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Methodology for Assessing Current Timber Supplies and Product Demands

Virginia E. Worthington
Chris B. LeDoux
William H. McWilliams
Hank Sloan
Toni Jones

Abstract

Describes a methodology developed for evaluating current timber supply and demand conditions within a given market area using USDA Forest Service Forest Inventory and Analysis data, forest-industry production information, and a stump-to-mill cost-prediction model. The methodology is applied to the Jefferson National Forest market area. Sensitivity analysis is used to assess the effects of changes in harvest costs, delivered log prices, landowner attitudes, and new primary wood-processing facilities in the market area.

The Authors

VIRGINIA E. WORTHINGTON is currently with the George Washington and Jefferson National Forests. She was an economist with the Northeastern Forest Experiment Station at Princeton, West Virginia, when this study was undertaken.

CHRIS B. LEDOUX is a supervisory industrial engineer with the Northeastern Forest Experiment Station at Morgantown, West Virginia.

WILLIAM H. MCWILLIAMS is a research forester with the Northeastern Forest Experiment Station at Radnor, Pennsylvania.

HANK SLOAN is a logging engineer with the George Washington and Jefferson National Forests at Roanoke, Virginia.

TONI JONES is a computer specialist with the Northeastern Forest Experiment Station at Morgantown, West Virginia.

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Introduction

Under the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA), as amended, National Forests are charged with developing land and resource management plans (LMP) which guide all resource management activities, including the level of timber production. A key element in developing these plans is a thorough analysis of the Forests' ability to supply goods and services in response to society's demands. In the Eastern United States, all of the National Forests have completed their initial round of forest planning. The first periodic revision of these plans as required by the National Forest Management Act of 1976 is underway.

The appropriate level of timber harvest from National Forest lands has been and continues to be a contentious issue in management planning for public forest land (O'Toole 1988). In the East, where more than 70 percent of the timberland is nonindustrial private forest (Powell et al. 1993), it is difficult for individual Forests to clearly identify their role in and contribution to local timber economies.

While projections of long-term supply and demand have been developed as part of periodic RPA Program Assessments (Haynes 1990), they are typically at geographic and time scales that are too broad for use by individual Forests attempting to develop 10-year timber sale schedules for relatively small market subregions. Also, demand and supply equations derived from regional econometric models often are too complex for local forest planning applications in which the public is expected to understand and scrutinize each step. As a result, individual Forests struggle with assessments of timber supply and demand, and find this facet of their LMP analysis particularly vulnerable to criticism (Wheeler 1993).

We have developed an approach for evaluating current timber supply/demand conditions within a given market area using USDA Forest Service Forest Inventory and Analysis (FIA) data, forest-industry production information, and a stump-to-mill cost-prediction model. The methodology is applied to a case study of the market area served by the Jefferson National Forest (JNF) in southwestern Virginia. The JNF currently is examining issues related to timber supply and demand as part of initial revisions to its land management plan.

In the first part of this report we describe how the market area was determined and discuss the timber resources found there. Next, we assess timber demand by examining the primary wood-processing industry located in the market area. We provide a baseline comparison between timber supply and demand, ignoring the effects of physical and market constraints. Next, we estimate the economic availability of the timber supply under current market conditions. Sensitivity analysis is used to evaluate how the available timber supply could change under more restrictive Best Management Practices (BMP's) and with increased log prices. We explore the potential effect of landowner attitudes on available timber supply from nonindustrial private forest lands. We contrast supply and demand levels when the timber is segmented by resource quality. In the final section, we examine the impact of new and expanded wood-processing capacity in the market area.

Although the results presented here are specific to the JNF market area, the general approach could be used in other forest-planning applications and in other market areas. The methodology is appealing for several reasons. First, it uses a logical sequence of analysis steps that can be easily understood by the range of publics involved in forest-planning activities. Second, it explicitly recognizes timber supplies from all ownerships. Third, the approach is flexible. Changes in assumptions about harvest costs, Best Management Practices, delivered log prices, and landowner attitudes can be modeled and evaluated.

Market Area Determination and Description

A market can be defined as "a group of current and potential customers with similar needs for a product or service" (Sinclair 1992). In this study, the relevant market area was defined by answering the question: "When the JNF sells timber, where are the primary manufacturers (mills) that would potentially use this timber in their production process?" Timber sale records for the Forest were analyzed to determine the general location of timber purchasers and primary manufacturers. On the basis of these records, it was determined that the market area served by the JNF generally lies within an 80-mile radius around the Forest's boundary. For low-value products (pulpwood, firewood), the actual buying radius probably is much shorter; for high-value products (veneer logs), the distance is longer. However, in general, this 80-mile zone represents the maximum hauling distance that most mills currently reach out to in fulfilling their procurement needs. Implicit in this definition of the market area is the assumption that movement of timber supplies into the area is approximately equal to the outflow.

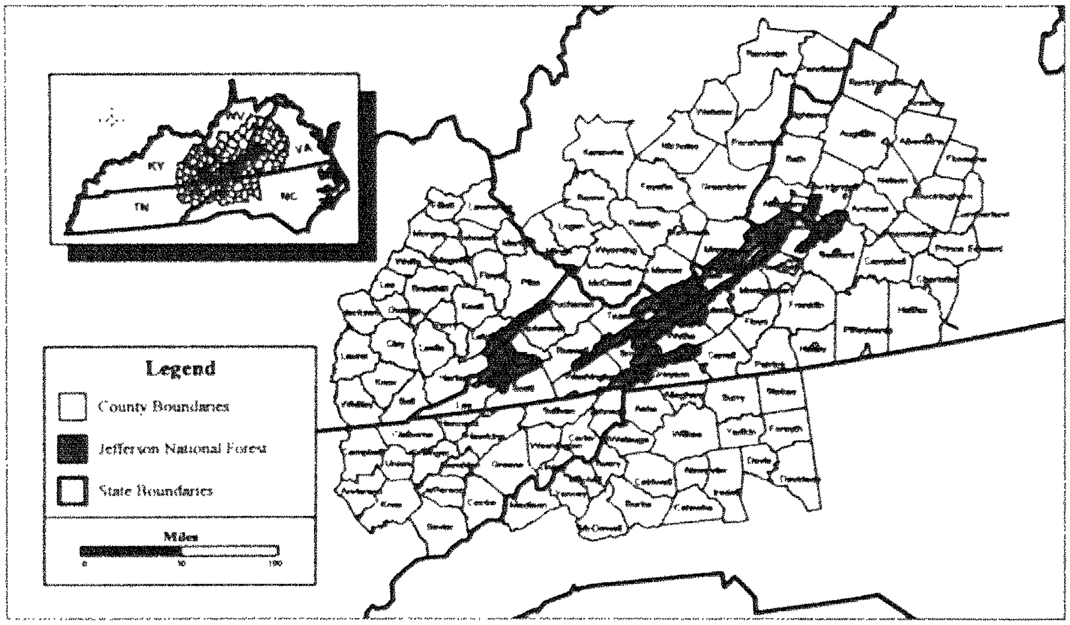

Figure 1.—Jefferson National Forest market area.

Most of the counties whose approximate midpoints fell within the 80-mile zone were included in the market area. To simplify the analysis of FIA and forest-industry production data, only whole counties were included. The 121 counties in the five-state area that comprise the JNF market area are shown in Figure 1.

Timber Resources Within the Market Area

Source data on timber resources within the market area were derived from the most recent FIA inventories for each of the five states (Alerich 1990, DiGiovanni 1990; Johnson 1991, 1992; Vissage and Duncan 1990). Most of this information is available on tape from the Eastwide Forest Inventory Data Base (Hansen et al. 1992). Since the individual state inventories were completed within a 6-year period (1987-92), no attempt was made to bring the data to a common year. Inventory data were aggregated for the 121-county region to summarize major timber-resource attributes (timberland area, ownership, size class, stocking, site-productivity class, forest type, species group, tree grade, diameter class, volume, annual growth, mortality, and removals).

From these data it was determined that the market area covers approximately 35.4 million acres, with nearly 70 percent of the land area (24.3 million acres) classified as timberland. Under FIA definitions, timberland is any forested land capable of growing at least 20 cubic feet of industrial wood per acre per year. The remaining land area is in nonforest land, water, reserved timberland, or other forest land. Figure 2 shows the percentage of timberland area by county within the market area.

Figure 3 shows the distribution of timberland area by ownership in the market area. Eighty percent of the timberland is in nonindustrial private forest (NIPF) ownership, which includes individuals, farmers, and corporations other than forest industry. National Forest lands include the JNF and substantial portions of the Cherokee (Tennessee), Daniel Boone (Kentucky), George Washington (Virginia), Monongahela (West Virginia), and Pisgah (North Carolina) National Forests.

The oak/hickory forest type dominates, accounting for nearly 75 percent of the timberland area in the market area. The timber resource is fairly mature and of low quality, with a significant amount of timber on steep slopes. More than half (59 percent) of the timberland is in the sawtimber stand-size class, and 60 percent of the sawtimber volume is in tree grade three or lower. Thirty percent of the sawtimber is in the 19-inch or larger diameter classes. Nearly half of the timberland area (47 percent) is considered fully stocked or overstocked. Approximately 40 percent of the timberland is on slopes in excess of 35 percent. On National Forest lands within the market area, more than 45 percent of the timberland is on slopes in excess of 35 percent.

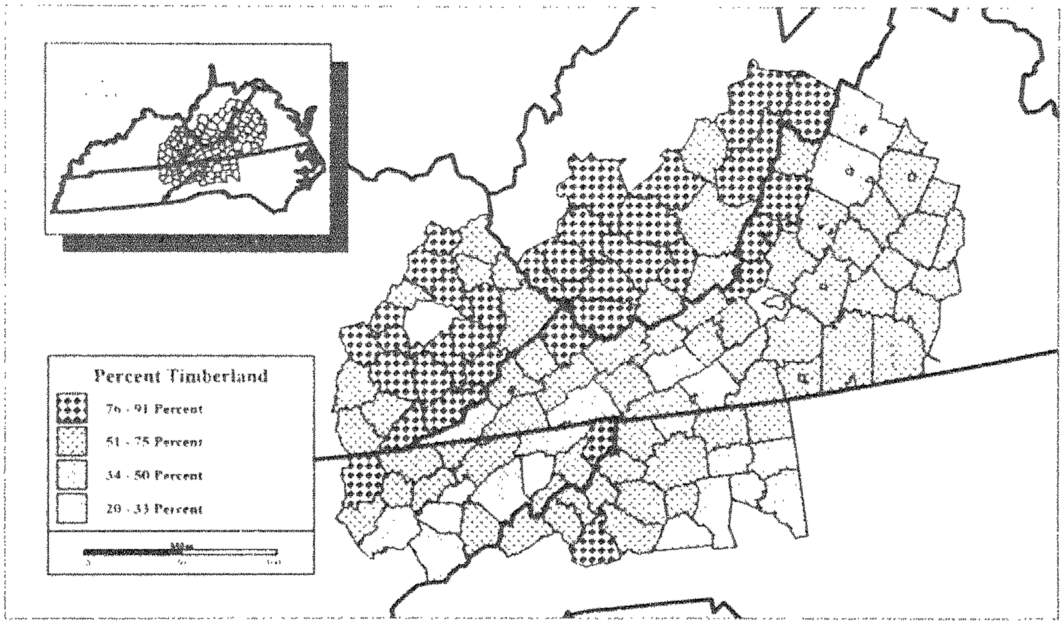

Figure 2.—Timberland as a percentage of land area by county, Jefferson National Forest market area.

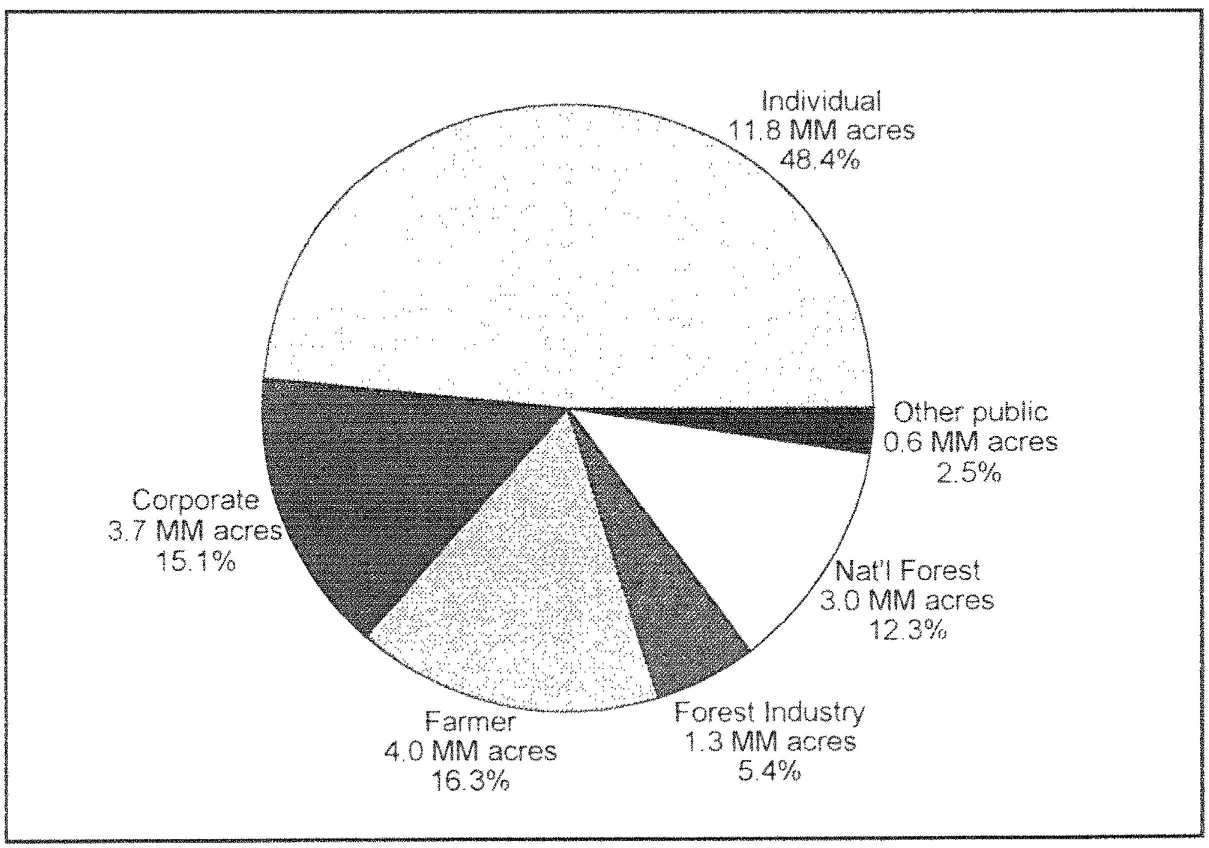

Figure 3.—Distribution of timberland area by ownership, Jefferson National Forest market area.

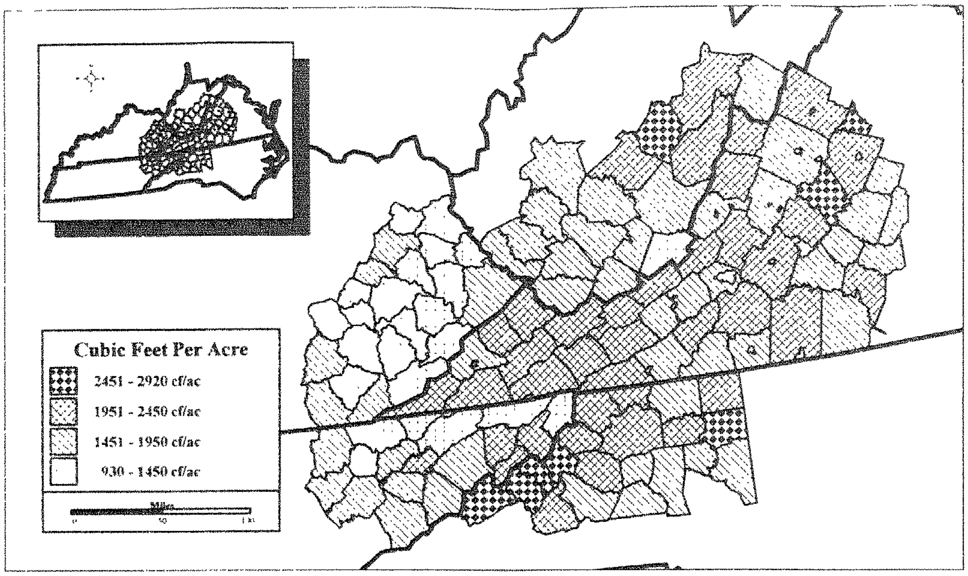

Figure 4.—Average volume of timber per acre on timberland by county, Jefferson National Forest market area.

The estimated total volume of live trees in the market area is approximately 43.0 billion cubic feet (bcf), with nearly 94 percent of this volume classified as growing stock. Growing-stock volume is defined as the cubic-foot volume of sound wood from a 1-foot stump to a 4-inch top for commercial species of trees 5 inches or larger in diameter at breast height (d.b.h.) that are capable of producing sawlogs. Figure 4 shows the average per-acre volume of growing stock by county on timberland within the market area.

The total net annual growth of growing stock (net of mortality) is nearly 1.1 bcf. Estimated annual removals of growing stock total 0.53 bcf. This includes removals from both commercial harvest and cultural operations, land clearing, and changes in land-use classification.

Sawtimber volume is defined by FIA as the board-foot volume between a 1-foot stump and a 9-inch top for softwoods and an 11-inch top for hardwoods (to a point where the bole breaks into limbs before the diameter limit). For this study, sawtimber volume was defined in the same way but was limited to trees classified as grade three or better. The estimated total inventory of grade three or better sawtimber trees in the market area is 102.2 billion board feet (bbf), with a projected net annual growth rate of 4.5 bbf and annual removals of 1.8 bbf.

In addition to the standard descriptive information about the timber resources for the entire market area, individual FIA plot-level data were used to examine the effects of timber quality, operability, and market conditions on resource availability within the market area (See Economic Availability of the Timber Resource). The plot-level forest-inventory variables used in the study are listed in Table 1.

Forest Products Industry Within the Market Area

Within the primary wood-processing industry in the market area is a diverse sawmill sector that serves a variety of secondary processors, including a major hardwood furniture-manufacturing industry and a growing subsector for pulp and paper and composite products. In this analysis, estimated total annual consumption of roundwood timber for the primary processors in the market area was used as a proxy for current timber demand. No attempt was made to measure the demand for fuelwood. Consumption of mill residues was netted out from estimates of total consumption to avoid double counting. Similarly, production from concentration yards was excluded because most of the yards serve processing mills in the defined market area and already are reflected in production figures for individual mills.

Estimates of mill consumption were derived from production data reported in individual state directories of primary wood processors in Kentucky (Kentucky Div. of For. 1994), North Carolina (North Carolina Div. of For. Resour. 1993), Tennessee (Tennessee Div. of For. 1991), Virginia (Virginia Dep. of For. 1992), and West Virginia (West Virginia Div. of For. 1992), with additional input from utilization and marketing foresters in these states. These directories, which represent the most recent listings of mills available at the time of this study, provide only a "snapshot" of timber consumption in the area. While new mills have come on line since the listings were published, other existing mills have closed. To account for such changes, total timber consumption has been portrayed in terms of a minimum, midpoint, and maximum of a broad range rather than a single point estimate. On balance, this range is a reasonable benchmark for current timber demand within the market area.

Table 1.—FIA plot level variables used in study

Variable	Variable description and data type
STATE[a]	State 2-digit Federal Information Processing Standards (FIPS) code
COUNTY[a]	County 3-digit FIPS code
PLTNUM[a]	Plot number
OWNER[a]	Owner code
ADFOR[a]	Administrative forest code
TYPCUR[a]	Current forest-type code
STDSIZE[a]	Stand size-class code
SI[a]	Site index (feet)
SLOPE[a]	Average slope (%) of sample area
EXPACR[a]	Area expansion factor (acres)--number of acres the sample plot represents
EXPGRO[a]	Net-growth expansion factor (acres)
LONG[a]	Longitude of FIA plot location (decimal degrees)
LAT[a]	Latitude of FIA plot location (decimal degrees)
MDATE[a]	Plot measurement date (month and year)
PULL[b]	Distance from FIA plot to nearest all-weather access road (miles)
SAW1[c]	Total board-foot volume per acre (bf/acre) of trees classified as tree grade 1
SAW2[c]	Total board-foot volume per acre (bf/acre) of trees classified as tree grade 2
SAW12[c]	Total board-foot volume per acre (bf/acre) of trees classified as tree grade 1 and 2
SAW123[c]	Total board-foot volume per acre (bf/acre) of trees classified as tree grade 1, 2, and 3
$BFSPTG_{ij}$[c]	Board-foot volume per acre (bf/acre) of trees classified as tree grade i in species group j, where $\sum_{i=1}^{3} \sum_{j=1}^{29} BFSPTG_{ij} = SAW123$
PULP[c]	Total cubic-foot volume per acre (cf/acre) of growing-stock trees not included in SAW123
CF[c]	Total cubic-foot volume per acre (cf/acre) of live trees
GROWTH[c]	Net annual cubic-foot growth per acre (cf/acre) of live trees. Volume is net of mortality.
AVEDBH[c]	Average diameter of live trees $\geq$ 5.0 inches d.b.h. (inches)
AVESAW[c]	Average diameter of sawtimber-size trees (inches)

[a]Values from plot level records in Eastwide Forest Inventory Data Base (Hansen et al. 1992).
[b]Data item not part of Eastwide Forest Inventory Data Base. Information obtained from more detailed databases maintained by USDA Forest Service FIA projects at the Northeastern, Southeastern, and Southern Forest Experiment Stations.
[c]Values from tree-level records in Eastwide Forest Inventory Data Base.

There are 634 sawmills and 12 pulp and fiber mills within the JNF market area (Fig. 5). Combined, these mills consume 414.4 mmcf of roundwood annually (the midpoint of a consumption range of 228.5 to 631.6 mmcf). Approximately one-fourth of this material is used for the production of chips, composite products (oriented-strand board, waferboard, medium-density fiberboard, hardboard), and pulp and paper. The remainder is used in the manufacture of sawtimber products including lumber, veneer, plywood, and other industrial products (posts, rail and fence material, and mine cribbing and timbers).

Baseline Timber Supply-Demand Comparison

An initial baseline estimate of timber supply and demand was established by contrasting total annual timber consumption by primary processing mills in the market area with estimates of current timber inventories (standing inventory and net annual growth) (Table 2). This comparison assumes that all supplies of timber in the market area are available for commercial timber harvest, and ignores such factors as harvest economics, resource quality, and landowner attitudes.

Table 2.—Current timber demand as a percentage of timber inventory, JNF market area

Roundwood consumption range	Demand/total inventory[a]	Demand/net annual growth[b]
Minimum (228.5 mmcf/yr)	0.5	20.8
Midpoint (414.4 mmcf/yr)	1.0	37.7
Maximum (631.6 mmcf/yr)	1.5	57.4

[a]42,977.8 mmcf (includes growing stock and all other live trees).
[b]1,085.2 mmcf (based on growing-stock volume).

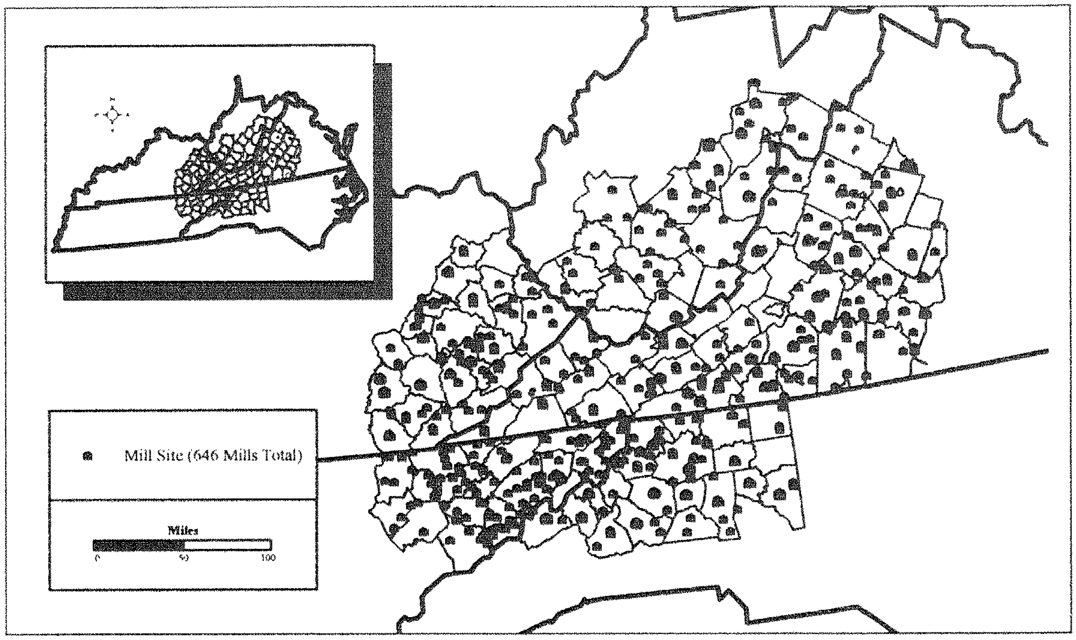

Figure 5.—Primary wood-processing mills in the Jefferson National Forest market area.

Under this baseline estimate, current annual demand represents only 0.5 to 1.5 percent of the total inventory and 20.8 to 57.5 percent of net annual growth. On the basis of these numbers, there appears to be sufficient timber supply in the market area to sustain current consumption patterns indefinitely. These figures are consistent with FIA estimates of growth and removal within the market area for the most recent inventory periods, that is, the calculated net annual growth was more than twice that of estimated removals.

According to this simple comparison, expanded timber consumption within the market area should not result in upward price pressures. The standing inventory of timber should continue to increase because growth exceeds consumption over the entire estimated range. Similarly, any limited withdrawal of timberland from commercial production should not unduly restrict supplies.

Economic Availability of the Timber Resource

In the previous section, the reported comparison between current timber consumption and supply assumed that all of the inventory was available for harvest. Numerous other studies have documented the effects of physical, geographic, operability, ownership, and market constraints on the actual availability of timber inventories for consumption by the forest-products industry (McWilliams and Rosson 1988; Araman and Tansey 1990; Sheffield and Bechtold 1990; May and LeDoux 1992; Thompson and Johnson 1994). In all of these studies, the estimated effects of these constraints significantly reduced the available timber supply; the reduction in timber volume ranged from 38 to 89 percent.

For this part of the analysis, ECOST Version 2,[1] a stump-to-mill cost-prediction model, was used to assess the combined effects of operability constraints (terrain, tree size, logging technology, access, merchantable volume per acre) and market conditions on the economic availability of the timber resources within the market area.

ECOST estimates the costs of felling, limbing, bucking, skidding/yarding, and loading/hauling wood from each inventory plot to the nearest primary processing mill. The cost of stumpage and logger/landowner profits are not included in the model. The production functions in the model are based on actual time studies and simulations of logging operations typical of those in eastern upland hardwood forests. The ECOST model is described in detail in LeDoux (1985).

[1]LeDoux, Chris B. 1988. ECOST Version 2—stump-to-mill production cost equations and computer program. Unpublished report on file at Northeastern Forest Experiment Station, Morgantown, WV.

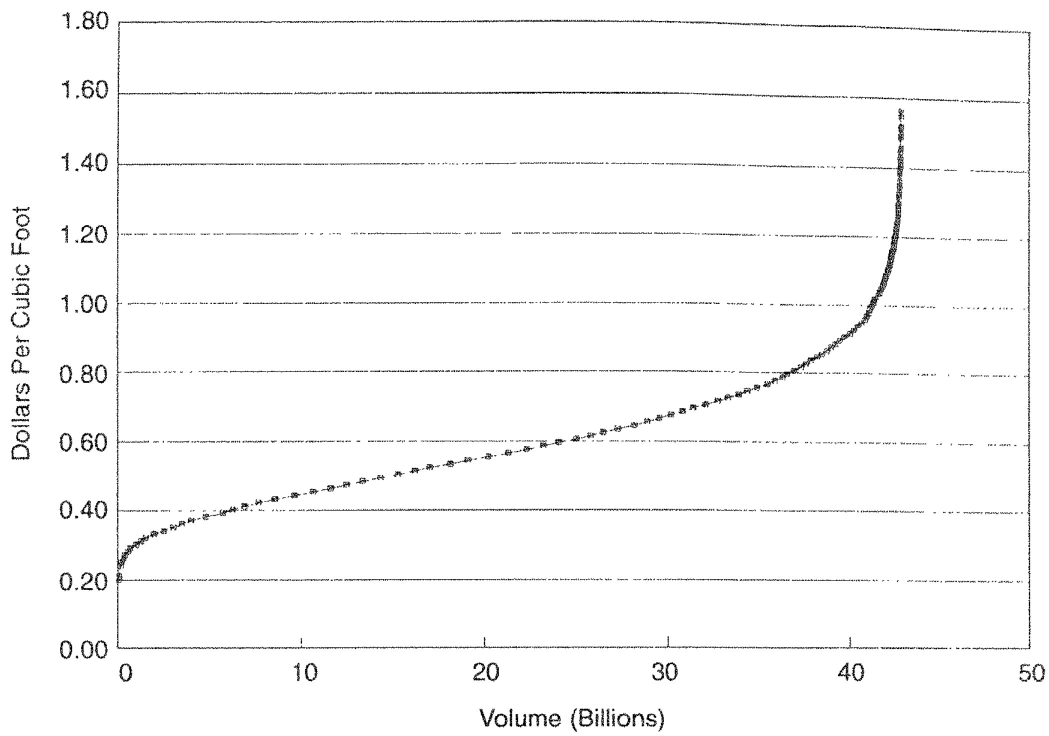

Figure 6.—Unit stump-to-mill cost versus harvest volume under current market conditions.

The following assumptions were used in determining harvest volumes and associated production costs in the model:

- Regeneration harvest method—all of the merchantable volume (live trees larger than 5 inches d.b.h.) was removed from each inventory plot.
- On slopes greater than 35 percent, a cable yarding system with an average yarding distance of 550 feet was used. On slopes of 35 percent or less, a conventional rubber-tired-skidder logging system with an average yarding distance of 800 feet was used.
- All hauling was done with a semitrailer truck. Truck speeds were assumed to average 4 mph on temporary logging or "pull" roads and 25 mph on all-weather haul roads.
- All sawtimber on a plot was delivered to the nearest sawmill. Similarly, small roundwood (including poletimber, cull trees, and sawlog tops) on each plot was delivered to the nearest fiber mill.
- The pull road-haul distance was based on FIA measurements of the distance from the plot to the nearest all-weather road (PULL variable, Table 1). The all-weather road-haul distance to the nearest mill was calculated as the straight-line distance between the FIA plot location and mill site for each product based on Universal Transverse Mercator coordinates (Zone 17). Where actual location coordinates were not available for individual mills, coordinates for the centroid of the mill's zip code region were used.
- Unit logging costs were based on an earlier study (May and LeDoux 1992) and adjusted for rates typical for the JNF market area. All costs were adjusted to 1994 dollars using the Producer Price Index (All Commodities).

Figure 6 shows the predicted stump-to-mill cost of harvesting timber from each plot in the market area. At a production cost of $1.56 per cubic foot, the entire inventory (43 bcf) could be harvested and transported to the nearest mill. However, at a rate of $0.56 per cubic foot, only about half of the inventory could be harvested and delivered to the mill. The shape of the cost curve is a function of the characteristics of the timber on each plot and the distance to the mills. Production costs rise rapidly for lower quality plots at remote distances from a processing mill.

To evaluate the profitability of timber harvest, the predicted stump-to-mill cost was compared with delivered value. For each plot, the delivered value was calculated as the volume in each product type, species, and grade multiplied by the appropriate delivered log price.

Table 3.—Delivered log prices by species and grade, in dollars/mbf, International 1/4-inch rule

Species group	Grade 1	Grade 2	Grade 3
Select white oak	408	279	138
Select red oak	561	397	225
Other white oak	347	241	126
Other red oak	209	141	86
Hickory	128	104	93
Yellow birch	107	86	85
Hard maple	319	242	136
Soft maple	251	192	131
Beech	106	91	86
Sweetgum	76	76	76
Tupelo/black gum	107	107	107
Ash	420	297	169
Cottonwood/aspen	76	76	76
Basswood	321	239	143
Yellow-poplar	268	174	98
Black walnut	532	372	239
Butternut	184	120	73
Cucumbertree	164	103	68
Black cherry	571	400	259
Other hardwoods	76	76	76
Loblolly/shortleaf pine	150	150	150
Other yellow pine	150	150	150
Eastern white pine	150	150	150
Spruce/balsam fir	150	150	150
Eastern hemlock	150	150	150
Other softwoods	150	150	150
Noncommercial[a]	632	632	632
Pulpwood[b]	632	632	632

[a]Treated as pulpwood (poletimber) regardless of species or diameter; in dollars/mcf.
[b]In dollars/mcf.

Table 3 summarizes the delivered log values used in this analysis. Prices of hardwood sawtimber represent an average of published and quoted prices paid at the mill gate at the time of the analysis (third and fourth quarter of 1994) for delivered logs from a sample of hardwood sawmills in the JNF market area. Softwood sawlog and pulpwood prices represent a six-quarter average (first quarter of 1993 to second quarter of 1994) of FOB mill prices for delivered products reported in "Timber Mart-South" for Area 1 of Kentucky, North Carolina, Tennessee, and Virginia (Timber Mart-South 1993, 1994).

To simplify the analysis, tree grade was equated with log grade in calculating delivered value. Thus, the entire sawtimber volume in a grade 1 tree on a plot was assigned a value of log grade 1. This is not strictly valid, as FIA tree-grade rules are based on the best 12 feet of the butt log (Hanks 1976) and do not correspond to log-grade rules used by many sawmills in the market area. This simplification would tend to overestimate the value of the tree, as grade generally is lower in upper stem logs. Offsetting this somewhat is that reported gatewood prices tend to represent the lowest prices paid by mills for logs. Mills are willing to pay more for stumpage to gain greater control over log flow and quality (R. Shaffer, Virginia Polytechnic Inst. and State Univ., pers. commun.).

Figure 7 shows the volume of timber available at various revenue levels (net of production costs) to cover stumpage and logger profits. At current market prices, delivered value equals or exceeds production cost for about 67 percent (28.76 bcf) of the timber inventory in the market area. The

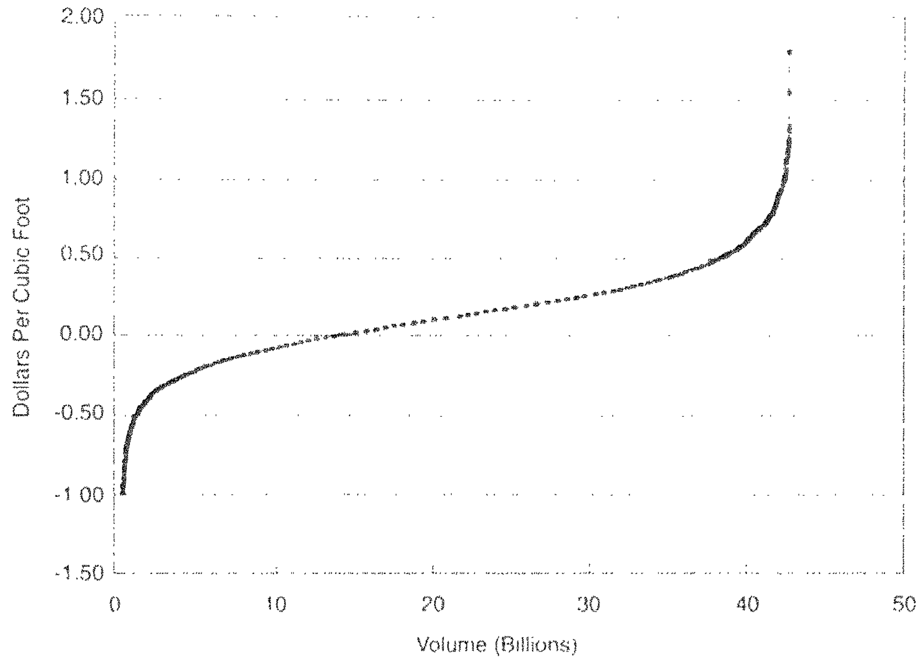

Figure 7.—Potential profit versus harvest volume under current market conditions.

remaining 33 percent (14.22 bcf) is unprofitable to harvest and from an economic standpoint would be viewed as unavailable. Figure 8 shows the percentage of profitable timberland acres by county in the market area under current market conditions.

The ownership distribution of this "economically available" timber supply mirrors the general pattern of timberland ownership in the market area (Fig. 3), with approximately 77 percent of the supply on NIPF land, 16 percent on the National Forest (3 percent on the JNF), 5 percent on forests owned or leased by forest industry, and 2 percent on other public timberland.

Table 4 summarizes descriptive information about the timber supplies estimated to be economically available for harvest in the market area under current market conditions.

Under current market conditions, estimated annual demand (Table 2, midpoint) represents only 1.4 percent of the economically available timber supply from all ownerships in the market area (Table 4), and only 62 percent of net annual growth. Ignoring any changes in timber inventories due to growth or mortality, the estimated economically available stock of timber in the market area could sustain current annual consumption for nearly 70 years.

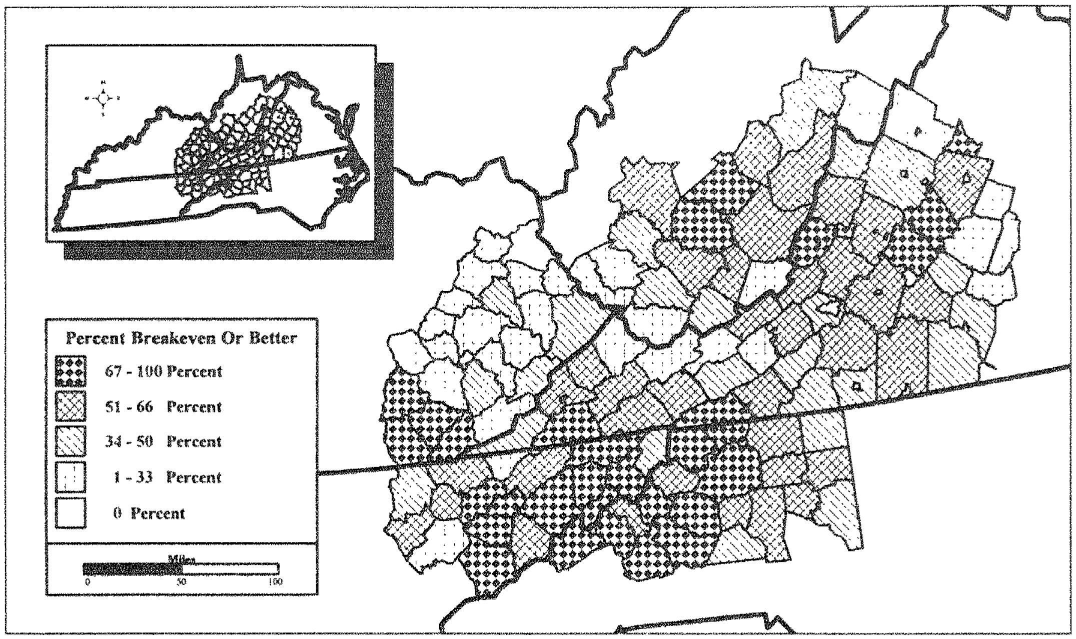

Figure 8.—Percentage of break-even or better timberland by county under current market conditions, Jefferson National Forest market area.

Table 4.—Characteristics of "economically available" timber supplies under current market conditions, all ownerships and Jefferson National Forest

Resource characteristic	All ownerships	Jefferson National Forest
Total volume (bcf)	28.76	0.83
Net annual growth (mmcf/yr)	671.0	12.30
Avg. profit ($/cf)	0.25	0.29
Avg. stump-to-mill cost ($/cf)	0.51	0.49
Avg. sawtimber volume/acre (bf)	6715	7571
Avg. growing-stock volume/acre (mcf)	2343	2680
Avg. haul distance--sawlogs (miles)	5.60	6.90
Avg. haul distance--pulpwood (miles)	29.3	27.4
Avg. sawlog diameter (inches)	14.9	15.2
Grade 1 sawlogs (percent)	16	13
Grade 2 sawlogs (percent)	31	30
Grade 3 sawlogs (percent)	53	57
Select species (percent)	18	15
On slopes $\geq$ 36 percent (percent)	39	22

Sensitivity Analysis—More Restrictive BMP's

Local forest regulatory ordinances and state environmental protection measures such as BMP's have become common in many eastern states over the past two decades (Martus et al. 1995). Various studies have documented the effects of these measures on the cost of harvesting and transporting timber (Lickwar et al. 1992) and on the available timber supply (Greene and Siegel 1994).

In this part of the analysis, the effects of more restrictive BMP's on the economically available timber supply in the market area were evaluated. BMP's focus primarily on the control of soil erosion and nonpoint-source pollution through such measures as the layout and design of skid trails; use of vegetative buffer strips and protected streamside management zones; installation of culverts, water bars, and broad-based dips; and postharvest application of seed, fertilizer, and mulch on exposed soils. Skidding and yarding costs are particularly sensitive to these control measures. To simulate more restrictive BMP's, skidding/yarding costs were increased by 15 percent on all plots (Huyler and LeDoux 1995).

As expected, the increased harvest cost results in a reduction of the volume of timber that is profitable to harvest in the market area. The estimated supply of the economically available timber drops by 7 percent to 26.76 bcf (Fig. 9). Average stump-to-mill costs increase from $0.51 to $0.53 per cubic foot. Under this scenario, the ownership distribution of this timber supply remains unchanged and supply continues to exceed current demand.

Sensitivity Analysis—Increased Log Prices

Prices for hardwood logs delivered at the mill have shown continued real increases since the late 1980's, particularly for the more desired species. Nolley (1995) reported price increases of 35 percent for red oak, 46 percent for white oak, and 88 percent for hard maple grade 1 logs in eastern Tennessee for 1990-94. These increases have not been limited to higher log grades, reflecting a growing trend by sawmillers and secondary manufacturers to turn to lower quality material in an attempt to control costs of raw material (Barrett 1993a).

Delivered log prices for select red oak, select white oak, ash, yellow-poplar, basswood, hard maple, walnut, and black cherry were increased by 50 percent over current market conditions to show the impact of changes in delivered log prices on the economically available supply of timber in the market area. This increase was applied to all three log grades for each of the eight species.

Under this scenario, the "economic" timber supply increases by 9 percent to 31.24 bcf (Fig. 10), and the average profit increases by nearly 50 percent to $0.37 per cubic foot. This increase in profit offsets the increase in unit harvest costs associated with the removal of smaller diameter materials, smaller volumes, and harvest on steeper slopes. The average haul distance also is greater under this scenario. The increased value of the sawtimber volume on many plots in effect "carries" the added cost of transporting the wood—particularly small roundwood—farther to the mill.

The ownership distribution of the economically available timber supply remains unchanged, with 77 percent of the supply on NIPF land. Supply continues to exceed current estimated annual consumption levels by a large margin.

Landowner Attitudes and Timber Supply on NIPF Land

In the previous sections, estimates of the available timber supply ignored the potential effects of landowner attitudes on harvest activities. Several studies have examined timber management behavior by NIPF owners (Force and Lee 1991; Birch 1992; Birch et al. 1992). In all of these studies, only 30 to 40 percent of the landowners indicated that they planned to harvest timber from their land within the next 10 years. While factors such as tract size, landowner demographics, timber management experience, location, pecuniary and nonpecuniary objectives, forest type, stumpage prices, and the availability of technical and financial assistance have been correlated with timber harvest on NIPF land (Thompson and Jones 1981; Greene and Blatner 1986; Young and Reichenbach 1987; de Steiguer et al. 1989), the results have been ambiguous.

Predicting timber availability from these lands remains elusive. Yet, as Doolittle (1992, p. 160) points out, "Without some idea of which NIPF owners are willing to sell timber and under what conditions, the timber supply question cannot be answered with great confidence." This issue is particularly critical in regions such as the JNF market area, where more than three-fourths of the timber supply occurs on NIPF land.

Uncertainty about timber management on NIPF land was incorporated into estimates of available timber supplies by reducing timber inventory on NIPF plots. This was done in a two-step process. First, results from the 1994 national forest-land ownership survey (Birch 1996) on harvest intent were used to "discount" NIPF plot acres. Next, we assumed that timber harvest from NIPF land must yield a specific dollar-per-acre return to the landowner before the plot would be available for harvest.

"Never Harvest" Upper Bound

Results of the most recent national forest-land ownership survey indicate that 10 to 17 percent of NIPF land in the five states encompassing the JNF market area is held by owners who never intend to harvest timber from their land. To reflect this "never harvest" segment, area expansion factors (EXPACR, Table 1) were reduced by 13.8 percent for all NIPF plots within the market area. This implicitly assumes that these lands are distributed equally across all NIPF plots in the market area, regardless of location, tract size, quality/volume of timber, or category of NIPF owner. In the absence of spatially specific data on harvest intentions

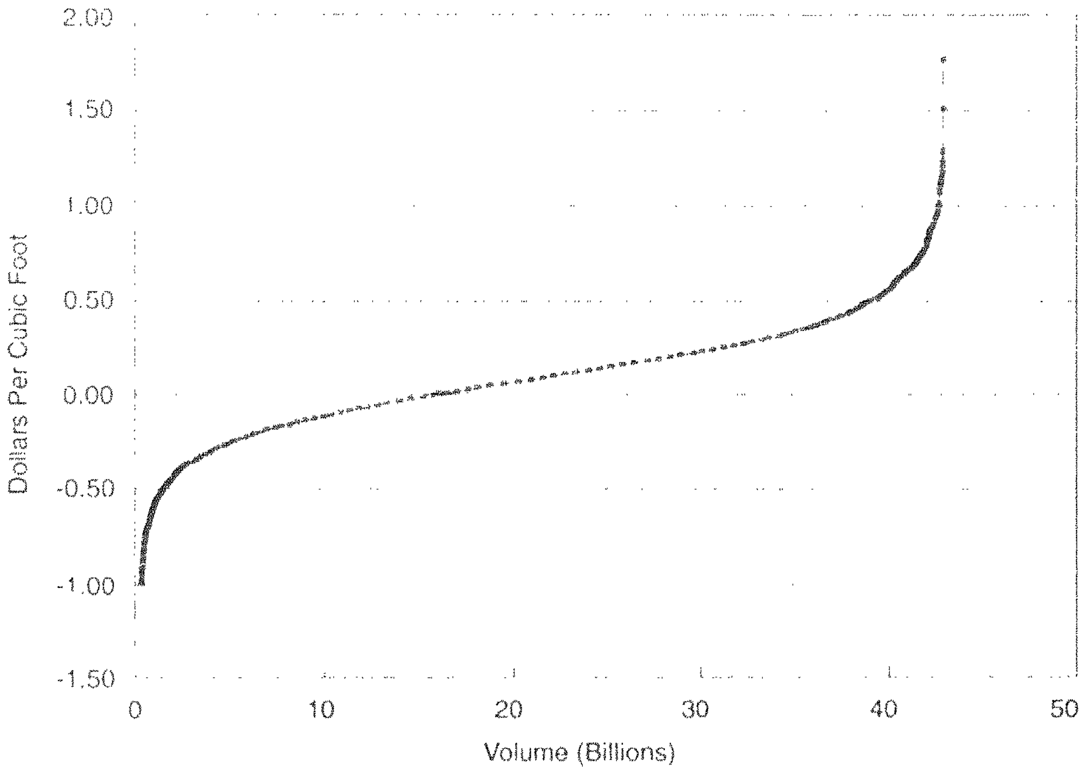

Figure 9.—Potential profit versus harvest volume under more restrictive BMP's.

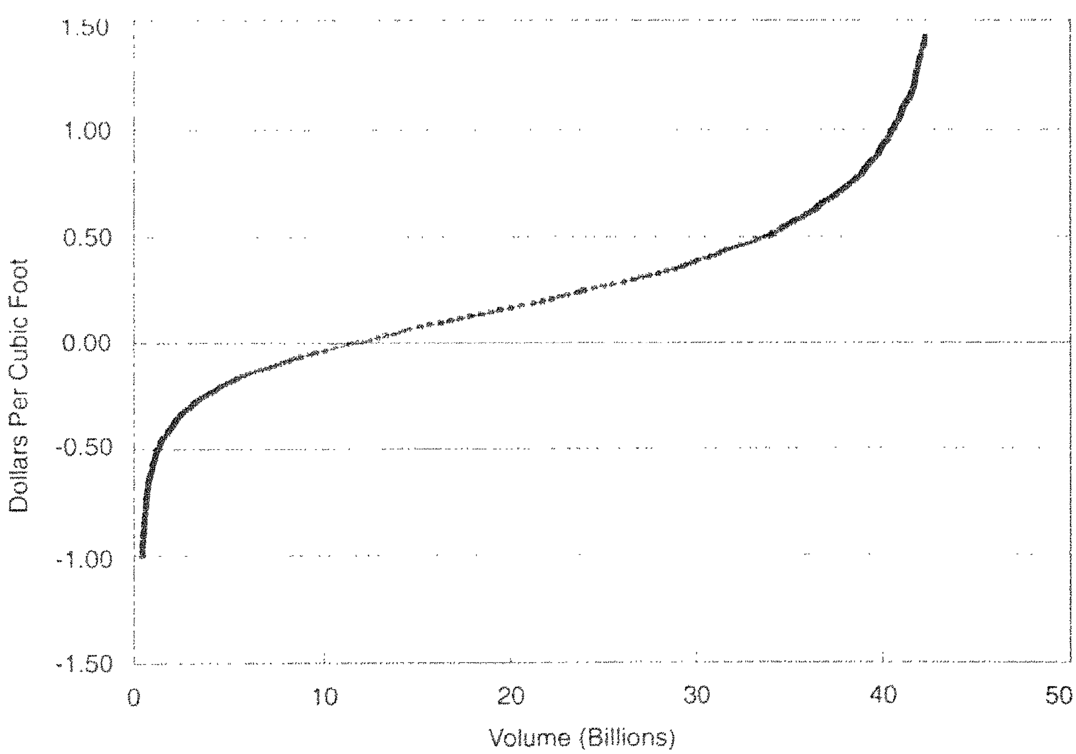

Figure 10.—Potential profit versus harvest volume for increased log prices.

of individual landowners, this approach seems reasonable as an upper bound for available timber supply on NIPF land.

As a result of this discounting, the economically available volume of timber off NIPF land falls nearly 3.1 bcf to 19.04 bcf, and the total economic supply from all ownerships drops to 25.71 bcf. The average stump-to-mill cost, profit, and haul distance remain unchanged. Supply continues to outstrip demand at the upper bound of assumptions about timber availability from NIPF land.

Minimum Dollar Return

Next, we assumed that timber harvest from NIPF land must return a certain profit in the ECOST model before the plot is available for commercial harvest. Although NIPF landowner studies have discussed the importance of nonmonetary returns in timber management decisions (Hyberg and Holthausen 1989), most have found a positive correlation between stumpage price and timber harvest (Alig et al. 1990). Doolittle (1992) concluded that income production was the most important motivation for selling timber in a study of NIPF landowners in the Midsouth. In this study, we set the minimum return at $300 per acre on NIPF land. Only NIPF plots capable of returning a profit of $300 or more per acre to the landowner were included in the timber supply base. No minimum profit level was established for forest industry, industry-leased, or public timberlands since management of these lands often involves objectives other than income production.

At this minimum-profit rate, the "economic" timber supply on NIPF land within the market area drops an additional 31 percent to 13.11 bcf, reducing the total economically available supply from all ownerships by nearly 9 bcf to 19.79 bcf. Figure 11 shows the volume of timber from NIPF land available at various profit levels in excess of the $300/acre minimum-return rate. At $0.00 per cubic foot, delivered value just equals stump-to-mill production costs plus the return of $300/acre to the landowner. At rates lower than this, supplies are unprofitable to harvest and considered economically unavailable. As might be expected, NIPF plots on average were of higher quality than in the baseline scenario, containing greater sawtimber volume per acre and a larger sawlog diameter, with a lower unit stump-to-mill cost.

Combined, the "never harvest" acreage discount and the minimum profit requirement reduce the total economic supply from NIPF land by nearly 41 percent, and the total supply from all ownerships by 31 percent. Even with this reduction, the total estimated economically available timber supply in the market area still greatly exceeds current annual consumption. However, the margin between consumption and net annual growth narrows, with the ratio approaching 1.0.

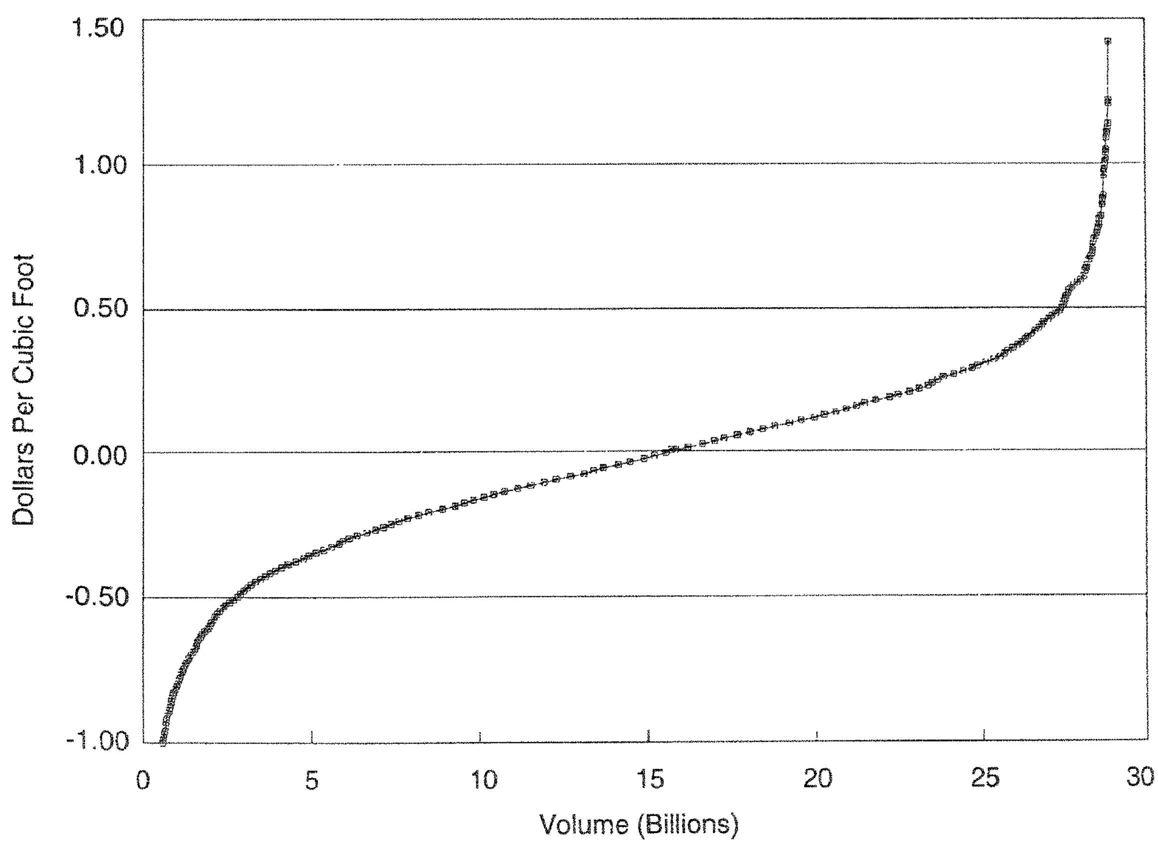

Figure 11.—Potential profit versus harvest volume for $300/acre minimum return on NIPF plots.

Supply-Demand Segmented by Resource Quality

The timber resources within the JNF market area are not homogeneous as there is substantial variation in species composition, size, and quality. This, in turn, affects the demand and price paid for timber supplies. In this part of the analysis, timber inventories in the JNF market area were segmented into three quality classes—high, average, and low—and compared to the demand for each quality segment to determine how resource quality affects the current supply-demand situation.

Segmented Supply

To segment the resource, each inventory plot was assigned a quality code based on the species and tree-grade mix and volume per acre of the sawtimber on the plot. The decision rule used in assigning this plot quality code is shown in Table 5.

High-value species included the traditional "select" hardwoods—select white and red oaks, ash, hard maple, black walnut, and black cherry—as well as basswood, butternut, cucumber tree, and yellow-poplar. Yellow-poplar was included as a high-value species because of the heightened interest in this species in recent years (Barrett 1993b).

Once a plot was assigned a quality code, the entire sawtimber volume on that plot was assigned the same quality code regardless of the actual species or grade of the individual sawlogs. On the basis of this segmentation, approximately 21 percent (21.6 bbf) of the sawtimber inventory in the market area (all ownerships) was classified

Table 5.—Criteria for assigning plot quality codes

Plot quality	Criteria
High	1. More than 50 percent of the sawtimber volume on plot is in high-value species.
	2. More than 50 percent of the sawtimber volume on plot is in tree grades 1 or 2.
	3. The total volume of sawtimber in tree grades 1-3 on plot is > 5 mbf/acre.
Average	1. More than 25 percent of the sawtimber volume on plot is in high-value species.
	2. More than 25 percent of the sawtimber volume on plot is in tree grades 1 or 2.
	3. The total volume of sawtimber in tree grades 1-3 on plot is > 2 mbf/acre.
Low	All other plots.

as on high-quality plots, 32 percent (33.1 bbf) on average-quality plots, and 47 percent (47.5 bbf) on low-quality plots. On the JNF, the timber resource was skewed more to the lower quality segment, with 23 percent of the Forest's sawtimber volume on high-quality plots, 21 percent on average-quality plots, and 56 percent on low-quality plots.

Not surprisingly, the vast majority (78 percent) of the high-quality plots were on NIPF land. National Forest lands accounted for 15 percent of the high-quality plots (2 percent on the JNF), while forest industry and other public timberlands contained the 5 and 2 percent of the high-quality plots, respectively. Figure 12 shows the general distribution of the high-quality plots as a percentage of timberland by county. The ownership distribution was the same for average- and low-quality plots as for high-quality plots.

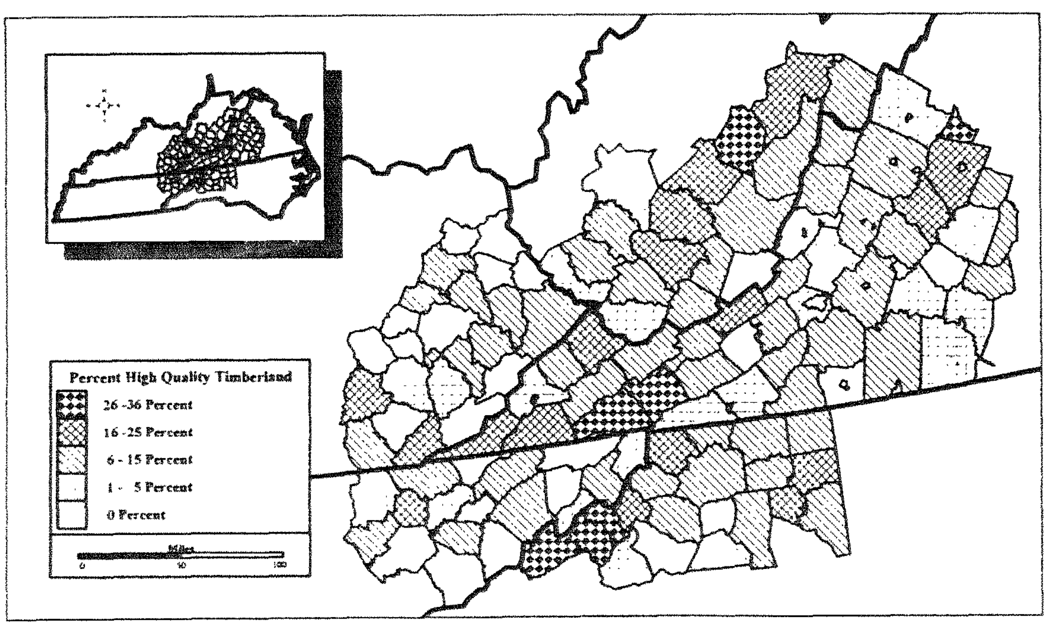

Figure 12.—Distribution of high-quality plots as a percentage of the timberland area by county, Jefferson National Forest market area.

Segmented Demand

Timber-resource consumption by primary processing mills in a market area also can be segmented by quality categories. Typically, fiber-based operations such as pulp and paper mills, chip mills, and composite-product mills are not as concerned with high-quality timber. However, for the solid-wood sector (i.e., hardwood sawmills), timber quality is a critical consideration in the yield and value of the end product(s). Each hardwood sawmill tries to procure the highest quality timber it can afford simply because the yield of the higher grade lumber is worth so much more and potential profits are higher. Although locational factors play a role, larger hardwood sawmills generally have a competitive advantage in acquiring higher quality timber due to economies of size and increased market power (Luppold 1995). Conversely, small sawmills usually lack the financial resources to outbid the larger mills for limited high-quality hardwood resources.

In this analysis, timber consumption by the primary processing mills in the market area was segmented into three resource-use categories—high, average, and low quality—based on such factors as the production capacity of the mill, types of products produced, types of equipment used, and species purchased (Table 6).

Table 6.—Criteria for segmenting primary processing mills, by resource use

Resource quality	Criteria
High	1. Hardwood sawmills producing > 5 mmbf/year.
	2. Hardwood sawmills producing moulding, millwork, or veneer products.
	3. Hardwood sawmills with optimizing equipment and thin-kerf gang saws, resaws, and/or head rigs.
	4. Hardwood sawmills with full-time procurement personnel.
Average	1. Hardwood sawmills producing 2 to 5 mmbf/year.
	2. Softwood sawmills producing > 5 mmbf/year.
	3. Softwood sawmills with scanners, optimizers, or mechanical sorters.
Low	1. Pulp, paper, chip, or composite-product mills.
	2. Sawmills producing primarily fence and rails, posts and mine timbers, or local-use products.
	3. Hardwood sawmills producing < 2 mmbf/year.
	4. Softwood sawmills producing < 5 mmbf/year.

On the basis of this segmentation strategy, approximately 51 percent of the current sawtimber consumption in the market area is by 79 sawmills that demand high-quality timber resources. Consumption of 30 to 35 percent is by the 134 sawmills demanding average-quality sawtimber; the remaining 13 to 19 percent is by 421 sawmills that process low-quality sawlogs. The 12 fiber mills in the market area consume 37.5 to 199.8 mmcf of roundwood per year. Figure 13 shows the distribution of these mills within the market area.

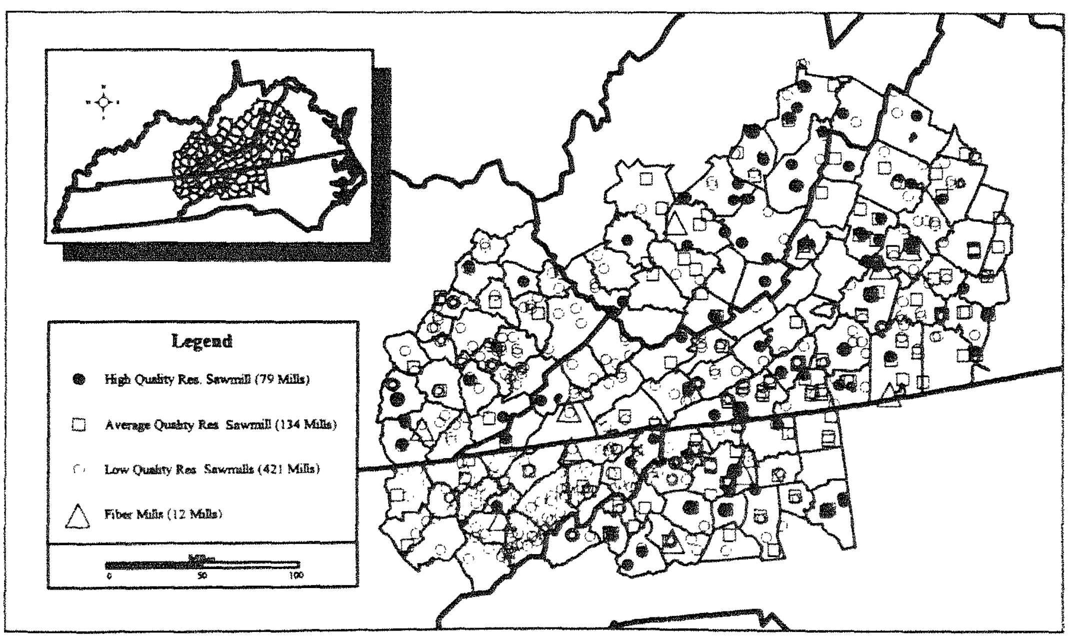

Figure 13.—Primary wood-processing mills segmented by resource quality, Jefferson National Forest market area.

Supply-Demand Comparison

To evaluate the economically available supply of each resource segment, the ECOST program was modified to restrict timber delivery to the nearest like-quality mill. Thus, the entire sawtimber volume from high-quality plots could be delivered only to high-quality resource sawmills in the market area. Similarly, sawtimber from average- and low-quality plots could be delivered only to average- and low-quality resource sawmills. Small roundwood on each plot was delivered to the nearest fiber mill.

It is important to note that although a plot may have been classified as high quality, it actually contains a mixture of high-, average- and low-quality sawtimber. Hence, a so-called high-quality resource sawmill would be using a range of sawlog material. Similarly, a low-quality plot also would contain high- and average-quality sawtimber. Table 7 summarizes characteristics of sawtimber supplies delivered to area sawmills, by resource quality.

The volume of timber available at various revenue levels for each resource segment is shown in Figures 14-16. As expected, harvest economics has the greatest effect on the low-quality resource. Fifty-one percent of the volume on the low-quality plots is unprofitable to harvest. For the average-quality plots, 27 percent of the volume is

Table 7.—Characteristics of sawtimber supplies delivered to area sawmills, by resource quality

Resource quality	Grade mix	Species mix[a]	Avg. sawlog diameter	Avg. haul distance
	Percent		*Inches*	*Miles*
High	27 Grade 1 38 Grade 2 35 Grade 3	13	15.8	14.1
Average	15 Grade 1 35 Grade 2 50 Grade 3	17	15.1	13.0
Low	8 Grade 1 22 Grade 2 70 Grade 3	21	14.3	7.1

[a]Percent Selects.

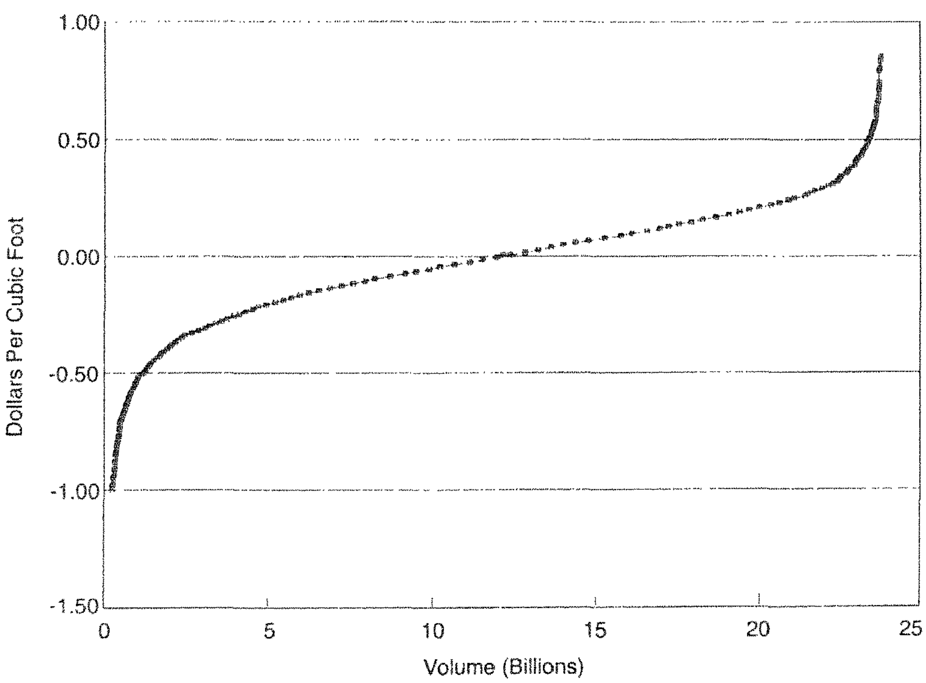

Figure 14.—Potential profit versus harvest volume for low-quality plots.

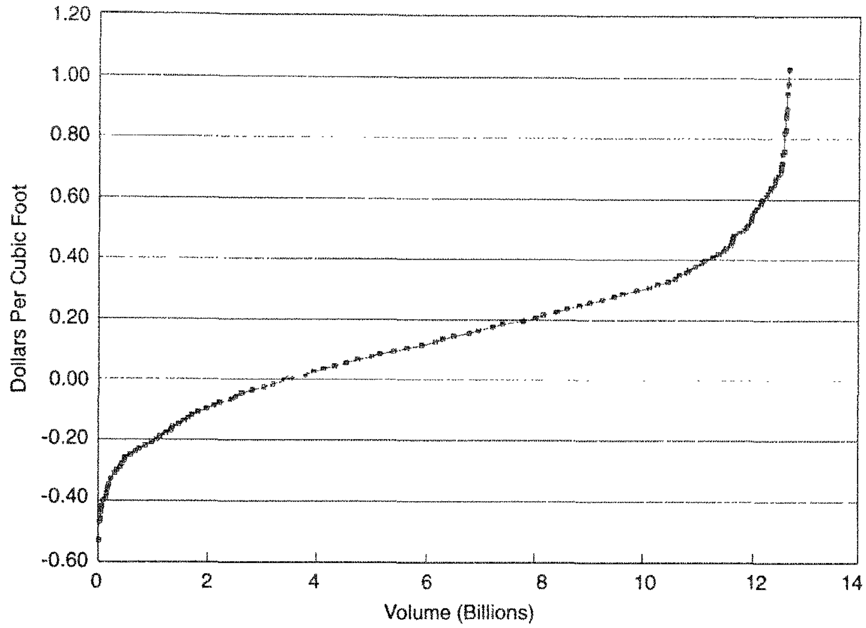

Figure 15.—Potential profit versus harvest volume for average-quality plots.

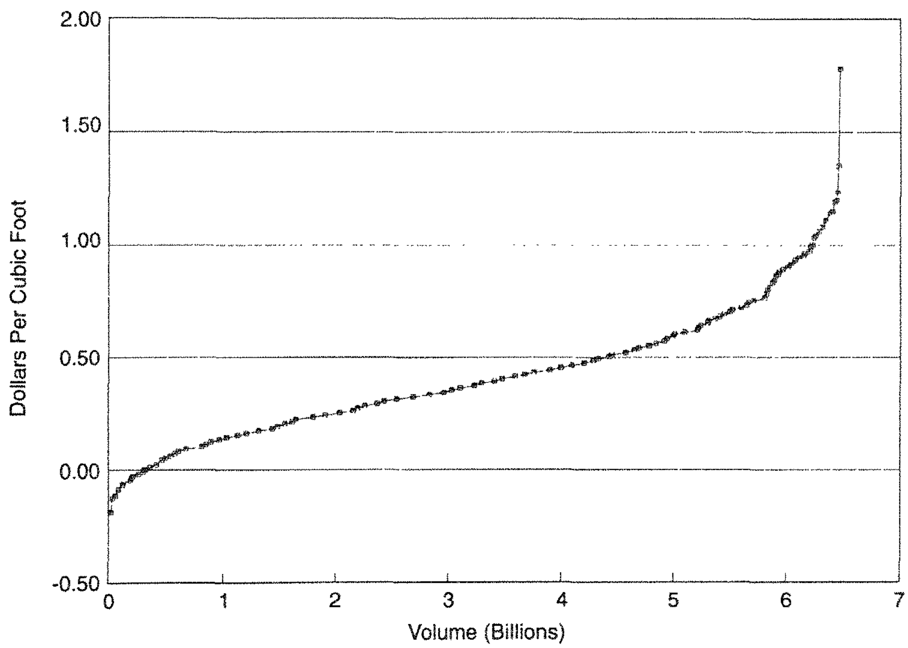

Figure 16.—Potential profit versus harvest volume for high-quality plots.

unprofitable; for high-quality plots, only 5 percent is unprofitable to harvest.

The ownership distribution of the economically available timber supply is virtually identical for each resource segment, and mirrors the general pattern of timberland ownership in the market area.

In Table 8, current annual timber consumption segmented by resource quality is contrasted with the economically available supply. As the results indicate, the high-quality sawtimber resource is under the greatest pressure within the market area. Although consumption is only a fraction of the total inventory of this resource segment, it exceeds annual growth for the midpoint and upper end of the estimated consumption range. This suggests that economic pressures are growing on the high-quality resource. Prices for this resource are expected to rise in response to these pressures. Mills that have traditionally relied on this resource segment may find it more difficult to sustain current consumption levels. As the price margin between the high- and average-quality timber resource widens, these mills can be expected to pursue a variety of adaptation strategies, including greater reliance on average- and lower-quality resources, higher prices for end products, and new technologies for improving yields.

When assumptions about restricted timber availability off NIPF land are imposed (see Landowner Attitudes), the pressures on the high-quality segment become even more intense. This is reflected in the ratio of demand to net annual growth (Table 9).

Introduction of New Mills to Market Area

Previous estimates of roundwood consumption by primary wood-processing mills in the market area were based on recent production figures from industry directories. As noted previously, these estimates represent a snapshot of timber consumption in the area. In reality, roundwood consumption is not static over time, but expands and contracts as new mills open and existing mills close or undergo changes in capacity.

Table 8.—Current timber demand as a percent of the "economically available" supply, by resource quality

Roundwood consumption range	Demand/economically available inventory	Demand/net annual growth
High-quality sawlogs	20,826 mmbf	711.6 mmbf
Minimum (580.6 mmbf/yr)	2.8%	81.6%
Midpoint (932.2 mmbf/yr)	4.5%	131.0%
Maximum (1283.7 mmbf/yr)	6.2%	180.4%
Average-quality sawlogs	26,214 mmbf	1007.2 mmbf
Minimum (398.9 mmbf/yr)	1.5%	39.6%
Midpoint (583.9 mmbf/yr)	2.2%	58.0%
Maximum (768.8 mmbf/yr)	2.9%	76.3%
Low-quality sawlogs	31,210 mmbf	1325.6 mmbf
Minimum (143.7 mmbf/yr)	0.5%	10.8%
Midpoint (315.8 mmbf/yr)	1.0%	23.8%
Maximum (487.6 mmbf/yr)	1.6%	36.8%
Pulpwood	10,016 mmcf	245.9 mmcf
Minimum (37.5 mmcf/yr)	0.4%	15.3%
Midpoint (102.8 mmcf/yr)	1.0%	41.8%
Maximum (199.8 mmcf/yr)	2.0%	81.3%

Table 9.—Current sawtimber demand as a percent of the "economically available" supply, by resource quality (restricted NIPF supplies)

Roundwood consumption range	Demand/economically available inventory	Demand/net annual growth
High-quality sawlogs	18,541 mmbf	628.3 mmbf
Minimum (580.6 mmbf/yr)	3.1%	92.4%
Midpoint (932.2 mmbf/yr)	5.0%	148.4%
Maximum (1283.7 mmbf/yr)	6.9%	204.3%
Average-quality sawlogs	20,864 mmbf	759.3 mmbf
Minimum (398.9 mmbf/yr)	1.9%	52.5%
Midpoint (583.9 mmbf/yr)	2.8%	76.9%
Maximum (768.8 mmbf/yr)	3.7%	101.3%
Low-quality sawlogs	21,257 mmbf	834.7 mmbf
Minimum (143.7 mmbf/yr)	0.7%	17.2%
Midpint (315.8 mmbf/yr)	1.5%	37.8%
Maximum (487.6 mmbf/yr)	2.3%	58.4%

In the past several years, the market area has received considerable scrutiny by wood industries seeking to expand or locate new operations in the eastern Appalachian hardwood region. Nine new fiber mills (five chip mills, three oriented-strand board, one laminated-strand lumber) have begun operations or announced plans to construct new plants in the market area. In addition, several high-production (20+ mmbf/year) hardwood sawmills have come on line.

In this section of the analysis, 23 new wood-processing mills were introduced into the market area to examine the resulting effects on annual roundwood consumption and the estimated economically available timber supply (Fig. 17). Also demonstrated is the flexibility of the methodology in incorporating changes in patterns of demand and timber consumption. Location, size, and type of mill, determined by an informal canvass of utilization and marketing foresters in each of the five states encompassing the market area, reflect current or likely industry expansion in the area during the next 5 to 10 years.

Annual roundwood consumption by new mills is shown in Table 10. The most significant change was the large increase (131 percent) in demand by new fiber mills in the market area. This increase represents the midpoint consumption range by fiber mills over the baseline scenario (Table 8). Most (93 percent) of the increase in sawtimber consumption was by so-called high-quality resource sawmills. In addition, annual production capacity of existing sawmills within the market area has experienced an estimated net increase of nearly 10 mmbf.

The data on new and expanded mill production information were inputted into the ECOST model to evaluate their impact on the estimated economically available supply of timber. The greater number and distribution of the fiber mills resulted in a significant reduction in the average haul distance for pulpwood compared to the baseline model (29.3 to 24 miles). This reduction boosted the volume of small-diameter and lower quality timber that was profitable to harvest. Under current price and cost assumptions, nearly three-fourths of the inventory (31.89 bcf) would be economical to harvest (Fig. 18), an 11-percent increase over the baseline scenario. Other characteristics of the economic supply (ownership, grade mix, diameter, average per-acre volume) remain relatively unchanged. Again, supplies dwarf consumption both in terms of the standing inventory and net annual growth. When supply and demand are segmented by resource quality, only the high-quality sawtimber segment is under pressure.

Summary and Conclusions

In forest planning, it is critical that the timber supply-demand situation be portrayed in a context appropriate to the region. The size of the market area, patterns of timber consumption, and timberland ownership mix are important dimensions. In this report we have outlined a methodology that focuses on these factors in assessing current commercial timber supply and demand for a given market area. FIA resource data and information on forest-industry production and location are used to contrast timber inventories with annual consumption rates. A stump-to-mill cost-prediction model is then used to assess the economics of timber harvest to determine the economic availability of these timber supplies under various market conditions.

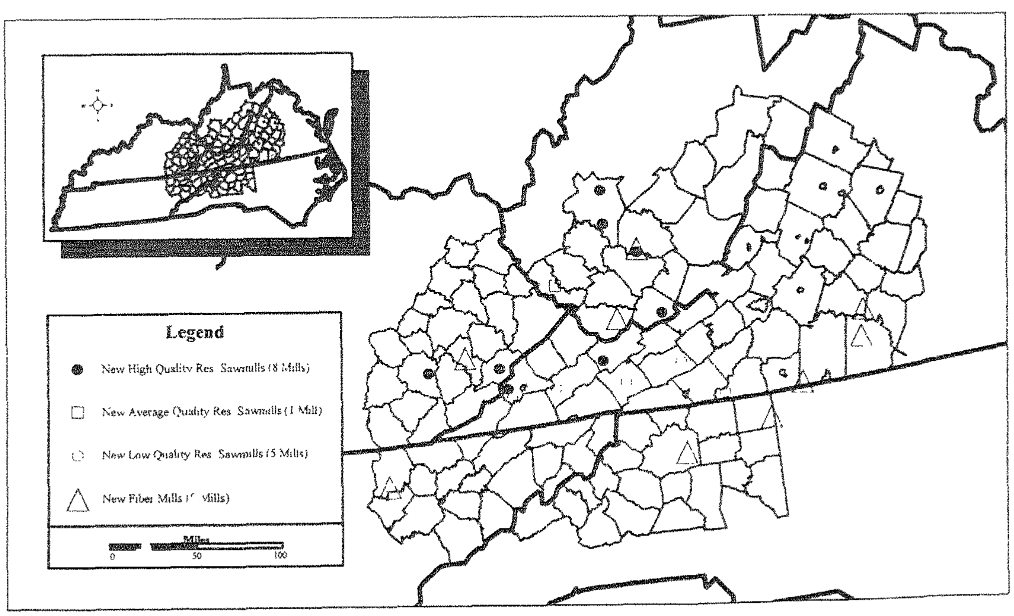

Figure 17.—Location of new primary wood-processing mills in the study area.

Table 10.—Annual roundwood consumption by the new mills

Mill type	Roundwood consumption range		
	Minimum	Midpoint	Maximum
Sawmills (mbf/yr)	69,650	121,000	176,600
Fiber mills (mcf/yr)	82,000	135,150	196,000
Total (mmcf/yr)	93.8	155.7	226.0

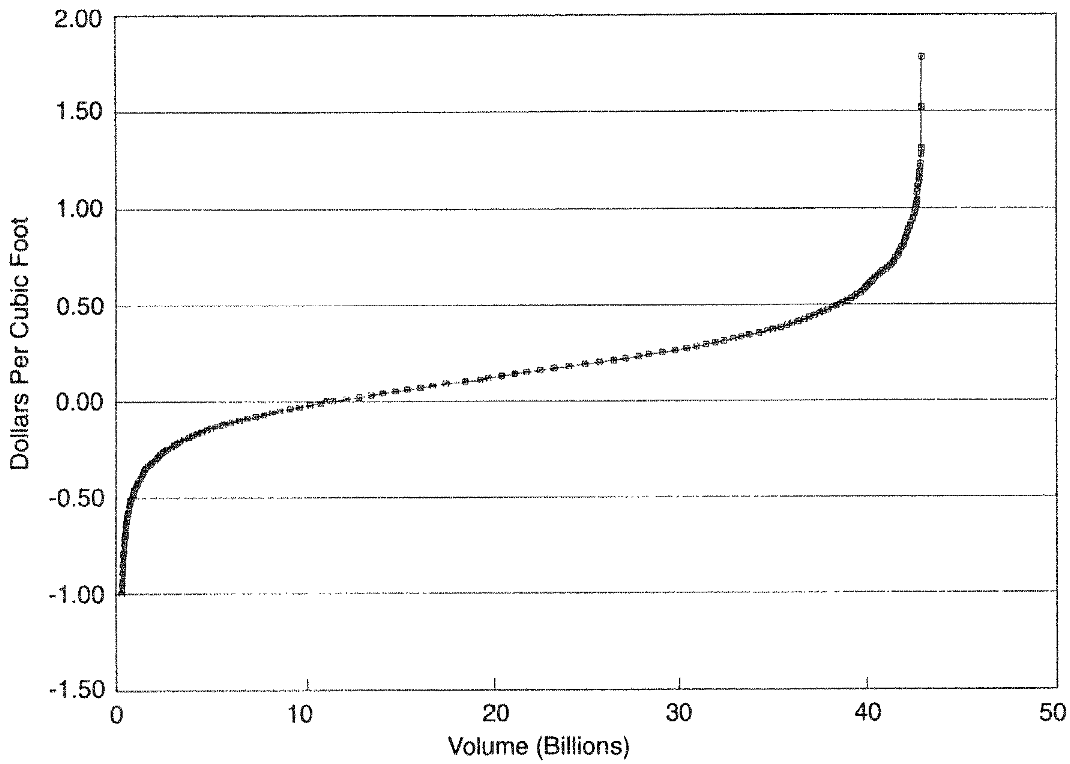

Figure 18.—Potential profit versus harvest volume for additional mill capacity.

Table 11 summarizes characteristics of the economically available timber supply under various market assumptions imposed in the case study. Not surprisingly, the timber supply-demand situation in the market area is critically dependent on what happens on NIPF land. Two-thirds to 75 percent of the estimated economic supply of timber is on NIPF land. Over the long run, only this ownership segment can sustain current patterns of timber consumption (see consumption to supply, growth ratios in Table 11), depending on assumptions about harvest behavior by NIPF landowners.

The Jefferson National Forest contributes only minimally, representing less than 3 percent of the total timber inventory in the market area. Nearly 70 percent of the Forest's timber inventory is economical to harvest under current market conditions.

Estimates of the total economic timber supply in the market area dwarf current annual consumption rates both in standing inventory and net annual growth. However, when the resource is segmented by quality, consumption rates for high-quality sawtimber exceed growth, suggesting that this segment is under increasing economic pressure. Upward stumpage and log price pressures may hasten the shift by area producers to lower quality and smaller diameter timber resources. The recent movement of new engineered wood-product manufacturing facilities into the market area suggests that such changes already are occurring. At the same time, these price increases may result in greater harvests from NIPF land.

Although the results presented here are specific to the Jefferson National Forest market area, the methodology used could be applied in other timber supply-demand assessments and in other market areas. The flexibility in model specification allows potential users to pose a variety of "what if" questions and evaluate the sensitivity of the results to changes in market conditions, industry location and processing capacity, logging practices, landowner attitudes, and timber availability.

Table 11.—Comparison of economic timber-supply availability under alternative assumptions, all and select ownerships

Attribute	Current market conditions		Increased harvest costs		Increased log prices		NIPF landowner attitude: Never harvest discount		NIPF landowner attitude: $300/acre min. return		New mills	
	All owners	JNF	All owners	JNF	All owners	JNF	All owners	NIPF	All owners	NIPF	All owners	JNF
Supply-demand												
Total annual consumption (midpoint, mmcf/yr)[a]	414.4	414.4	414.4	414.4	414.4	414.4	414.4	414.4	414.4	414.4	571.3	571.3
Economically available supply (bcf)[b]	28.76	0.83	26.76	0.75	31.24	0.87	25.71	19.04	19.79	13.11	31.89	0.89
Avg. annual inventory growth (mmcf/yr)[a]	671.0	12.3	617.0	11.0	726.4	13.4	600.7	439.5	446.5	285.3	757.4	13.6
Ratios												
Ann. consumption/supply	0.014	0.50	0.016	0.55	0.013	0.48	0.016	0.02	0.021	0.03	0.018	0.64
Ann. consumption/growth[c]	0.62	33.7	0.67	37.7	0.57	30.9	0.69	0.88	0.93	1.45	0.75	42.0
Economics												
Average profit ($/cf)	0.25	0.29	0.25	0.30	0.37	0.40	0.25	0.24	0.24[d]	0.23[d]	0.25	0.28
Average stump-to-mill cost ($/cf)	0.51	0.49	0.53	0.49	0.53	0.50	0.51	0.51	0.48	0.35	0.50	0.49
Average haul distance												
Sawlogs (miles)	5.6	6.9	5.6	7.1	5.7	6.8	5.6	5.5	5.6	5.5	5.7	6.6
Pulpwood (miles)	29.3	27.4	29.2	26.0	30.3	28.5	29.3	28.8	29.3	28.4	24.0	24.1
Resource Characteristics												
Average growing-stock volume (cf/acre)	2343	2680	2401	2749	2286	2621	2348	2304	2611	2682	2281	2589
Average sawtimber volume (bf/acre)	6715	7571	7034	8094	6389	7307	6728	6609	8003	8505	6262	7138
Average sawlog diameter (inches)	14.9	15.2	14.9	15.3	14.8	15.3	14.9	14.8	15.1	15.1	14.8	15.5
% Select sawlog species	18	15	18	15	18	15	18	18	17	17	18	15
% Grade 1 sawlogs	16	13	17	13	16	13	16	16	18	18	16	12
% Grade 2 sawlogs	31	30	31	29	31	29	31	31	31	33	31	29
% Grade 3 sawlogs	53	57	52	57	53	58	53	53	51	49	53	59
% Slopes ≥ 36%	39	22	38	21	41	25	39	40	38	38	40	25
Ownership												
% NIPF	77	-	77	-	77	-	74	100	66	100	78	-
% NF	16	-	16	-	16	-	18	-	24	-	15	-
% JNF	3	100	3	100	3	100	3	-	4	-	3	100
% Forest industry/leased	5	-	5	-	5	-	5	-	7	-	5	-
% Other public	2	-	2	-	2	-	3	-	3	-	2	-

[a]Volume in million board feet for sawtimber market segmentation.
[b]Volume in billion board feet for sawtimber market segmentation.
[c]Annual consumption exceeds net annual growth when ratio is greater than 1.0.
[d]Profit is less $300/acre minimum return to landowner on NIPF.

Table 11.—Continued

Attribute	Sawtimber market segmentation: High quality, All owners	Sawtimber market segmentation: High quality, JNF	Sawtimber market segmentation: Average quality, All owners	Sawtimber market segmentation: Average quality, JNF	Sawtimber market segmentation: Low quality, All owners	Sawtimber market segmentation: Low quality, JNF	Sawtimber market segment--$300/acre minimum return on NIPF: High quality, All owners	Sawtimber market segment--$300/acre minimum return on NIPF: High quality, NIPF	Sawtimber market segment--$300/acre minimum return on NIPF: Average quality, All owners	Sawtimber market segment--$300/acre minimum return on NIPF: Average quality, NIPF	Sawtimber market segment--$300/acre minimum return on NIPF: Low quality, All owners	Sawtimber market segment--$300/acre minimum return on NIPF: Low quality, NIPF
Supply-demand												
Total annual consumption (midpoint, mmcf/yr)[a]	932.2	932.2	583.9	583.9	315.8	315.8	932.2	932.2	583.9	583.9	315.8	315.8
Economically available supply (bcf)[b]	26.83	0.54	26.21	0.48	31.21	1.28	18.54	13.95	20.86	14.37	21.25	13.26
Avg. annual inventory growth (mmcf/yr)[a]	711.6	10.7	1007.2	11.4	1325.5	37.1	628.3	457.1	759.3	529.7	834.7	487.8
Ratios												
Ann. consumption/supply	0.045	1.73	0.022	1.22	0.001	0.25	0.050	0.07	0.028	0.04	0.015	0.02
Ann. consumption/growth[c]	1.31	87.1	0.58	51.2	0.24	8.5	1.48	2.04	0.77	1.10	0.38	0.65
Economics												
Average profit ($/cf)	0.43	0.66	0.23	0.19	0.16	0.20	0.41[d]	0.37[d]	0.22[d]	0.20[d]	0.15[d]	0.14[d]
Average stump-to-mill cost ($/cf)	0.55	0.42	0.56	0.64	0.51	0.50	0.48	0.47	0.50	0.64	0.47	0.50
Average haul distance												
Sawlogs (miles)	13.7	11.1	11.4	17.8	7.2	8.1	5.7	5.7	5.5	5.4	5.6	5.3
Pulpwood (miles)	34.4	25.4	30.0	32.1	25.4	26.9	34.3	32.9	29.8	28.0	25.6	24.9
Resource Characteristics												
Average growing-stock volume (cf/acre)	2921	3280	2316	2729	2183	2549	2951	2857	2478	2523	2524	2717
Average sawtimber volume (bf/acre)	9860	11925	6536	8307	5879	6582	9964	9805	7287	7596	7434	8423
Average sawlog diameter (inches)	15.8	16.0	15.1	15.5	14.3	15.0	15.9	15.8	15.3	15.3	14.3	14.3
% Select sawlog species	14	16	17	10	21	17	17	19	17	17	21	21
% Grade 1 sawlogs	28	26	16	12	10	8	28	27	17	17	11	11
% Grade 2 sawlogs	37	39	35	26	23	27	37	38	34	35	24	24
% Grade 3 sawlogs	35	35	49	63	67	65	35	35	49	48	65	65
% Slopes ≥ 36%	47	19	42	43	31	18	47	49	42	41	26	25
Ownership												
% NIPF	77	-	77	-	76	-	74	100	69	100	60	100
% NF	15	-	15	-	18	-	18	-	21	-	29	-
% JNF	2	100	2	100	4	100	3	-	2	-	7	-
% Forest industry/leased	5	-	6	-	4	-	5	-	7	-	7	-
% Other public	3	-	2	-	2	-	3	-	3	-	4	-

[a]Volume in million board feet for sawtimber market segmentation.
[b]Volume in billion board feet for sawtimber market segmentation.
[c]Annual consumption exceeds net annual growth when ratio is greater than 1.0.
[d]Profit is less $300/acre minimum return to landowner on NIPF.

Table 11.—Continued

Attribute	Sawtimber market segmentation- -new mills					
	High quality		Average quality		Low quality	
	All owners	JNF	All owners	JNF	All owners	JNF
Supply-demand						
Total annual consumption (midpoint, mmcf/yr)[a]	1059.9	1059.9	586.9	586.9	316.3	316.3
Economically available supply (bcf)[b]	21.22	0.54	28.25	0.56	34 31	1 40
Avg. annual inventory growth (mmcf/yr)[a]	729 6	10.7	1099.0	11.4	1561.9	42.4
Ratios						
Ann. consumption/supply	0.050	1 96	0.021	1.05	0.009	0.23
Ann. consumption/growth[c]	1.45	50.5	0 53	51 5	0 20	7.5
Economics						
Average profit ($/cf)	0 44	0 66	0 23	0.21	0 15	0 19
Average stump-to-mill cost ($/cf)	0.53	0.42	0.55	0.63	0.51	0.50
Average haul distance						
Sawlogs (miles)	13 2	12 0	11.9	18.6	7 4	7.7
Pulpwood (miles)	29.1	21 4	24.7	27.7	21 2	23.9
Resource Characteristics						
Average growing-stock volume (cf/acre)	2909	3280	2276	2729	2117	2433
Average sawtimber volume (bf/acre)	9768	11925	6214	8307	5351	6087
Average sawlog diameter (inches)	15 8	16.0	15.1	15 5	14 2	15.4
% Select sawlog species	14	16	17	10	21	17
% Grade 1 sawlogs	28	26	16	10	10	7
% Grade 2 sawlogs	37	39	35	22	23	27
% Grade 3 sawlogs	35	35	49	68	67	66
% Slopes ≥ 36%	48	19	43	43	31	22
Ownership						
% NIPF	78	-	79	-	78	-
% NF	15	-	14	-	16	-
% JNF	3	100	2	100	4	100
% Forest industry/leased	5	-	5	-	4	-
% Other public	2	-	2	-	2	-

[a]Volume in million board feet for sawtimber market segmentation.
[b]Volume in billion board feet for sawtimber market segmentation.
[c]Annual consumption exceeds net annual growth when ratio is greater than 1.0.
[d]Profit is less $300/acre minimum return to landowner on NIPF.

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