for upland hardwood forests incapable of producing commercial crops of timber due to legal restrictions or adverse sites.

LOGGING PROFITABILITY MODEL

To determine the impact of in-woods product merchandizing on profitable logging opportunities within southern upland hardwood forests, an economic assessment of the profitability of logging each selected sample plot was made for each of three alternative product-merchandizing options using procedures similar to those described by May and LeDoux (1992). The profitability of logging each selected sample plot was based on a comparison of the costs and revenues associated with procuring, felling, limbing, bucking, skidding, and loading the wood products from each upland hardwood forest plot and delivering them to wood-using mills. The costs and revenues were derived from wood-price reports and ECOST-version 2 (LeDoux[1], LeDoux 1985, LeDoux and Baumgras 1990). The ECOST-version 2 model estimates logging costs in 1984 dollars-per-cubic-foot-harvested based on the size and volume of wood removed from each plot, the distance the wood was hauled, and the production functions of conventional logging systems working in conditions typically encountered in upland hardwood forests.

[1]LeDoux, Chris B. 1988. ECOST-version 2 – stump-to-mill production cost equations and computer program. Unpublished report. On file with: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Morgantown, WV. 9 p.

Dennis M. May is a research forester, U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station, St. Paul, MN 55108, formerly with the U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Starkville, MS 39759; Chris B. LeDoux is a supervisory industrial engineer, U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Morgantown, WV 26505; John B. Tansey (deceased) was a supervisory forester, U.S. Department of Agriculture, Southeastern Forest Experiment Station, Asheville, NC 28802; and Richard Widmann is a research forester, U.S. Department of Agriculture, Northeastern Forest Experiment Station, Radnor, PA 19087.

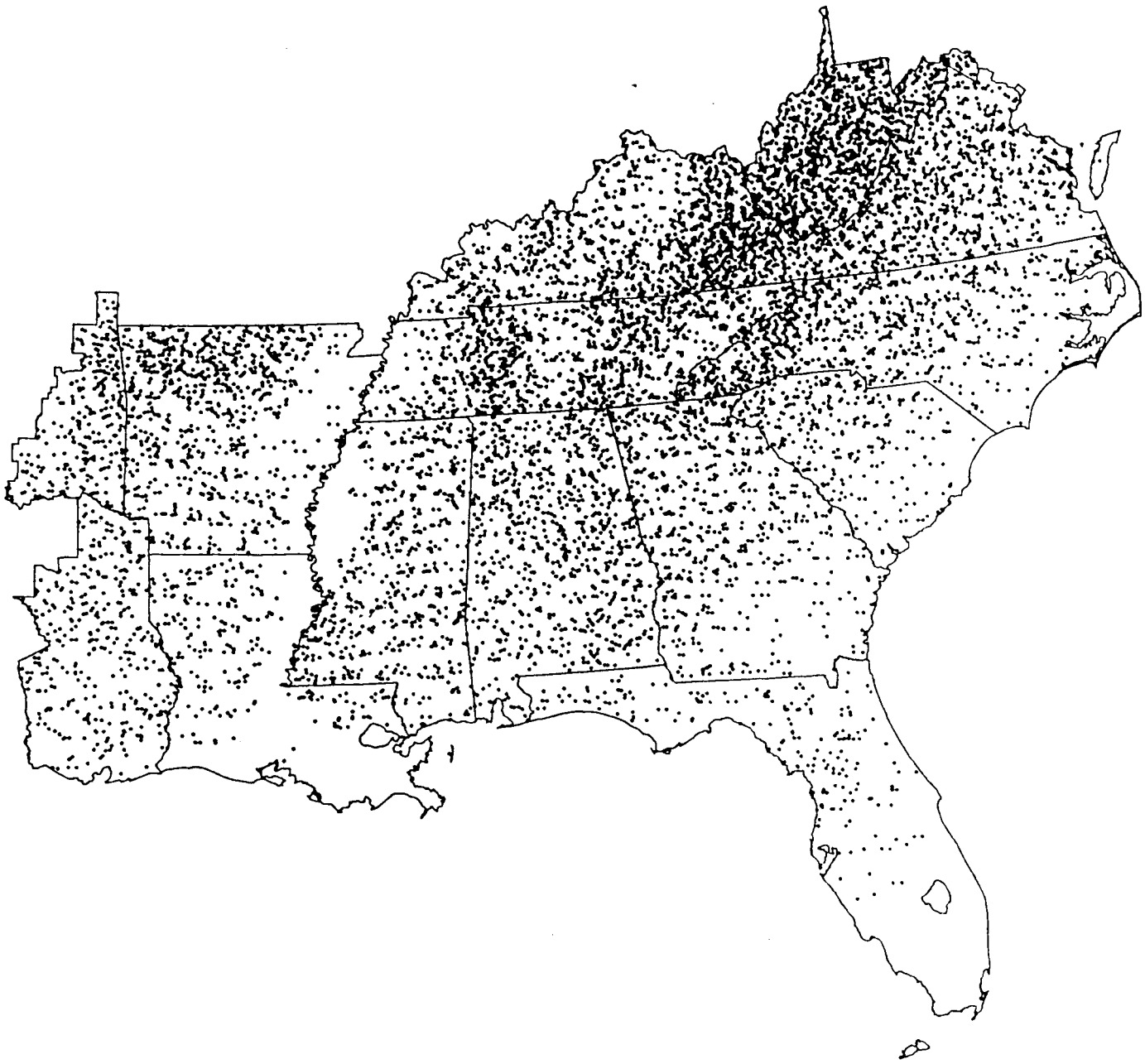


Figure 1.—*Distribution of upland hardwood forests in the South (each dot represents 10,000 acres of timberland).*

MODEL INPUTS/ASSUMPTIONS

The ECOST-version 2 model inputs and assumptions were derived either directly from sample-plot data or selected to represent conditions within the 14-State region and took the following form:

Harvest volume—represented by the entire growing-stock volume on each selected upland hardwood sample plot in the 14-State region. Growing-stock volume is the cubic-foot volume from a 1-foot stump to a minimum 4-inch top diameter outside bark (d.o.b.), or the point where the main stem breaks into limbs, for live trees 5 inches in d.b.h. and larger that are capable of producing sawlogs, currently or prospectively. In reality, some growing-stock volume remains after harvest, and some nongrowing-stock volume, in trees or portions of trees too rough, rotten, or small to be considered growing stock, is removed. However, growing-stock volume is the volume routinely reported by FIA against which most availability assessments are made and is therefore the focus of the study.

The growing-stock volume on each plot was harvested using three alternative product mixes:

Option 1 – merchandize all growing-stock volume into pulpwood.
Option 2 – merchandize growing-stock volume into pulpwood and sawlogs.
Option 3 – merchandize growing-stock volume into pulpwood, sawlogs, and veneer logs.

For the two multiproduct harvesting options, the growing-stock volume was allocated into product groups based on the following:

Sawlog volume – the growing-stock volume in trees of sawtimber size (9 inches in d.b.h. and larger for softwoods and 11 inches in d.b.h. and larger for hardwoods) from a 1-foot stump to a minimum sawlog top (7 inches in d.o.b. for softwoods and 9 inches in d.o.b. for hardwoods), or the point where the main stem breaks into limbs.

Pulpwood volume – the growing-stock volume in trees too small to be sawtimber plus the remainder of the growing-stock volume that is not included in the sawlog volume.

Veneer volume – a proportion of sawlog volume based on the latest harvest volumes of sawlogs and veneer logs reported in each State.

Because the model assumes commercial clearcutting, merchandizing options, such as selectively removing only sawlogs or veneer logs, were not considered. Additionally, no adjustments were made to the product bucking/sorting/decking costs for differences that might exist between each option's product mix and the product mix inherent in the model (differences assumed to be small) or for any marginal costs associated with added products between the options, which Baumgras and LeDoux (1990) have shown to be small and to not adversely affect total harvesting cost. As a consequence, the only differences in logging costs between merchandizing options would be those associated with hauling each product to its respective mill.

Haul distances – represented by the mileage equivalent of the straight-line distances between each FIA sample plot and the nearest mill communities accepting the wood products harvested, as determined by differencing their respective geographic coordinates. To accommodate the multiple products harvested from each plot, mill communities were identified as pulpwood, sawlog, or veneer log markets, either singularly or in some combination, based on the types of primary wood-using mills associated with each community. Communities with pulp, chip, chipboard, charcoal, or shaving mills were classified as pulpwood markets; those with mills producing sawn products, as sawlog markets; and those with mills producing peeled, sliced, or stamped veneers, as veneer log markets. It is realized that this is a simplification of the wood-products market within the region, and that wood products may not always be delivered to the nearest market and almost never are delivered via a straight delivery route. This approach does, however, recognize the number and location of product markets relative to the resource and should provide meaningful assessments of the relative costs associated with hauling harvested wood products from upland hardwood plots under each product-merchandizing option.

Harvest tree size – represented by the average d.b.h. of all growing-stock trees (5 inches in d.b.h. and larger) on each selected FIA sample plot.

Logging system – the ECOST-version 2 model currently allows a choice of one of several ground- or cable-based logging systems. The John Deere 540B rubber-tired skidder system was the option considered most representative of the logging systems commonly operating in the region's upland hardwood forests.

Average skidding distance – set at 700 feet and based on the average harvest tract size in the region, estimated with FIA data to be about 75 acres and corroborated by State forestry departments.

Truck class – the ECOST-version 2 model currently allows a choice of one of five truck classes. The 4-by-2, single-axle truck tractor with tandem trailer was the option considered most representative of the trucks hauling wood in the region.

Road class – the ECOST-version 2 model currently allows a choice of five road classes based on the design speed of the roads. Haul distance for each product was divided into two road classes. The slowest road class (4 miles per hour) was assigned to the distance from each sample plot to the nearest all-weather road (one of the plot description variables collected by FIA) as an estimate of the "pull" road needed to access the timber. The remaining haul distance, after subtracting pull-road distance, was assigned a road class of 2 (35 miles per hour) deemed representative of average truck speeds on State roads.

Delay cost – an estimate, based on the user's knowledge of the logging system, of the unproductive time in all aspects of harvesting and delivering wood to the mill (set at 2 cents per cubic foot of harvest volume for the demonstration).

Move cost – an estimate, based on the user's knowledge of the logging system, of the cost associated with moving equipment into, out of, or within the harvest tract (set at 1 cent per cubic foot of harvest volume for the demonstration).

Stumpage cost – an average cost of procuring the harvest volume under each product-merchandizing option based on product stumpage costs reported by Timber-Mart South (1984). The stumpage costs were specific to the location (State) of each plot, product distribution of each option, and species composition of each product.

Delivered price—an average price paid for the harvest volume under each product-merchandizing option based on product-delivered prices reported by Timber-Mart South (1984). The delivered prices were specific to the location (State) of each mill community, product distribution of each option, and species composition of each product.

For every sample plot, the profitability of each product-merchandizing option was determined by comparing the revenues and costs associated with procuring and harvesting the wood products and delivering them to market (that is, financial return equals delivered price minus procurement, harvesting, and hauling costs). Options with break-even or positive financial returns were classified as profitable to log.

PROFITABLE LOGGING OPPORTUNITIES

Individual Merchandizing Options

Under any one merchandizing option, only a fraction of the South's reported inventory of upland hardwood forests can be profitably logged (table 1). However, as in-woods product merchandizing intensifies from harvesting a single, lower valued product to harvesting multiple, higher valued products, the proportion of the reported inventory that is profitable to log increases. Only the better quality stands in the inventory (plots with higher volumes and larger trees) can "pay their way out of the woods," but multiproduct harvesting allows stands of lower quality to be profitably logged (table 2). Since logging costs increase as stand quality decreases, the increase in profitable logging opportunities associated with multiproduct harvesting can be attributed to compensating decreases in hauling costs and favorable changes in product pricing.

With the addition of sawlogs to the product mix between options 1 and 2, hauling distances decreased (tables 2, 3), a consequence of the numerous and widely distributed sawlog markets in the South (fig. 2). The resulting drop in hauling costs explains some of the increase in profitable logging opportunities under option 2. In contrast, the increase in hauling distances associated with the addition of veneer logs to the product mix helped to suppress the increase in profitable logging opportunities between options 2 and 3.

The importance of product pricing in determining logging profitability is keyed to the difference between delivered price and stumpage cost for a product. This differential price is the amount available to pay for harvesting costs, hauling costs, and profit. Products with large differential prices can absorb higher harvesting and hauling costs and still be profitable. Therefore, products with large differential prices relative to those of other products have a merchandizing advantage. So, even though Timber Mart South (1984) reported delivered-price premiums for sawlogs over pulpwood and veneer logs over sawlogs, after taking into account the stumpage-cost premiums demanded for these products by the landowners, higher valued products did not necessarily have a merchandizing advantage over lower valued products. The consequences of this are evident in the differences between the average differential prices for each merchandizing option (table 2).

For the region as a whole, there is a price differential favoring the merchandizing of sawlogs over pulpwood.

Table 1.—*Profitable logging opportunities in southern upland hardwood forests for each alternative product-merchandizing option*

State	Reported area	Area profitable to log			Reported volume	Volume profitable to log		
		Option 1	Option 2	Option 3		Option 1	Option 2	Option 3
	Thousand acres				*Million cubic feet*			
Alabama	7,661.4	1,217.4	1,674.9	1,949.4	6,786.8	2,272.4	3,017.5	3,364.8
Arkansas	7,264.6	1,208.4	1,494.0	1,499.4	6,054.9	1,972.9	2,345.3	2,354.6
Florida	1,890.4	243.6	413.4	431.8	919.9	341.6	592.0	615.7
Georgia	5,917.6	1,374.1	2,318.6	2,499.1	7,322.3	3,080.4	5,024.4	5,242.1
Kentucky	10,186.5	854.5	2,949.6	3,176.4	13,470.1	1,847.7	5,696.9	6,036.0
Louisiana	2,107.9	854.1	819.7	820.1	1,943.1	1,365.0	1,328.3	1,323.8
Mississippi	5,531.4	1,628.4	1,778.9	1,736.7	4,860.3	2,679.6	2,922.8	2,880.8
North Carolina	7,202.4	3,655.0	5,075.1	5,009.2	13,092.5	9,679.6	11,893.5	11,820.9
Oklahoma	2,609.6	91.5	136.1	136.1	863.4	59.1	84.5	84.5
South Carolina	2,644.2	734.0	1,141.2	1,162.4	3,157.8	1,578.2	2,318.6	2,345.1
Tennessee	9,587.9	3,155.6	4,250.3	4,272.0	12,109.1	6,066.1	7,705.0	7,746.0
Texas	3,367.5	536.4	506.2	499.9	2,019.8	665.2	676.0	672.0
Virginia	9,772.5	3,075.0	5,222.6	5,303.6	14,906.2	7,187.7	11,040.6	11,153.4
West Virginia	10,860.2	1,657.9	4,018.0	4,137.0	18,031.5	4,118.8	9,440.4	9,627.5
Total	86,604.1	20,285.9	31,798.6	32,633.1	105,537.7	42,914.3	64,085.8	65,267.2

Table 2.—*Average characteristics of profitable logging opportunities in southern upland hardwood forests for each alternative product-merchandizing option.*

State	Option	Volume	Diameter	Haul distance	Price differential	Profit
		Ft³/acre	*Inches*	*Miles*	------ *Dollars/Ft³* ------	
Alabama	1	1,866.6	11.6	14.1	0.33	0.05
	2	1,801.6	11.3	10.9	0.35	0.07
	3	1,726.0	11.1	13.4	0.38	0.08
Arkansas	1	1,632.7	11.6	16.9	0.37	0.06
	2	1,569.8	11.8	11.7	0.36	0.07
	3	1,570.4	11.7	12.0	0.36	0.07
Florida	1	1,402.4	15.4	29.0	0.35	0.05
	2	1,431.9	14.1	17.1	0.40	0.12
	3	1,425.9	13.9	22.4	0.44	0.13
Georgia	1	2,241.7	11.9	31.6	0.38	0.06
	2	2,167.0	11.4	19.9	0.40	0.10
	3	2,097.6	11.3	22.4	0.42	0.12
Kentucky	1	2,162.4	11.7	31.1	0.36	0.04
	2	1,931.4	11.7	20.1	0.36	0.06
	3	1,900.3	11.7	20.9	0.36	0.06
Louisiana	1	1,598.2	12.2	17.4	0.40	0.10
	2	1,620.4	12.2	11.5	0.38	0.10
	3	1,614.2	12.3	12.8	0.38	0.10
Mississippi	1	1,645.6	11.4	18.1	0.39	0.08
	2	1,643.1	11.3	11.8	0.38	0.08
	3	1,658.8	11.3	12.7	0.38	0.08
North Carolina	1	2,648.4	11.6	28.2	0.39	0.09
	2	2,343.5	11.1	15.2	0.48	0.20
	3	2,359.9	11.1	16.9	0.47	0.19
Oklahoma	1	646.0	16.1	22.1	0.38	0.07
	2	621.3	14.9	12.6	0.36	0.06
	3	621.3	14.9	12.8	0.36	0.06
South Carolina	1	2,150.1	11.6	32.8	0.39	0.07
	2	2,031.8	11.0	20.9	0.46	0.15
	3	2,017.4	10.9	23.6	0.47	0.15
Tennessee	1	1,922.4	11.3	23.2	0.38	0.07
	2	1,812.8	11.1	13.7	0.38	0.09
	3	1,813.2	11.1	14.1	0.38	0.09
Texas	1	1,240.2	12.4	20.2	0.40	0.07
	2	1,335.5	12.5	15.0	0.36	0.05
	3	1,344.1	12.5	16.6	0.37	0.05
Virginia	1	2,337.5	12.0	24.9	0.35	0.06
	2	2,114.0	11.4	17.7	0.41	0.12
	3	2,103.0	11.4	18.6	0.42	0.13
West Virginia	1	2,484.3	11.4	30.3	0.35	0.04
	2	2,349.5	11.2	21.1	0.35	0.07
	3	2,327.2	11.2	21.5	0.36	0.07
Average	1	2,115.5	11.7	25.3	0.37	0.07
	2	2,015.4	11.4	16.8	0.40	0.11
	3	2,000.0	11.4	18.0	0.40	0.11

Table 3.—*Average hauling distance for each delivered product*

State	Product		
	Pulpwood	Sawlogs	Veneer logs
	Miles		
Alabama	14.1	7.9	29.5
Arkansas	16.9	6.5	42.0
Florida	29.0	10.8	34.6
Georgia	31.6	8.8	31.1
Kentucky	31.1	5.1	59.4
Louisiana	17.4	8.7	20.6
Mississippi	18.1	7.9	31.4
North Carolina	28.2	7.1	25.0
Oklahoma	22.1	7.9	41.8
South Carolina	32.8	10.7	30.2
Tennessee	23.2	5.6	53.6
Texas	20.2	10.4	23.5
Virginia	24.9	6.8	43.0
West Virginia	30.3	6.9	59.4
Average	25.3	7.1	41.5

However, in States with numerous and highly competitive pulpwood markets, such as Louisiana and Texas, the opposite is true. As a result, profitable logging opportunities are the highest in these two States under option 1, despite the longer haul distance to pulpwood markets.

For many States in the region, price differentials provide little incentive for merchandizing veneer logs. In Mississippi and North Carolina, for example, the lack of merchandizing incentive and the longer hauling distance to veneer markets result in profitable logging opportunities being greatest under option 2. In contrast, Alabama and Georgia are examples of two States where differential prices, market locations, and resource characteristics favor the most intensive level of product merchandizing as witnessed by the concentration of profitable logging opportunities in both States under option 3.

Optimal Mix of Merchandizing Options

Table 1 depicts the profitable logging opportunities for each option assuming the entire upland hardwood forests of the South could be logged using only one option to the exclusion of the other two. Logging upland hardwood forests using a mixture of the options would be more realistic. The optimal mix of merchandizing options can be determined from a comparison of the relative benefits derived from each option for each harvest tract. If the assumption is made that the logger is free to exploit all available markets and pursue maximum profits, then profit maximization can be used to judge the relative merits of each option and derive the optimal mix of merchandizing options.

Profit Maximization

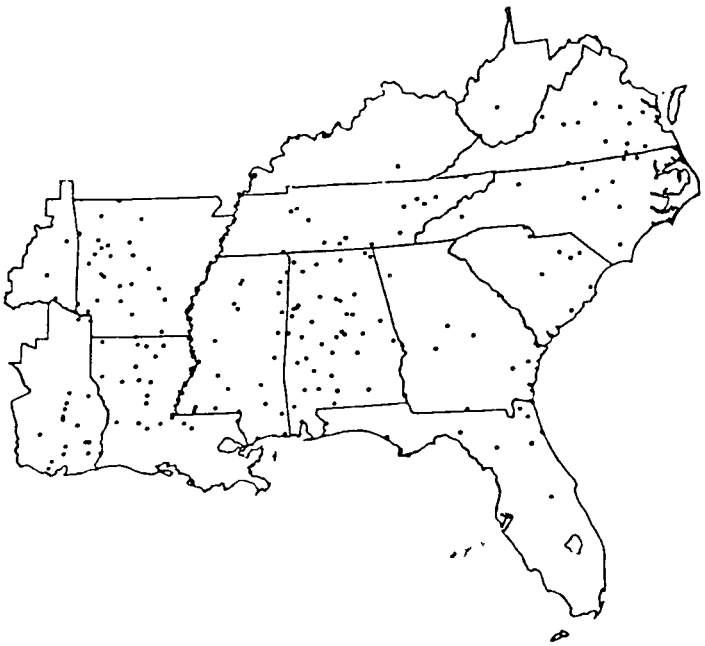
The optimal mix of merchandizing options based on profit maximization resulted in more profitable logging opportunities than any one option did individually (tables 1, 4). However, profit maximization shifted profitable logging opportunities from the least to the most intensive product-merchandizing option. The resulting concentration of profitable logging opportunities in option 3 is testimony to the advantages that can be gained through multiproduct harvesting when the necessary conditions of stand characteristics, market locations, and product prices are met.

In several States where price differentials and hauling costs disfavor the merchandizing of veneer logs, profit maximization concentrated profitable logging opportunities under option 2 (table 4; fig. 3). This is not to say that more of the upland hardwood forests in these States could not be profitably harvested using option 3, only that to do so would result in reduced profits. The optimal product mix (table 4) maximizes logging profits; each option in table 1 maximizes the yield of an individual product. The option combinations in tables 1 and 4 limit a range of option mixes that could be used to profitably log the upland hardwood forests in the South. Any shifting of the option mix from one extreme toward the other would result in a tradeoff between logging profits and product yields. Such tradeoffs occur on a daily basis for loggers who work under contracts, face product-production quotas, or must meet the landowner's financial expectations.

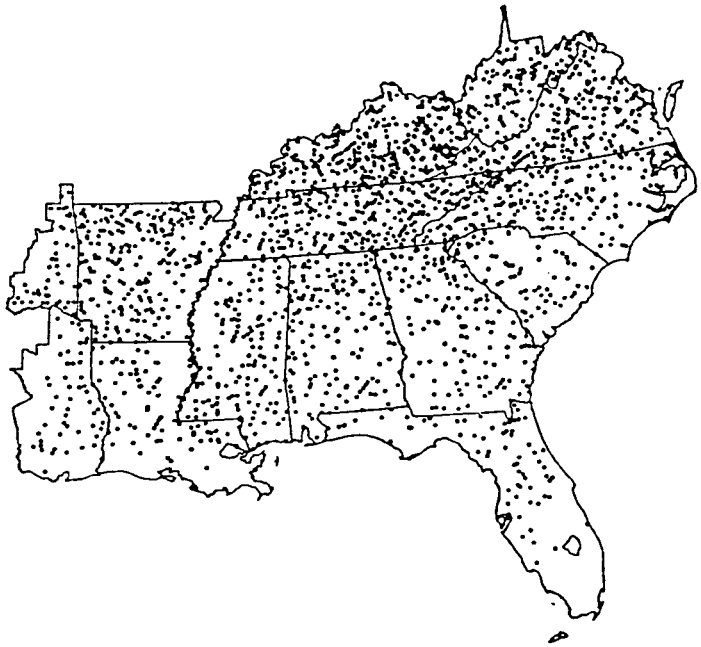
Despite the concentration of profitable logging opportunities in options harvesting multiple products, multiproduct harvesting options should not always be assumed to be the most profitable. There are 2.5 million acres where the exclusive merchandizing of pulpwood (option 1) returns the greatest profit to the logger (table 4). Most of these logging opportunities are concentrated in States with numerous and highly competitive pulpwood markets such as Louisiana and Texas. This situation contrasts the situation in Kentucky and West Virginia where the relative lack of pulpwood markets eliminates option 1 from the optimal mix of merchandizing options (figs. 2, 3).

From figure 3, it is also evident that the reporting structure of the price data used in this demonstration affected the estimates of logging profitability. The use of State-level price data created discrete transitions in prices at State boundaries. Each State, in effect, became an island of profitability advantage or disadvantage relative to other States and for products delivered across State lines. Despite this, State-level price data were deemed suitable for this demonstration because they were readily available and provided some measure of price variation across the region. However, users of this logging profitability model should be aware of the impact that price-reporting structure can have on the final estimates of logging profitability.

PULPWOOD MARKETS



SAWLOG MARKETS



VENEER LOG MARKETS

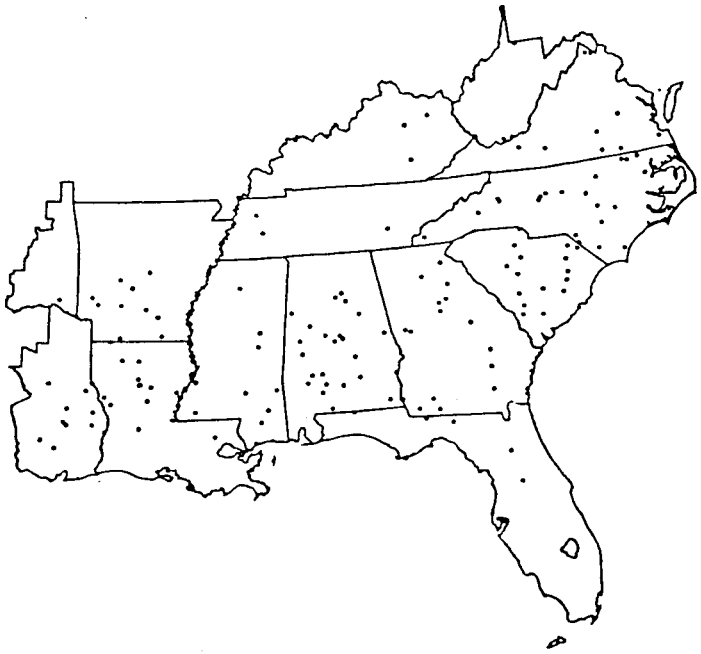


Figure 2 – *Distribution of pulpwood, sawlog, and veneer log markets in the South (each dot represents a community with at least one primary mill using the product indicated).*

Table 4.—*Optimal mix of merchandizing options for maximizing profits from profitable logging opportunities in southern upland hardwood forests*

State	Area profitable to log				Volume profitable to log			
	Option 1	Option 2	Option 3	All options	Option 1	Option 2	Option 3	All options
	Thousand acres				*Million cubic feet*			
Alabama	177.0	59.3	1,794.3	2,030.6	222.3	104.7	3,105.2	3,432.2
Arkansas	436.5	1,114.6	56.6	1,607.7	713.2	1,644.6	112.9	2,470.7
Florida	30.3	88.8	337.5	456.6	6.5	108.7	509.1	624.3
Georgia	115.7	45.0	2,373.5	2,534.2	147.4	74.4	5,042.9	5,264.6
Kentucky	0.0	393.9	2,789.7	3,183.6	0.0	825.0	5,224.2	6,049.3
Louisiana	521.2	233.7	153.3	908.2	784.9	364.5	258.0	1,407.4
Mississippi	592.2	1,204.9	115.3	1,912.3	905.6	1,942.3	182.8	3030.7
North Carolina	86.4	5,005.3	14.2	5,105.9	81.2	11,800.6	35.0	11,916.7
Oklahoma	30.0	107.3	23.1	160.5	14.1	54.4	17.9	86.4
South Carolina	90.0	301.9	831.6	1,223.6	80.2	595.8	1,713.9	2,389.9
Tennessee	109.2	1,277.4	2,920.5	4,307.1	198.9	2,366.5	5,220.6	7,786.0
Texas	358.0	51.5	194.7	604.2	429.3	68.8	258.0	756.1
Virginia	46.3	1,289.4	3,980.8	5,316.6	65.0	2,580.2	8,521.3	11,166.5
West Virginia	0.0	372.8	3,823.1	4,195.9	0.0	820.9	8,920.1	9,741.0
Total	2,592.8	11,545.8	19,408.2	33,547.0	3,648.6	23,351.4	39,121.9	66,121.8

Sensitivity Analysis

As suggested by Baumgras and LeDoux (1991), the harvesting revenues (delivered price minus harvesting and hauling costs) generated by this logging profitability model are sensitive to stand characteristics, market locations, and logging-system productivity. These revenue estimates set the maximum amount available to pay for stumpage and profit. The actual allocation of harvesting revenues between the landowner and logger depends on the monetary expectations of both parties and is difficult to assess for individual harvest tracts. If it is assumed, however, that the landowner shares the burden of excess costs when logging takes place in less than ideal conditions and demands a share of excess revenues when logging takes place under ideal conditions, then the average stumpage costs reported in published price reports provide a ready source of data to assist in partitioning harvesting revenue between the landowner's stumpage and the logger's profit. However, these stumpage costs are still just averages of the monetary expectations of landowners across a State. Because of this, and the importance of stumpage costs in determining differential prices, a sensitivity analysis was conducted in which stumpage costs were increased and decreased by one-third to demonstrate the impact on logging profitability and the optimal mix of merchandizing options.

Stumpage-cost increases shifted logging opportunities from the most to the least intensive merchandizing option and reduced total profitable logging opportunities (tables 4, 5, 6). Losses were concentrated in States with price differentials disfavoring the production of veneer logs, and gains were concentrated in States with highly competitive pulpwood markets. Although the stumpage-cost variations were proportionately equivalent, the impact on differential prices was greater for products with high stumpage costs than for those with low stumpage costs. As a result, stumpage-cost increases created merchandizing advantages for lower valued products causing profitable logging opportunities to shift from option 3 to option 1.

CONCLUSIONS

Within the limits set by the model's input variables and assumptions, about two-fifths of the South's reported upland hardwood forests, which contain about three-fifths of the reported inventory volume, can be profitably logged. At average prices, it would seem that multiproduct merchandizing usually increases profitable logging opportunities and profit margins. However, because of the extreme sensitivity of in-woods product merchandizing to shifts in price differentials, as well as other determinants, multiproduct harvesting should not always be assumed to return the greatest benefit. Only a careful analysis of stand characteristics, local markets, and product prices can determine the optimal product mix for individual harvest tracts. Fortunately, the procedure demonstrated is flexible enough for users to tailor inputs and assumptions to meet specific needs, whether the needs are regional assessments of profitable logging opportunities or local assessments of optimal product mixes to balance logging profits with product yields.

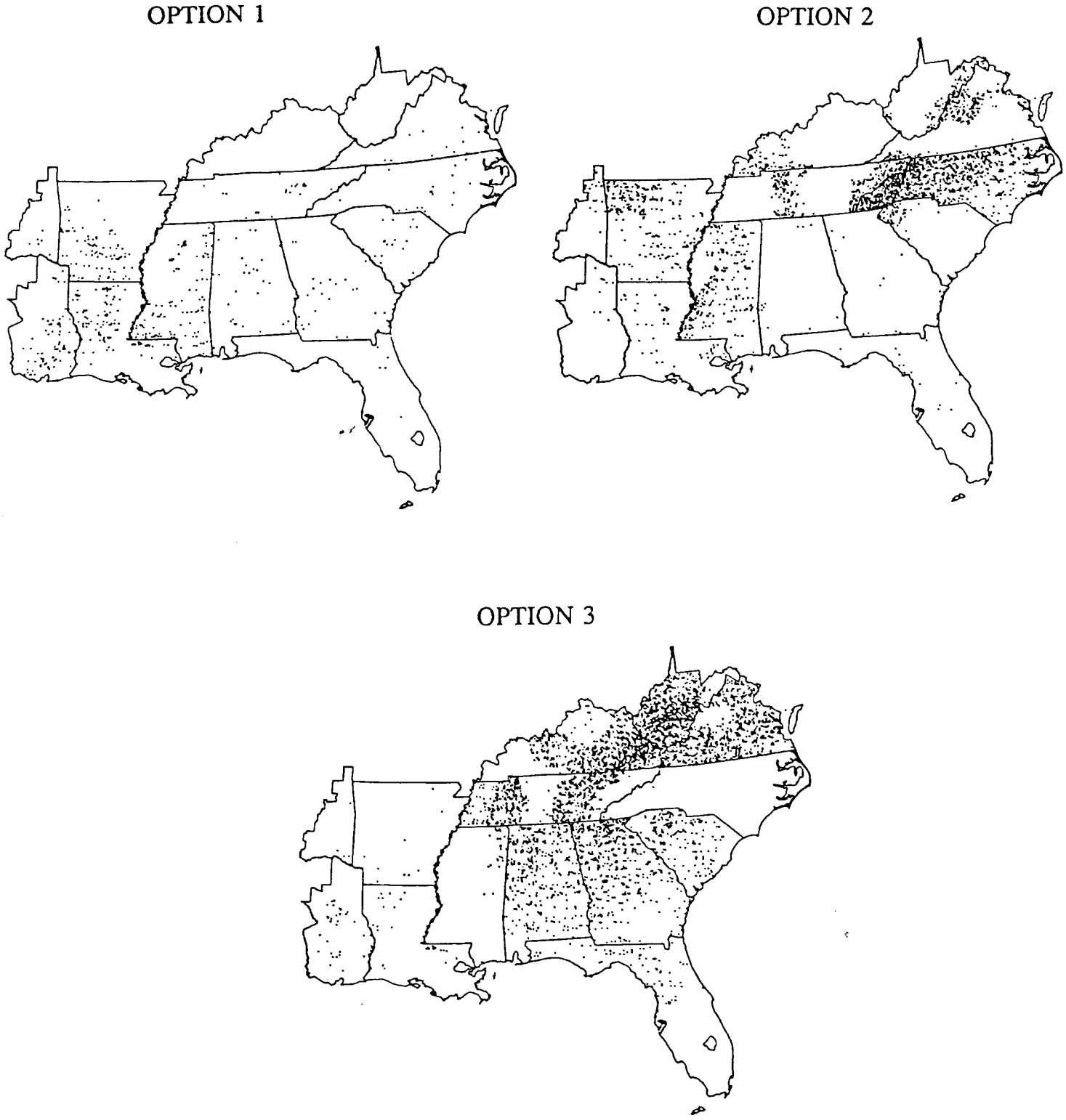


Figure 3.—*Distribution of southern upland hardwood forests that return the greatest profit to the logger when harvested by the product-merchandizing option indicated (each dot represents 5, 000 acres of timberland; option 1 is only pulpwood; option 2 is pulpwood and sawlogs; option 3 is pulpwood, sawlogs, and veneer logs).*

Table 5.—*Optimal mix of merchandizing options for maximizing profits from profitable logging opportunities in southern upland hardwood forests at low stumpage costs*

State	Area profitable to log				Volume profitable to log			
	Option 1	Option 2	Option 3	All options	Option 1	Option 2	Option 3	All options
	Thousand acres				*Million cubic feet*			
Alabama	5.4	104.7	3,446.1	3,556.2	2.8	97.1	4,864.2	4,964.1
Arkansas	0.0	1,115.5	1,519.0	2,634.5	0.0	1,507.9	2,035.0	3,542.9
Florida	0.0	175.2	549.6	724.8	0.0	37.9	731.8	769.7
Georgia	0.0	109.4	3,214.6	3,324.1	0.0	82.5	6,050.6	6,133.1
Kentucky	0.0	131.7	4,785.3	4,917.0	0.0	259.7	8,171.0	8,430.7
Louisiana	0.0	70.3	1,149.4	1,219.7	0.0	107.0	1,577.4	1,684.5
Mississippi	0.0	141.1	2,578.5	2,719.5	0.0	183.0	3,581.4	3,764.4
North Carolina	4.7	3,260.3	2,350.0	5,615.1	7.1	7,244.7	5,187.5	12,439.4
Oklahoma	0.0	10.2	300.1	310.3	0.0	0.5	184.9	185.4
South Carolina	5.2	87.3	1,425.9	1,518.5	1.6	153.2	2,539.0	2,693.7
Tennessee	12.5	910.1	5,167.1	6,089.7	20.3	1,698.5	8,040.6	9,759.4
Texas	0.0	182.5	958.5	1,141.0	0.0	196.2	984.3	1,180.5
Virginia	0.0	90.7	6,217.0	6,307.7	0.0	177.0	12,364.8	12,541.8
West Virginia	0.0	608.5	5,407.3	6,015.8	0.0	1,219.1	11,567.4	12,786.5
Total	27.8	6,997.5	39,068.4	46,093.9	31.8	12,964.3	67,879.9	80,876.1

Table 6.—*Optimal mix of merchandizing options for maximizing profits from profitable logging opportunities in southern upland hardwood forests at high stumpage costs*

State	Area profitable to log				Volume profitable to log			
	Option 1	Option 2	Option 3	All options	Option 1	Option 2	Option 3	All options
	Thousand acres				*Million cubic feet*			
Alabama	437.8	175.4	108.5	721.7	908.9	356.9	221.1	1,486.9
Arkansas	859.0	68.0	11.6	938.7	1,490.9	108.9	21.9	1,621.7
Florida	10.8	143.7	125.3	279.8	25.0	223.6	193.8	442.4
Georgia	460.3	165.0	956.1	1,581.3	1,003.1	413.7	2,221.9	3,638.7
Kentucky	480.9	375.0	256.3	1,112.2	1,031.3	824.4	562.6	2,418.3
Louisiana	699.4	28.3	0.0	727.7	1,187.7	46.0	0.0	1,233.7
Mississippi	1,129.5	95.3	22.3	1,247.1	1,953.6	183.8	42.3	2,179.6
North Carolina	522.5	3,827.5	0.0	4,350.0	1,252.8	9,608.5	0.0	10,861.3
Oklahoma	65.5	13.7	0.0	79.3	50.0	2.5	0.0	52.5
South Carolina	147.4	603.4	83.6	834.3	280.7	1,369.6	166.6	1,816.9
Tennessee	2,739.3	134.5	5.8	2,879.6	5,340.1	355.0	7.3	5,702.4
Texas	380.4	13.9	0.0	394.4	489.4	16.6	0.0	506.0
Virginia	338.7	2,841.1	866.5	4,046.2	771.9	6,465.6	1,902.2	9,139.8
West Virginia	1,015.2	291.5	715.8	2,022.6	2,419.1	712.4	2,032.6	5,164.1
Total	9,286.7	8,776.3	3,151.8	21,214.9	18,204.5	20,687.5	7,372.3	46,264.3

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Estimates profitable logging opportunities existing in upland hardwood forests in 14 Southern States and demonstrates the impact of three alternative product-merchandizing options on profitable logging opportunities and profit margins.

Keywords: Harvest, prices, profits, revenues, stumpage.