Assessing the Feasibility and Profitability of Cable Logging in Southern Upland Hardwood Forests

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ABSTRACT. *Procedures developed to assess available timber supplies from upland hardwood forest statistics reported by the USDA Forest Service's Forest Inventory and Analysis unit were modified to assess the feasibility and profitability of cable logging in southern upland hardwood forests. Depending on the harvest system and yarding distance used, cable logging can be profitable in as much as 14% of the area of upland hardwood forests on slopes that are 30% or greater. These slopes contain up to one-quarter of the board-foot volume in the 14-state area that was considered. The majority of the reported inventory that is profitable to log is on private and forest-industry land and would best be harvested by a medium-size yarder such as the Ecologger I. As the average slope yarding distance and yarder size increase, the available inventory that is profitable to log decreases. To achieve profitability with medium-size yarders at an average slope yarding distance of 500 ft, loggers must harvest trees that average at least 13.4 in. in dbh with a volume of at least 9200 bd ft/ac(2,300 ft3/ac). South J. Appl. For. 19(2):97–102.*

The upland hardwood forest inventory of the southern region is an enormous storehouse of wood fiber that could be used to meet the increasing demands for wood products by American and foreign consumers. The availability of this wood resource is affected by many constraints, including market conditions, legal restrictions, logging and transportation costs, landowner objectives and attitudes, and steep terrain. The impact of many of these factors on harvesting is difficult to assess, but all must be considered if we are to produce accurate assessments of potential timber supplies.

Because a considerable amount of this timber resource is on steep, difficult terrain, it is clear that cable-logging systems are needed. What is not clear is what acreages and volumes are on steeper slopes and what amount of the resource can be logged profitably with cable systems. In this article we assess the feasibility and profitability of cable logging the portion of the upland hardwood inventory of the South that is on slopes that are 30% or greater.

Cable-Logging Equipment

The type of cable yarder selected for yarding hardwood logs can affect production rates and costs (LeDoux 1985a). Harvesting machines vary in efficiency according to terrain, average size of stem harvested, and average slope yarding distance required. The ECOST (LeDoux 1985b) model, reported product prices, and the reported inventory were used to estimate cost and revenue for various combinations of equipment, terrain, average slope yarding distance, and average tree size. For this assessment we considered three cable yarders, one small, one medium, and one large machine.

The small system, a relatively inexpensive, low-capacity Bitterroot,[1] can yard small logs. The medium-size system, a slightly larger, relatively inexpensive, moderate-capacity Ecologger I, can harvest small and somewhat larger logs than the Bitterroot. The third system, an expensive, high-capacity Skylok 78, harvests both small and large logs. In this paper, "logs" refers to both conventional and tree-length sawlogs.

The three cable systems differ in hourly operating cost and the size of the crew required. The Bitterroot requires two people, the Ecologger I four, and the Skylok 78 six. The Bitterroot is the best selection for stands with an average tree dbh of 7 to 9 inches, the Ecologger I for stands with a dbh of 10 to 24 inches, and the Skylok 78 for stands with a dbh of 16 to 24 inches (LeDoux 1985b).

Procedures

Forest inventory statistics for the South's upland hardwood forests were compiled by the USDA Forest Service's Forest Inventory and Analysis (FIA) unit. The profitability of logging the stands represented by each FIA sample plot within an upland hardwood forest was estimated for each of the three cable logging systems at yarding distances of 300, 500, and 700 ft. This estimate was based on a comparison of the costs and revenues associated with procuring, felling, limbing, bucking, yarding, loading, and hauling wood from each upland hardwood forest plot and delivering it to the closest community with at least one primary wood-using mill.

Costs and revenues (in 1984 dollars per cubic foot harvested) were derived from wood price reports and cost predictions modeled from ECOST version 2 (LeDoux 1985b, LeDoux and Baumgras 1990, LeDoux, unpublished) and based on the size and volume of wood removed from each plot, the distance the wood was hauled, and production functions of the three cable-logging systems working in conditions typically encountered in upland hardwood forests.

Model Inputs

ECOST version 2 inputs and assumptions were derived directly from sample plot data or selected to represent conditions within the 14-state region for purposes of assessing the feasibility and profitability of cable logging in upland hardwood forests in the South.

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-ft stump to a minimum 4-in. dob top, or the point at which the main stem breaks into limbs, for live trees 5 in. in dbh and larger that are capable of producing sawlogs, currently or prospectively Some growing-stock volume remains after harvest, and some nongrowing-stock volume is removed (in trees or portions of trees too rough, rotten, or small to be considered growing stock). However, growing-stock volume is the volume routinely reported by FIA and therefore is used in this study.

Harvest Tree Size

Represented by the average dbh of all growing-stock trees (5 in. in dbh and larger) on each selected FIA sample plot

Logging System

ECOST version 2 currently allows a choice of one of several ground or cable-based logging systems.

Average Yarding Distance

Set at 300, 500, and 700 ft and based on the average harvest tract size in the region, estimated at about 75 ac.

Truck Class

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

Haul Distances

Represented by the mileage equivalent of the straight-line distance between each FIA sample plot and the nearest community with at least one primary wood using mill, as determined by differencing their respective geographic coordinates. Wood products may not always be delivered to the nearest market and almost never via a straight delivery route However, this approach recognizes the number and location of product markets relative to the resource and should provide meaningful assessments of relative costs associated with hauling harvested wood from upland hardwood plots across the region, though hauling costs in effect would be minimized.

Road Class

ECOST version 2 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 mph) 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 distance, was assigned a road class of 2 (35 mph), 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 $\$0.02/ft^3$ of harvest volume for the demonstration.

Move Cost

An estimate, based on user's knowledge of the logging system, of the cost associated with moving equipment into, out of, or within the harvest tract. Set at $\$0.02/ft^3$ of harvest volume for the demonstration.

[1] The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

Stumpage Cost

An estimate, based on stumpage costs reported by Timber-Mart South (1984), of the average cost of procuring the harvest volume from each plot. Average costs were specific to the location (state) of each plot and weighted by the species and product distributions of each state's most recent timber-harvest figures.

Delivered Price

An estimate, based on delivered prices reported by Timber-Mart South (1984), of the average price paid for the harvest volume when delivered to the nearest mill community Average prices were specific to the location (state) of each mill community and weighted by the species and product distributions of each state's most recent timber-harvest figures.

For each sample plot, the profitability of each cable logging system was determined using a procedure developed by May and LeDoux (1992), that compares the revenues and costs associated with procuring and harvesting wood products and delivering them to market (financial return = delivered price – procurement, logging, and hauling costs). Options with breakeven or positive financial returns were classified as profitable to log.

Profitable-to-Log Inventory

Of the 86,604,200 ac reported in the 14-state region, 22,435,900 ac (about 26%) are located on terrain with slopes of 30% or greater. The total volume is 326,255,000 bd ft, of which 114,043,200 (about 35%) are on slopes of 30% or greater. Arkansas, Kentucky, North Carolina, Tennessee, Virginia, and West Virginia have the largest acreages on the steeper slopes; West Virginia has nearly 61% of its area and 66% of its board-foot volume on steeper slopes.

Expanding and aggregating data from sample plots with profitable cable-logging options provided estimates of southern upland hardwood forest acres profitable to log for different machines and average slope yarding distances (Table 1). Only a fraction of the steep-slope inventory is profitable to log with any logging system though shorter slope yarding distances increase the amount of inventory that can be logged profitably. Generally, only stands of better quality (plots with higher volumes and larger trees) pay their way out of the woods.

The Bitterroot yarder is a relatively small machine with a limited payload capacity (LeDoux 1985b). For this research, stands with trees averaging more than 9 in. in dbh were considered as exceeding the capacity of the small yarder. North Carolina, Virginia, and West Virginia have the largest concentration of wood exceeding the capacity of the Bitterroot yarder. In many of these stands, it was feasible to log with the Ecologger I at an average slope yarding distance of 300 ft (Table 1). In fact, most of the profitable-to-log area would best be logged with the Ecologger I at yarding distances of 300 and 500 ft. Although the area and volume that is profitable to log with the Skylok 78 is greater, the profitability of logging similar stands is greater with the Ecologger I (Tables 2–4).

Of the total profitable-to-log area and volume, most (75%) is on forest industry and other private land ownerships. The Ecologger I is the most feasible yarder for these areas and volumes. The majority of profitable logging opportunities for the Ecologger I are on other private lands in North Carolina and Virginia (660,200 and 424,300 ac, respectively). Forest industry and other private ownerships account for about 73% of the board-foot volume available to log with the Ecologger I at a slope yarding distance of 500 ft. Although shorter average yarding distances will increase the profitable-to-log inventory, the ratio of private to public acreage and volume would remain high.

Attributes of Profitability

Of the 1,839,200 ac that are profitable to log with the Ecologger I at the 500-ft yarding distance, 42% of both the area and board-foot volume are on slopes of 30 to 45%. Thirty-six percent of the area and 38% of the board-foot volume are on slopes of 45 to 60%. The remaining 22% of area and 20% of volume are on slopes greater than 60%.

Table 1. Estimated area of southern upland hardwood forests profitable to log, by cable system and average slope yarding distance.

	Bitterroot			Ecologger I			Skylok 78		
State	300 ft	500 ft	700 ft	300 ft	500 ft	700 ft	300 ft	500 ft	700 ft
					(M ac)				
Alabama	14.0	14.0	8.5	36.1	19.5	5.5	5.5	5.5	5.5
Arkansas	0.0	0.0	0.0	16.9	11.2	5.6	5.6	5.6	0.0
Florida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Georgia	0.0	0.0	0.0	136.1	83.2	36.4	70.8	36.4	31.1
Kentucky	0.0	0.0	0.0	78.8	39.6	20.0	32.1	20.0	11.7
Louisiana	0.0	0.0	0.0	6.0	6.0	0.0	0.0	0.0	0.0
Mississippi	0.0	0.0	0.0	40.2	17.6	0.0	6.6	0.0	0.0
North Carolina	23.0	13.8	0.0	1414.4	967.7	570.8	921.9	739.4	567.8
Oklahoma	0.0	0.0	0.0	13.4	6.9	6.9	6.9	6.9	6.9
South Carolina	0.0	0.0	0.0	50.8	24.4	14.4	21.0	18.5	14.4
Tennessee	0.0	0.0	0.0	251.9	91.9	29.0	40.9	29.0	18.3
Texas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginia	29.7	25.0	10.2	958.2	542.8	331.3	466.5	357.0	249.5
West Virginia	0.0	0.0	0.0	169.0	28.3	4.7	4.7	0.0	0.0
All states	66.7	52.8	18.7	3171.7	1839.2	1024.4	1582.5	1218.2	905.3

Table 2 Estimated board-foot volume of southern upland hardwood forests profitable to log, by cable system and profit class, 300 ft yarding distance.

State	Bitterroot			Ecologger I			Skylok 78		
	0.0–0.08[a]	0.08–0.16	0.16+	0.0–0.08	0.08–0.16	0.16+	0.0–0.08	0.08–0.16	0.16+
					(mmbf)				
Alabama	59.1	0.0	0.0	179.6	53.9	0.0	53.9	0.0	0.0
Arkansas	0.0	0.0	0.0	41.2	30.7	0.0	30.7	0.0	0.0
Florida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Georgia	0.0	0.0	0.0	1131.1	303.5	0.0	792.5	0.0	0.0
Kentucky	0.0	0.0	0.0	499.0	48.1	0.0	169.9	0.0	0.0
Louisiana	0.0	0.0	0.0	65.3	0.0	0.0	0.0	0.0	0.0
Mississippi	0.0	0.0	0.0	393.3	0.0	0.0	93.7	0.0	0.0
North Carolina	121.8	0.0	0.0	8345.8	4828.9	735.2	8929.2	1580.9	77.7
Oklahoma	0.0	0.0	0.0	2.2	2.1	0.0	2.1	0.0	0.0
South Carolina	0.0	0.0	0.0	326.7	86.1	0.0	196.4	0.0	0.0
Tennessee	0.0	0.0	0.0	2284.2	340.5	0.0	528.6	0.0	0.0
Texas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginia	56.3	74.0	0.0	5526.6	2010.8	222.0	3879.0	232.0	114.4
West Virginia	0.0	0.0	0.0	1752.4	0.0	0.0	34.6	0.0	0.0
All states	237.2	74.0	0.0	20,547.4	7704.7	957.2	14,710.7	1,821.9	192.1

[a] Dollars per ft^3 harvested.

Table 3. Estimated board-foot volume of southern upland hardwood forests profitable to log, by cable system and profit class, 500 ft yarding distance.

State	Bitterroot			Ecologger I			Skylok 78		
	0.0–0.08[a]	0.08–0.16	0.16+	0.0–0.08	0.08–0.16	0.16+	0.0–0.08	0.08–0.16	0.16+
					(mmbf)				
Alabama	59.1	0.0	0.0	101.4	0.0	0.0	53.9	0.0	0.0
Arkansas	0.0	0.0	0.0	32.1	0.0	0.0	30.7	0.0	0.0
Florida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Georgia	0.0	0.0	0.0	722.7	139.4	0.0	366.6	0.0	0.0
Kentucky	0.0	0.0	0.0	262.4	0.0	0.0	48.1	0.0	0.0
Louisiana	0.0	0.0	0.0	65.3	0.0	0.0	0.0	0.0	0.0
Mississippi	0.0	0.0	0.0	200.2	0.0	0.0	0.0	0.0	0.0
North Carolina	48.9	0.0	0.0	7816.5	2585.3	213.1	8012.9	901.0	0.0
Oklahoma	0.0	0.0	0.0	2.1	0.0	0.0	2.1	0.0	0.0
South Carolina	0.0	0.0	0.0	206.7	30.3	0.0	163.6	0.0	0.0
Tennessee	0.0	0.0	0.0	793.6	129.0	0.0	373.2	0.0	0.0
Texas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginia	127.6	0.0	0.0	3747.0	802.1	114.4	2947.3	107.5	114.4
West Virginia	0.0	0.0	0.0	375.1	0.0	0.0	0.0	0.0	0.0
All states	235.7	0.0	0.0	14,325.2	3686.2	327.5	11,998.4	1008.6	114.4

[a] Dollars per ft^3 harvested.

Table 4. Estimated board-foot volume of southern upland hardwood forests profitable to log, by cable system and profit class, 700 ft yarding distance.

State	Bitterroot			Ecologger I			Skylok 78		
	0.0–0.08[a]	0.08–0.16	0.16+	0.0–0.08	0.08–0.16	0.16+	0.0–0.08	0.08–0.16	0.16+
					(mmbf)				
Alabama	39.6	0.0	0.0	53.9	0.0	0.0	53.9	0.0	0.0
Arkansas	0.0	0.0	0.0	30.7	0.0	0.0	0.0	0.0	0.0
Florida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Georgia	0.0	0.0	0.0	366.6	0.0	0.0	303.5	0.0	0.0
Kentucky	0.0	0.0	0.0	48.1	0.0	0.0	8.6	0.0	0.0
Louisiana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mississippi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
North Carolina	0.0	0.0	0.0	5755.3	957.7	0.0	6324.6	704.9	0.0
Oklahoma	0.0	0.0	0.0	2.1	0.0	0.0	2.1	0.0	0.0
South Carolina	0.0	0.0	0.0	128.1	0.0	0.0	128.1	0.0	0.0
Tennessee	0.0	0.0	0.0	373.2	0.0	0.0	246.3	0.0	0.0
Texas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginia	74.0	0.0	0.0	2572.8	107.5	114.4	2054.6	107.5	114.4
West Virginia	0.0	0.0	0.0	34.6	0.0	0.0	0.0	0.0	0.0
All states	113.6	0.0	0.0	9365.5	1065.2	114.4	9121.7	812.4	114.4

[a] Dollars per ft^3 harvested.

Some of the average individual plot stand attributes of profitability follow. The profitable-to-log chances for the Ecologger I at average slope distances of 300, 500, and 700 ft reveals that average board foot volumes available per acre are 9,209, 9,971, and 10,294 respectively for all states. The average tree diameter for the same conditions are 13.4, 14.2, and 15.0 in. The increasing volume/dbh trends with increasing slope yarding distances matches practical experience in that longer average slope yarding distances require larger dbh trees and higher volumes/acre to ensure profitable chances.

The states of Georgia, Louisiana, Mississippi, North Carolina, Tennessee, and West Virginia have the highest board foot volumes/acre. The larger diameter trees are located in the states of Oklahoma, Arkansas, Kentucky, and West Virginia. Care must be exercised when interpreting these state-level results, however. FIA statistics are based on extensive samples of each state's forest resources. As a consequence, the estimates of profitable cable logging chances in some states are based on very few on-the-ground observations. It would be prudent, therefore, to use state-land estimates only as relative measures of cable logging chances between states and to demonstrate the interactions of harvest volumes, stand diameters, and haul distances on cable logging profitability. For example, although the inventory shows Oklahoma has the larger diameter trees, the corresponding volumes are relatively low. The size of these trees make it profitable to log these low volumes. The most profitable stands are located within 6–7 miles of a mill community for all states. Stands located in the state of Oklahoma are within 1-3 miles of a mill contributing to the profitability of the low volumes mentioned earlier. In contrast, the states with higher volumes/acre can afford to transport their wood longer distances to sawmills and yet remain profitable.

Profitability

Tables 5–7 summarize the estimated cubic-foot volume of southern upland hardwood forests that are profitable to log, by cable system and profit class, for average slope yarding distances of 300, 500, and 700 ft Increasing average slope yarding distance increases the amount of time that the rigging (carriage and chokers) must travel (empty and loaded) from the landing to the log-hooking area. Increasing the cycle time (time to and from, empty and loaded) results in fewer cycles per unit of time. This means less production, which increases yarding costs. Increased yarding costs reduce or eliminate potential profits. For example, 5,291,000 ft^3 of wood is profitable to log with the Ecologger I at a yarding distance of 300 ft for the profit class of 0.0-0.08 (dollars per ft^3) (Table 5). Increasing the yarding distance to 500 ft decreases the volume that is profitable to log in this profit class by 34% to 3,514,800 ft^3 (Table 6). When the yarding distance is increased to 700 ft, the volume decreases by 58.8% to 2,178,400 when compared to average distances of 300 ft (Table 7). If we use \$0.04/ft^3 as the midpoint of the 0.0–0.08 profit class, the latter volume decrease translates to a decrease in profits of \$124.5 million.

Average slope yarding distance is one variable that logging engineers have some control of when laying out the shape, boundaries, and size of units to be harvested. The harvest-unit layout often is limited by roading, terrain, ownership boundaries, waterways, etc. that are beyond the control of planners. Clearly, managers and planners could increase profitability by keeping average slope yarding distances in the range of 200 to 500 ft.

Conclusion

The results from this research suggest that a substantial area and volume of the southern upland hardwood forests on slopes of 30% or greater can be logged profitably with cable-logging technology. As the average slope yarding distance increases, the area and volume that are profitable to log decrease. Generally, only those stands with large-diameter trees and high volumes per acre pay their way out of the woods. The size of yarder also affects the area and volume inventory available to log profitably. Except for Alabama, North Carolina, and Virginia, a yarder such as the Bitterroot

Table 5. Estimated volume of southern upland hardwood forests profitable to log, by cable system and profit class, 300 ft yarding distance.

	Bitterroot			Ecologger I			Skylok 78		
State	0.0–0.08[a]	0.08–0.16	0.16+	0.0–0.08	0.08–0.16	0.16+	0.0–0.08	0.08–0.16	0.16+
					($mmft^3$)				
Alabama	19.4	0.0	0.0	43.2	11.9	0.0	11.9	0.0	0.0
Arkansas	0.0	0.0	0.0	8.1	5.3	0.0	5.3	0.0	0.0
Florida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Georgia	0.0	0.0	0.0	261.7	71.9	0.0	186.6	0.0	0.0
Kentucky	0.0	0.0	0.0	112.6	1.0	0.0	35.4	0.0	0.0
Louisiana	0.0	0.0	0.0	11.7	0.0	0.0	0.0	0.0	0.0
Mississippi	0.0	0.0	0.0	73.5	0.0	0.0	16.2	0.0	0.0
North Carolina	43.5	0.0	0.0	2367.0	1119.5	159.7	2272.8	343.8	16.9
Oklahoma	0.0	0.0	0.0	0.4	0.4	0.0	0.4	0.0	0.0
South Carolina	0.0	0.0	0.0	87.0	19.6	0.0	46.2	0.0	0.0
Tennessee	0.0	0.0	0.0	487.9	63.4	0.0	101.8	0.0	0.0
Texas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginia	27.2	27.0	0.0	1439.8	452.3	45.2	894.4	60.5	22.3
West Virginia	0.0	0.0	0.0	398.1	0.0	0.0	7.5	0.0	0.0
All states	90.1	27.0	0.0	5291.0	1754.3	205.0	3578.6	404.2	39.2

[a] Dollars per ft^3 harvested.

Table 6 Estimated volume of southern upland hardwood forests profitable to log, by cable system and profit class, 500 ft yarding distance.

State	Bitterroot			Ecologger I			Skylok 78		
	0.0–0.08[a]	0.08–0.16	0.16+	0.0–0.08	0.08–0.16	0.16+	0.0–0.08	0.08–0.16	0.16+
					(mmft^3)				
Alabama	19.4	0.0	0.0	25.9	0.0	0.0	11.9	0.0	0.0
Arkansas	0.0	0.0	0.0	5.7	0.0	0.0	5.3	0.0	0.0
Florida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Georgia	0.0	0.0	0.0	170.0	33.0	0.0	85.8	0.0	0.0
Kentucky	0.0	0.0	0.0	55.2	0.0	0.0	1.0	0.0	0.0
Louisiana	0.0	0.0	0.0	11.7	0.0	0.0	0.0	0.0	0.0
Mississippi	0.0	0.0	0.0	35.6	0.0	0.0	0.0	0.0	0.0
North Carolina	23.2	0.0	0.0	2031.9	564.1	44.7	1977.8	194.7	0.0
Oklahoma	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.0	0.0
South Carolina	0.0	0.0	0.0	49.8	6.9	0.0	38.3	0.0	0.0
Tennessee	0.0	0.0	0.0	161.4	22.1	0.0	70.5	0.0	0.0
Texas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginia	50.7	0.0	0.0	890.7	176.9	22.3	680.2	22.9	22.3
West Virginia	0.0	0.0	0.0	76.6	0.0	0.0	0.0	0.0	0.0
All states	93.3	0.0	0.0	3514.8	803.2	67.0	2880.2	217.6	22.3

[a] Dollars per ft^3 harvested.

is too small to handle the size of trees in the reported inventory. Profit potential is greatest with medium-size yarders such as the Ecologger I. The use of large expensive yarders such as the Skylok 78 generally is less profitable as less area and volume are available for such machines.

Generally, our results show that for medium-size yarders to be profitable, stands should contain trees that average about 13.4 in. in dbh and at least 9,200 bd ft/ac (about 2,300 ft^3/ac). Within the 14-state region studied, most harvest blocks are within 2 to 8 miles of the closest receiving mill. Delivery to other than the closest mill would result in reduced profits and fewer opportunities for profitable harvests by cable logging.

The majority of the area and volume that is profitable to log is located on private and forest-industry land. The area and volume profitable to log is distributed about equally on slopes ranging from 30 to 60% or greater. Some of the stands on slopes up to 40% might be harvested with ground-based technology to increase profitability.

For the conditions assumed in this analysis, a significant area and volume is profitable to log with cable logging systems. Although our results are sensitive to changing assumptions and inputs to the models, the advantage of the procedure demonstrated is that it is flexible enough for users to tailor their inputs and assumptions to match specific needs Additional scenarios could be evaluated easily by conducting additional runs.

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Table 7. Estimated volume of southern upland hardwood forests profitable to log, by cable system and profit class, 700 ft yarding distance.

State	Bitterroot			Ecologger I			Skylok 78		
	0.0–0.08[a]	0.08–0.16	0.16+	0.0–0.08	0.08–0.16	0.16+	0.0–0.08	0.08–0.16	0.16+
					(mmft^3)				
Alabama	12.2	0.0	0.0	11.9	0.0	0.0	11.9	0.0	0.0
Arkansas	0.0	0.0	0.0	5.3	0.0	0.0	0.0	0.0	0.0
Florida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Georgia	0.0	0.0	0.0	85.8	0.0	0.0	71.9	0.0	0.0
Kentucky	0.0	0.0	0.0	1.0	0.0	0.0	1.8	0.0	0.0
Louisiana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mississippi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
North Carolina	0.0	0.0	0.0	1366.4	206.7	0.0	1498.7	152.2	0.0
Oklahoma	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.0	0.0
South Carolina	0.0	0.0	0.0	29.4	0.0	0.0	29.4	0.0	0.0
Tennessee	0.0	0.0	0.0	70.5	0.0	0.0	45.9	0.0	0.0
Texas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginia	27.0	0.0	0.0	591.2	22.9	22.3	471.5	22.9	22.3
West Virginia	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0
All states	39.2	0.0	0.0	2178.4	229.6	22.3	2131.4	175.1	22.3

[a] Dollars per ft^3 harvested.