United States
Department of
Agriculture

Forest Service

**Northeastern
Research Station**

General Technical
Report NE-280

Timber Supply and Demand Assessment of the Green and White Mountain National Forests' Market Area

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Abstract

This report describes a timber supply and demand assessment of the Green and White Mountain National Forests' market area using USDA Forest Service, Forest Inventory and Analysis data, production information provided by forest industry, and a stump-to-mill logging cost-prediction model. Nonavailable timberland that includes reserve and steep-terrain lands is analyzed, and the sustainability of regeneration, partial cut, and diameter-limit harvests is evaluated.

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Manuscript received for publication 5 March 2001

Published by:
USDA FOREST SERVICE
11 CAMPUS BLVD SUITE 200
NEWTOWN SQUARE PA 19073-3294

June 2001

For additional copies:
USDA Forest Service
Publications Distribution
359 Main Road
Delaware, OH 43015-8640
Fax: (740)368-0152

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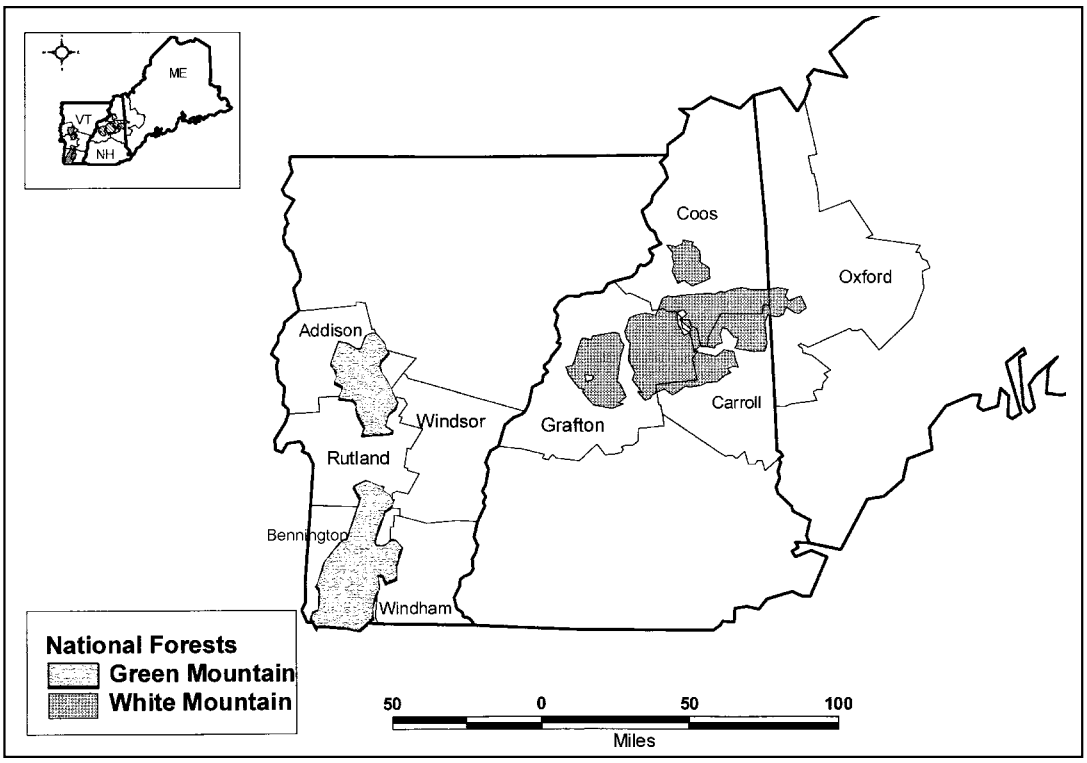

Figure 1.—Green and White Mountain National Forests' market area.

Introduction

As the National Forests revise their forest management plans, it is important that timber-harvest levels be balanced against the needs of the region's forest-based economy as well as nontimber demands on the land base. Planners must be knowledgeable about the timber resource and demands in the region, and the amount of the resource that is economically available at current market conditions. National Forest planners also need to understand their role in continuing as a source of pulpwood and sawtimber to local economies. In this report we summarize the results of a comprehensive timber supply and demand assessment of the Green and White National Forests' market area using USDA Forest Service, Forest Inventory and Analysis data, production information from forest industry, and a stump-to-mill logging cost-prediction model.

First, we describe how the market area was defined and the timber resources available there. Next, we assess timber demand by examining the primary wood-processing industry in the market area, and provide a baseline comparison between timber supply and demand, ignoring the effects of physical and market constraints. We then estimate the economical availability of the timber supply under current market conditions, and evaluate the impact of timberland that is unavailable for harvest by removing from the inventory lands classified as reserve and those with steep terrain. Next, we evaluate the impact of silvicultural treatments by considering regeneration, partial cutting, and diameter-limit harvests. Finally, we contrast timber supply and demand levels when supply and demand are segmented by resource quality.

We considered supplies from all ownerships and demands from all pulpwood and sawmills in the Green and White Mountain National Forests' market area, detailed stump-to-mill logging costs, and current timber prices. This procedure is easily understood by a range of publics engaged in forest planning activities. Changes in assumptions regarding logging costs, delivered log prices, landowner attitudes, and other variables can be modeled and evaluated in a sensitivity analysis mode.

Market Area and Description

The market area was defined as that in which most of the timber cut on the Green and White Mountain National Forests is transported for primary processing. The market area was defined as Coos, Carroll, and Grafton Counties in New Hampshire, Oxford County in Maine, and Bennington, Windham, Rutland, Windsor, and Addison Counties in Vermont (Fig. 1). We assumed that the

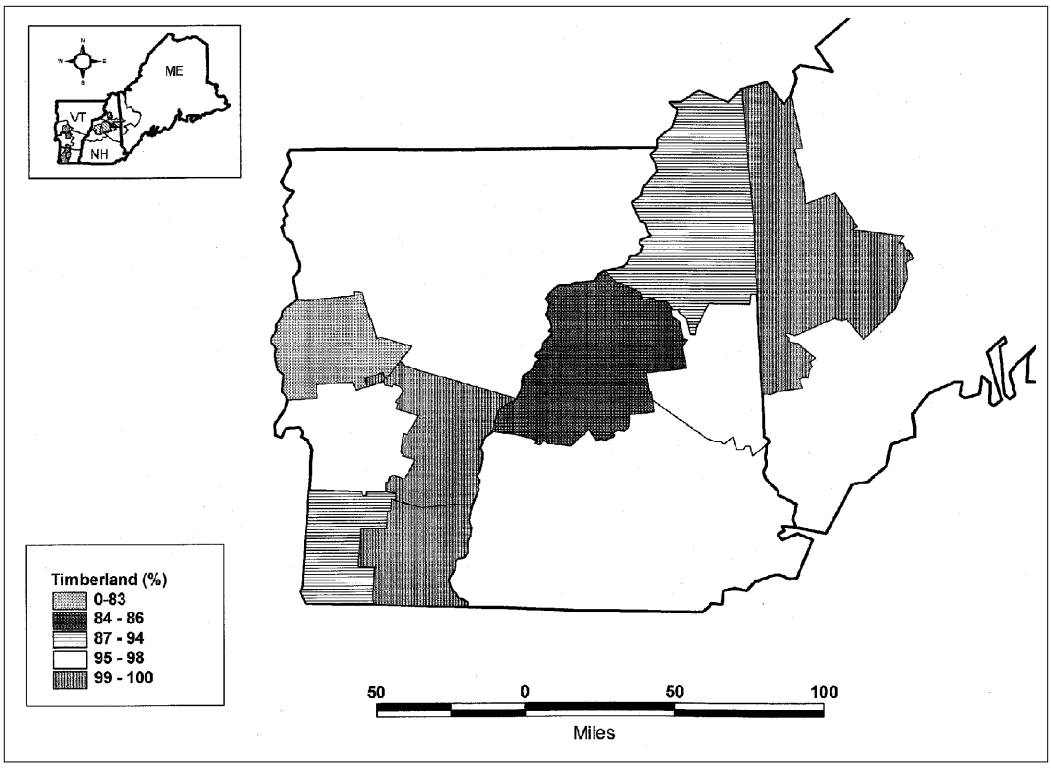

Figure 2.—Timberland as a percentage of land area, by county, Green and White Mountain National Forests' market area.

movement of timber supplies into the area is approximately equal to the outflows.

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 three states. Inventory data was aggregated for the nine-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, average annual growth, mortality, and removals).

From these data it was determined that the market area covers approximately 5.8 million acres; nearly 95 percent of the land area (5.5 million acres) is classified as timberland. Under FIA definitions, timberland is any forested land capable of growing at least 20 ft^3 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. Sixty-one percent of the timberland is in nonindustrial private forest ownership, which includes individuals, farmers, and corporations other than forest industry. Federal lands include all of the Green and White Mountain National Forests.

The northern hardwood forest-type group accounts for nearly all of the timberland area in the market area. The timber resource is maturing and of moderate to low quality; about 11 percent of timberland is located on steep slopes (≥ 35 percent). About 92 percent of the timberland is in the sawtimber stand-size class, and 51 percent of the sawtimber volume is grade 3 or lower. About 70 percent of the sawtimber is in the 12-inch or larger diameter classes. Nearly all of the timberland area is considered fully stocked or overstocked. On National Forest lands within the market area, about 15 percent of the timberland is on slopes of 35 percent or higher.

The estimated total volume of live trees in the market area is approximately 11.8 billion ft^3; nearly 94 percent of this volume is 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. Total net annual growth of growing stock (net of mortality) is about 373.11 million ft^3.

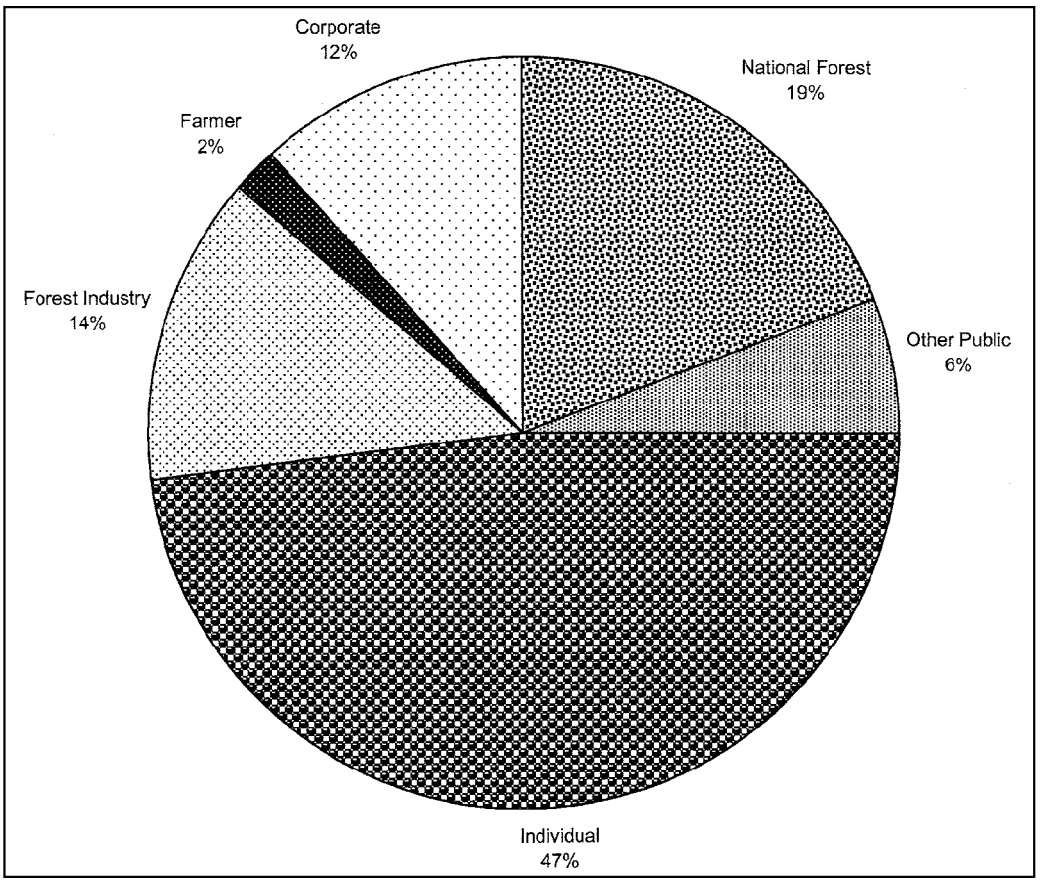

Figure 3.—Distribution of timberland area, by ownership, Green and White Mountain National Forests' market area.

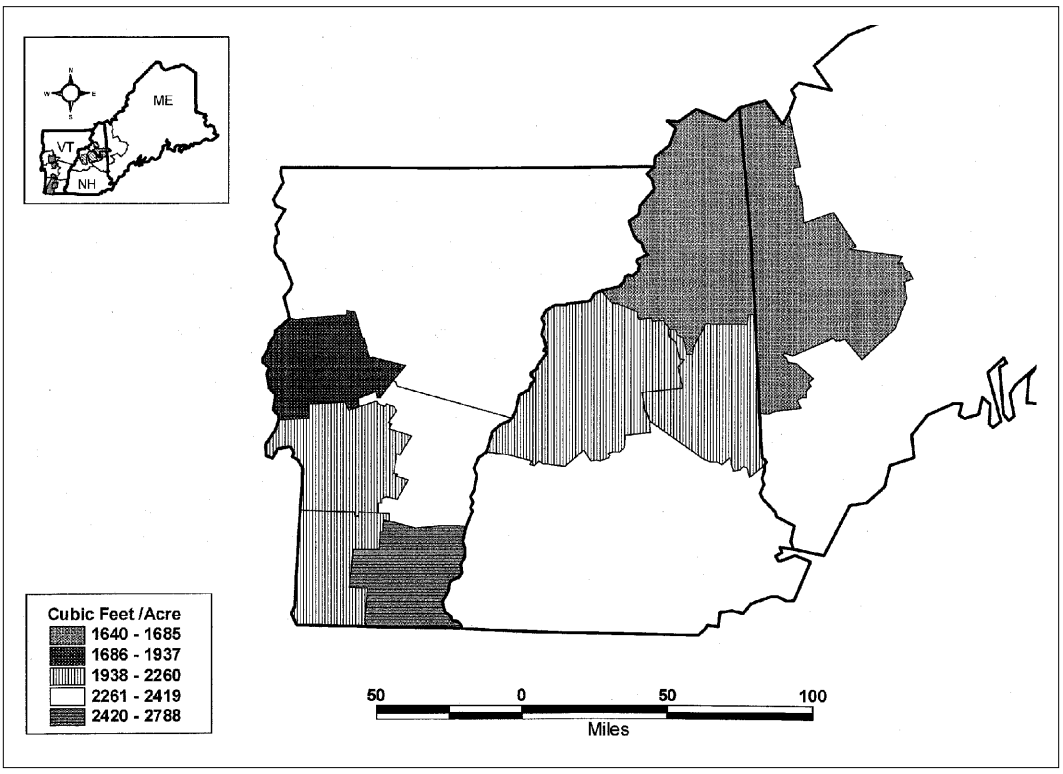

Figure 4.—Average volume of timber per acre on timberland, by county, Green and White Mountain National Forests' market area.

Table 1.—FIA plot-level variables used in study

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
PLU[a]	Land use code
SLOPE[a]	Average slope (%) of sample area
EXPACR[a]	Area expansion factor (acres)—number of acres the sample plot represents
EXPCUR[a]	Expansion factor for volume
LONG[a]	Longitude of FIA plot location
LAT[a]	Latitude of FIA plot location
PREMPER[a]	Previous measurement period
PULL[b]	Distance from FIA plot to nearest all-weather access road (miles)
SAW1[c]	Total board-foot volume per acre of trees classified as tree grade 1
SAW2[c]	Total board-foot volume per acre of trees classified as tree grade 2
SAW12[c]	Total board-foot volume per acre of trees classified as tree grade 1 and 2
SAW123[c]	Total board-foot volume per acre of trees classified as tree grade 1, 2, and 3
$BFSPTG_{ij}$[c]	Board-foot volume per 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 of growing-stock trees not included in SAW123
CF[c]	Total cubic-foot volume per acre of live trees
GROWTH[c]	Net annual cubic-foot growth per acre of live trees. Volume is net of mortality.
AVEDBH[c]	Average diameter of live trees $\geq$ 5.0 inches d.b.h.
AVESAW[c]	Average diameter of sawtimber-size trees (inches)
CCCF[c]	Total regeneration cut cubic-foot volume per acre of live trees
CCBF[c]	Total regeneration cut board-foot volume per acre of live trees
PCCF[c]	Total partial cut cubic-foot volume per acre of live trees
PCBF[c]	Total partial cut board-foot volume per acre of live trees
DLCF[c]	Total diameter-limit cubic-foot volume per acre of live trees
DLBF[c]	Total diameter-limit board-foot volume per acre of live trees

[a]Values from plot-level records in Eastwide Forest Inventory Data Base (Hansen et al. 1992).
[b]Not part of Eastwide Forest Inventory Data Base; information obtained from detailed data bases maintained by FIA unit at Northeastern Research Station.
[c]Values from tree-level records in Eastwide Forest Inventory Data Base.

Sawtimber volume is defined as the board-foot volume between a 1-foot stump and a 9-inch top for softwoods and an 11-inch top for hardwoods (or 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 3 or better using the standard hardwood tree-grading system (Hanks 1976). The estimated total inventory of grade 3 or better sawtimber trees in the market area is 22.4 billion board feet.

FIA plot-level data also were used to examine the effects of timber quality, operability, and market conditions on resource availability within the market area (see Economic Availability of Timber Resource). The plot-level forest inventory variables used in this study are listed in Table 1.

Forest Products Industry Within Market Area

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

Table 2.—Current timber demand as a percentage of timber inventory, Green and White Mountain National Forests' market area

Roundwood consumption range[a]	Demand/total Inventory[b]	Demand/net annual growth[c]
Minimum (89.89)	0.76	24.1
Midpoint (162.66)	1.38	43.6
Maximum (235.43)	2.00	63.1

[a]In million ft^3/year.
[b]11,796.86 million ft^3 (includes growing stock and all other live trees).
[c]373.11 million ft^3 (based on growing-stock volume).

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 New Hampshire, Vermont, and Maine. These directories, which represent the most recent listings of mills available at the time of this study, provide a "snapshot" of timber consumption in the area. While new mills came 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. There are 147 sawmills and 36 pulp- and fiber-producing mills within the Green and White Mountain National Forests' market area. Combined, these mills consume 105.55 million ft^3 of sawtimber and 57.11 million ft^3 of pulpwood (the midpoints of consumption range from 61.34 to 149.77 million ft^3 for sawmills and 28.55 to 85.66 million ft^3 for pulp/fiber mills). This material is used for the production of chips, pulp and paper, and sawtimber products, including lumber, veneer, plywood, and other industrial products (posts, rail and fence material, and related products).

Baseline Timber Supply-Demand Comparison

An initial baseline estimate of timber supply and demand was established by comparing 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, reserve and steep terrain lands, resource quality, and landowner attributes.

Under this baseline estimate, current annual demand represents only 0.76 to 2.0 percent of the total inventory. On the basis of these numbers, there appears to be sufficient timber supply in the market area to sustain current consumption rates 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 exceeded estimated removals. The standing inventory of timber should continue to increase because growth exceeds demand consumption over the entire estimated range.

Economic Availability of Timber Resource

In the previous section, the reported comparison between current timber consumption and supply assumed that the entire 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; Sheffield and Bechtold 1990; May and LeDoux 1992; Worthington et al. 1996). 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

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

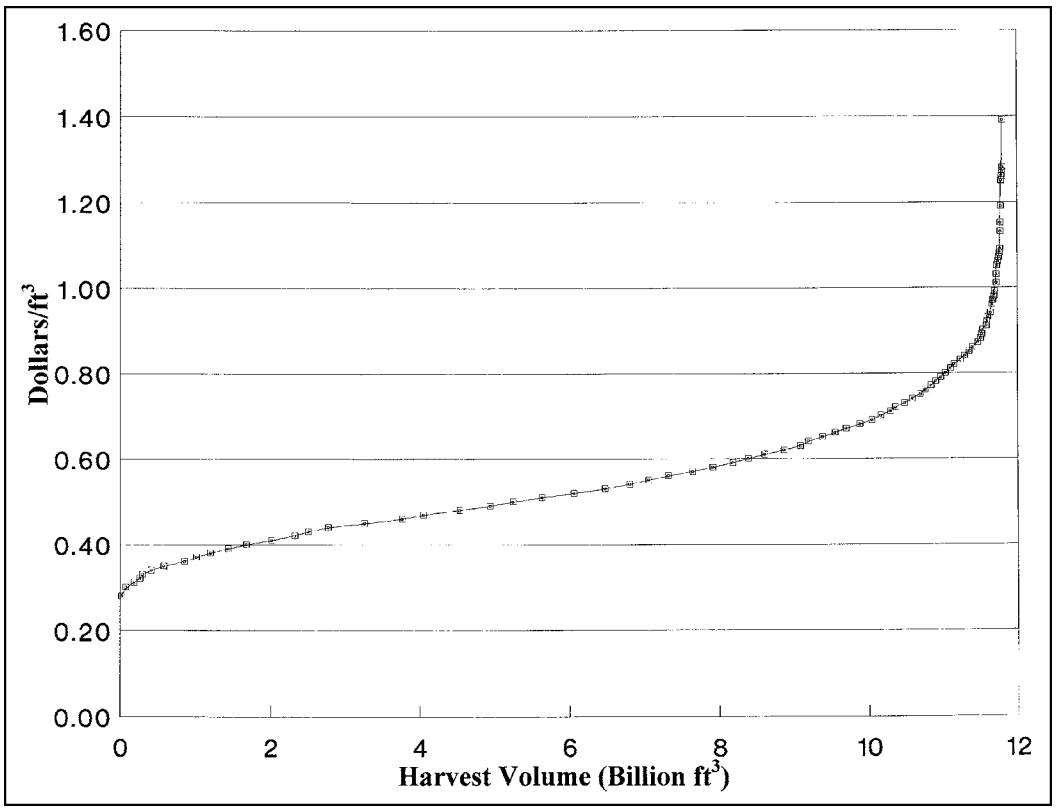

Figure 5.—Unit stump-to-mill cost versus harvest volume under current market conditions, Green and White Mountain National Forests' market area.

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).

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 of 35 percent or less, a conventional rubber-tired skidder logging system with an average yarding distance of 2,000 feet was used. On slopes greater than 35 percent, a cable yarding system with an average yarding distance of 550 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 and from a sample of pull distances in the three-state market area (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 Green and White Mountain National Forests' market

Table 3.—Delivered log prices by species group and grade, in dollars/thousand board feet; pulpwood by species, in dollars/thousand ft^3

Species group	Grade 1	Grade 2	Grade 3
Sawlogs			
Red oak	960	420	330
Sugar maple	930	545	270
Ash	425	265	180
Yellow birch	555	325	180
Red maple	315	185	125
Beech	185	150	130
Aspen	165	165	165
Other hardwoods	185	185	185
White pine	310	210	105
Spruce	230	230	230
Fir	230	230	230
Hemlock	150	150	150
Tamarack	150	150	150
Cedar	100	100	100
Other softwoods	100	100	100
Pulpwood			
Spruce-fir	706	706	706
Hemlock	647	647	647
Pine	588	588	588
Hardwood	688	688	688

area. All costs were adjusted to year 2000 dollars using the Producer Price Index (All Commodities).

Figure 5 shows the predicted stump-to-mill cost of harvesting timber from each plot in the market area. The entire inventory could be harvested and transported to the nearest mill at a production cost of $1.40 per cubic foot. However, at a rate of about $0.50 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 summarizes the delivered log and pulpwood prices used in the analysis. Prices of hardwood and softwood sawlogs are an average of prices from six large sawmills in or near the three-state study area. Prices are for logs delivered to the mill. They were obtained from the May 1999 and April 2000 issues of the "Sawlog Bulletin" and averaged by quality class. The log- price estimates were compared to delivered price ranges reported for Carroll County, New Hampshire by the "New Hampshire Forest Market Report" and for northern and central New Hampshire by the "Town Crier," published by the New Hampshire Timberland Owners Association. No major differences were noted among the three sources of information. Pulpwood prices for the third and fourth quarters of 1999 were obtained from the "Town Crier" and averaged for the northern and central New Hampshire reporting region. Pulpwood prices are for roundwood delivered to the mill.

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.

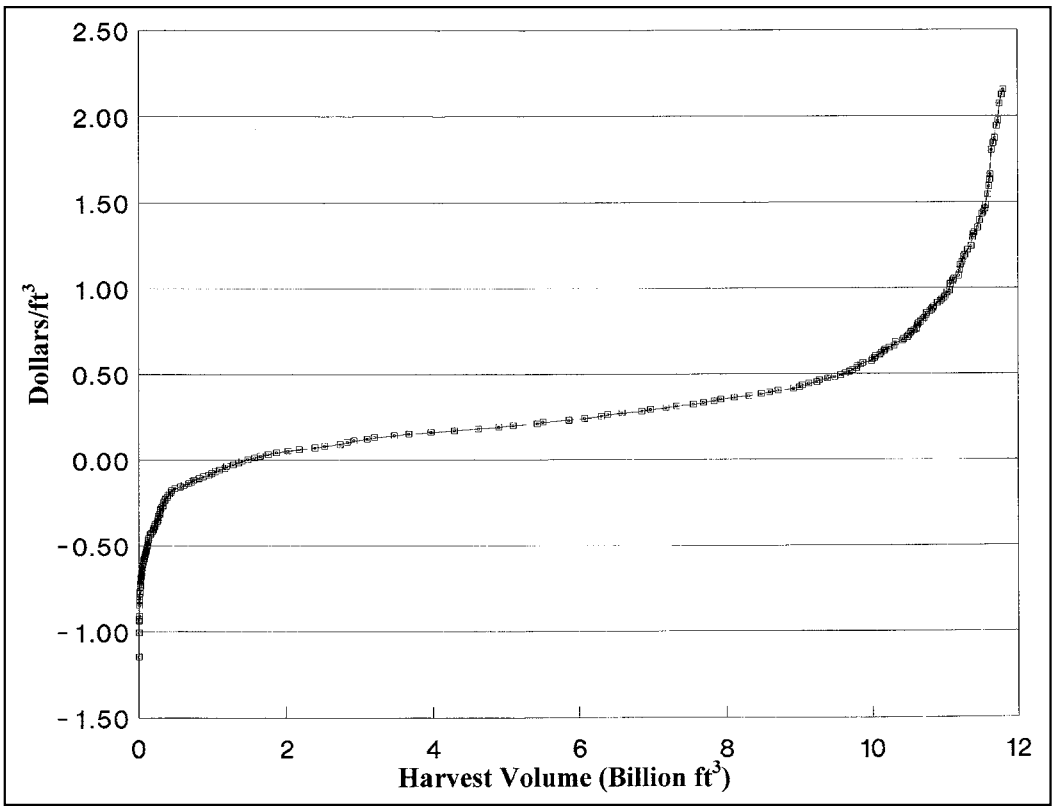

Figure 6.—Potential profit versus harvest volume under current market conditions, Green and White Mountain National Forests' market area.

Figure 6 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 87.5 percent (10.32 billion ft^3) of the timber inventory in the market area. The remaining 12.5 percent (1.47 billion ft^3) is unprofitable to harvest and from an economic standpoint would be viewed as unavailable. Figure 7 shows the percentage of profitable timberland acres by county in the market area under current market conditions. 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 1.56 percent of the economically available timber supply from all ownerships in the market area (Table 4), and 49.9 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 64 years.

Timberland Not Available for Harvest

In the previous sections, estimates of the available timber supply ignored the potential effects of land that is reserved from harvest and land that is not available for harvest due to terrain conditions such as percent sideslope. The impact of reserve and unavailable land on steep slopes was evaluated in a two-step process. First, the total inventory was reduced by the amount of timberland in reserve. Next, we assumed that lands with percent sideslopes ≥ 35 percent were unavailable.

Reserve Lands

Table 5 summarizes the descriptive information about the timber supplies estimated to be economically available for harvest in the market area under current market conditions with the economically available reserved timberlands removed from the inventory. The economical timberland area is reduced by 3.9 percent or 168,263.3 acres. The majority of the reserve timberlands was located on the National Forests, the Green and White Mountain National Forests had 82,313.3 and 151,710.30 acres, respectively. The remaining 5,449.60 acres of reserved land were located on state timberlands. Eliminating the

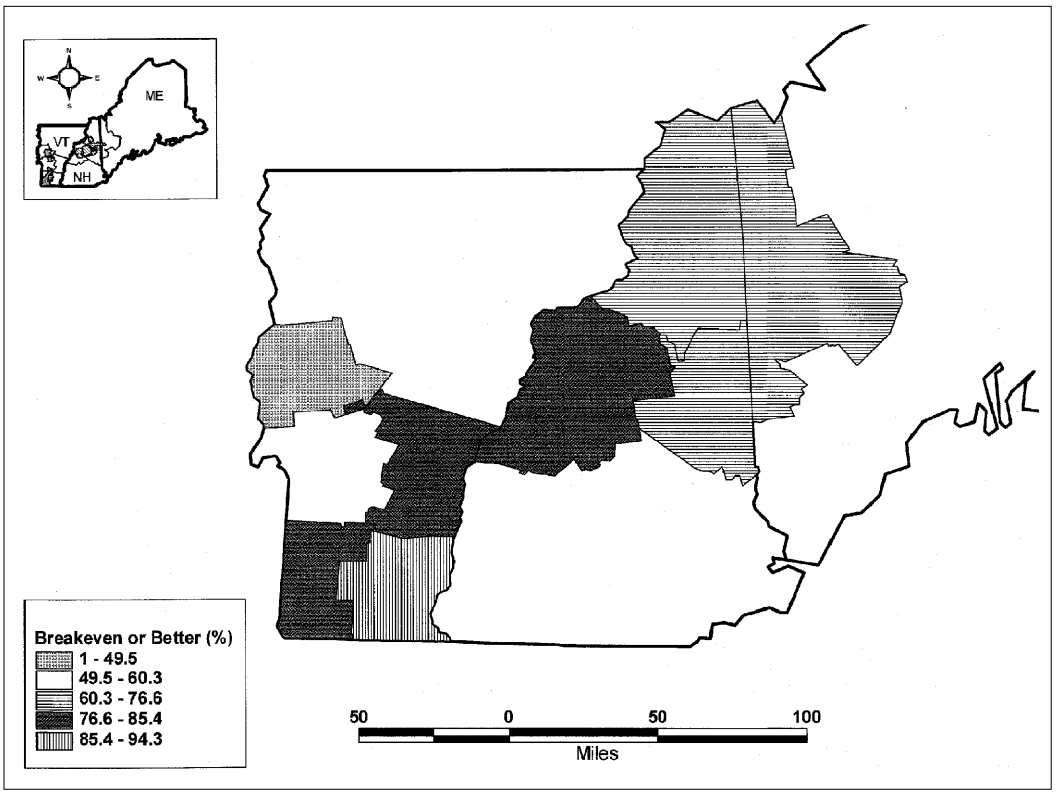

Figure 7.—Percentage of breakeven or better timberland under current market conditions, by county, Green and White Mountain National Forests' market area.

economically available reserve timberlands from the inventory reduces the economically available board-foot volume by 2.9 percent to 25.21 billion board feet.

Steep Slopes

Table 6 summarizes the descriptive information about the timber supplies estimated to be economically available for harvest in the market area under current market conditions with the reserved timberland and all lands with sideslopes greater than or equal to 35 percent removed from the inventory. Eliminating steep slope lands reduced the economically available timberland acreage by another 425,011.90 to 3,758,828.70. The economically available board-foot volume was reduced to 22.7 billion board feet. The impact of removing reserve and steep-slope lands from the economically available inventory reduces the total acreage and board-foot volume by 31.7 and 19.0 percent, respectively. Under current market conditions, estimated annual demand (Table 2, midpoint) represents only 1.8 percent of the economically available supply from all ownerships in the market area (Table 6), and only 58.4 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 55 years. Reducing the total inventory for reserve and steep terrain lands has little impact on the availability and sustainability of the timber resources in the market area assuming regeneration harvests.

Silvicultural Treatment

In the previous sections, a regeneration cut (clearcut) was assumed as the primary silvicultural treatment. To evaluate the impact of alternative silvicultural treatments on timber availability, we simulated a partial cut and a diameter-limit cut. The partial cut was assumed to remove one-third of the volume per acre equally from all diameter classes. The diameter-limit was assumed to remove all sawtimber trees per acre that were $\geq$ 12 inches d.b.h. Both silvicultural treatments were evaluated with the reserve and steep slope lands removed from the total inventory.

Partial Cut

Table 7 summarizes descriptive information about the timber supplies estimated to be economically available for partial cut harvest in the market area under current market conditions. Under partial cut conditions, the total

Table 4.—Characteristics of "economically available" timber supplies under current market conditions, all ownerships, Green and White Mountain National Forests

Resource characteristic	All ownerships	Green Mountain	White Mountain
Total volume (billion ft^3)	10.40	0.53	1.62
Net annual growth (million ft^3)	326.01	18.74	43.84
Avg. profit (dollars/ft^3)	0.34	0.40	0.38
Avg. stump-to-mill cost (dollars/ft^3)	0.54	0.62	0.51
Avg. sawtimber volume/acre (bf)	5963.30	6015.85	6226.38
Avg. growing-stock volume/acre (ft^3)	2390.11	2206.52	2636.79
Avg. haul distance—sawlogs (miles)	6.39	5.71	7.56
Avg. haul distance—pulpwood (miles)	14.29	31.75	9.56
Avg. sawlog diameter (inches)	13.55	14.49	12.78
Grade 1 sawlogs (percent)	35.8	31.4	50.1
Grade 2 sawlogs (percent)	26.9	28.4	18.2
Grade 3 sawlogs (percent)	37.3	40.2	31.7
On slopes ≥ 35 percent (percent)	12.4	9.2	18.2

Table 5.—Characteristics of "economically available" timber supplies under current market conditions, (reserved removed) all ownerships, Green and White Mountain National Forests

Resource characteristic	All ownerships	Green Mountain	White Mountain
Total volume (billion ft^3)	10.01	0.43	1.34
Net annual growth (million ft^3)	312.32	15.47	33.43
Avg. profit (dollars/ft^3)	0.35	0.46	0.41
Avg. stump-to-mill cost (dollars/ft^3)	0.54	0.60	0.50
Avg. sawtimber volume/acre (bf)	6024.54	6334.46	6685.01
Avg. growing-stock volume/acre (ft^3)	2392.49	2259.54	2675.04
Avg. haul distance—sawlogs (miles)	6.38	5.71	7.66
Avg. haul distance—pulpwood (miles)	14.11	30.79	9.17
Avg. sawlog diameter (inches)	13.61	14.62	13.24
Grade 1 sawlogs (percent)	35.4	30.8	49.3
Grade 2 sawlogs (percent)	27.3	29.2	19.7
Grade 3 sawlogs (percent)	37.3	40.0	31.0
On slopes ≥ 35 percent (percent)	12.3	11.8	17.6

Table 6.—Characteristics of "economically available" timber supplies under current market conditions, (reserved removed, and slope ≥ 35 percent removed) all ownerships, Green and White Mountain National Forests

Resource characteristic	All ownerships	Green Mountain	White Mountain
Total volume (billion ft^3)	9.00	0.41	1.12
Net annual growth (million ft^3)	278.63	14.10	28.95
Avg. profit (dollars/ft^3)	0.35	0.50	0.42
Avg. stump-to-mill cost (dollars/ft^3)	0.53	0.59	0.50
Avg. sawtimber volume/acre (bf)	6033.74	6654.23	6535.14
Avg. growing-stock volume/acre (ft^3)	2395.55	2366.00	2610.66
Avg. haul distance—sawlogs (miles)	6.33	5.99	7.40
Avg. haul distance—pulpwood (miles)	13.95	30.66	9.02
Avg. sawlog diameter (inches)	9.34	15.35	13.35
Grade 1 sawlogs (percent)	35.3	31.4	49.1
Grade 2 sawlogs (percent)	26.4	29.5	16.1
Grade 3 sawlogs (percent)	38.3	39.1	34.8

Table 7.—Characteristics of "economically available" timber supplies under current market conditions, (partial cut, reserve removed, slope ≥ 35 percent removed) all ownerships, Green and White Mountain National Forests

Resource characteristic	All ownerships	Green Mountain	White Mountain
Total volume (billion ft^3)	1.65	0.07	0.26
Net annual growth (million ft^3)	140.42	6.94	16.42
Avg. profit (dollars/ft^3)	0.34	0.58	0.40
Avg. stump-to-mill cost (dollars/ft^3)	0.64	0.68	0.63
Avg. sawtimber volume/acre (bf)	2937.64	2835.76	2991.64
Avg. growing-stock volume/acre (ft^3)	987.24	855.04	1023.23
Avg. haul distance—sawlogs (miles)	5.43	5.66	7.16
Avg. haul distance—pulpwood (miles)	13.89	30.14	8.61
Avg. sawlog diameter (inches)	14.38	15.30	13.96
Grade 1 sawlogs (percent)	37.1	31.7	54.3
Grade 2 sawlogs (percent)	28.4	31.3	16.6
Grade 3 sawlogs (percent)	34.5	37.0	29.1

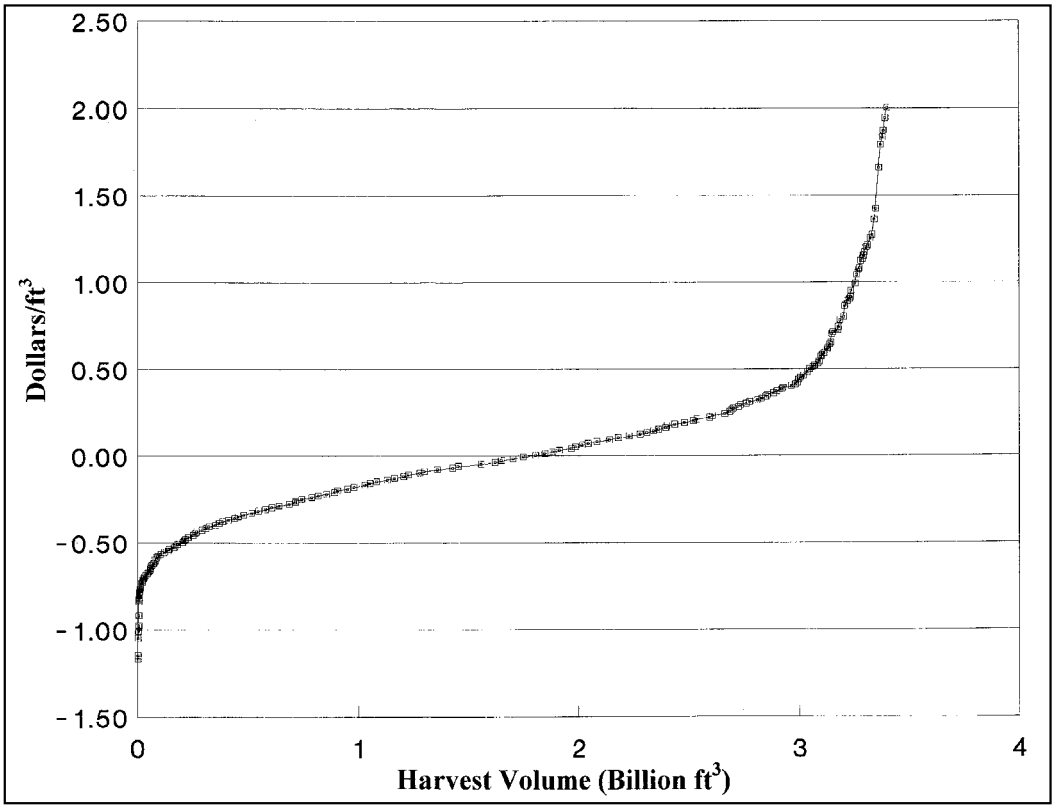

Figure 8.—Potential profit versus harvest volume under current market conditions, Green and White Mountain National Forests' market area (partial cut with reserve and steep-terrain plots removed).

economically available volume is 1.6 billion ft^3. Since the volume and dollar values removed are one-third of the inventory on a per-acre basis and in total, the average economical acre will yield a lower profit, suggesting that partial cutting is less profitable than regeneration harvests and that removals of one-third of the volume and value will be economical only on reduced acreage. Figure 8 shows the volume 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 48 percent (1.65 billion ft^3) of the timber inventory in the market area. The remaining 52 percent is unprofitable to harvest and from an economic standpoint would be viewed as unavailable.

Table 8.—Characteristics of "economically available" timber supplies under current market conditions, (diameter limit, reserve removed, slope ≥ 35 percent removed) all ownerships, Green and White Mountain National Forests

Resource characteristic	All ownerships	Green Mountain	White Mountain
Total volume (billion ft^3)	4.38	0.25	0.56
Net annual growth (million ft^3)	236.53	14.32	23.38
Avg. profit (dollars/ft^3)	0.56	0.74	0.66
Avg. stump-to-mill cost (dollars/ft^3)	0.45	0.49	0.44
Avg. sawtimber volume/acre (bf)	5764.51	5840.71	6146.24
Avg. growing-stock volume/acre (ft^3)	1412.29	1403.17	1529.36
Avg. haul distance—sawlogs (miles)	5.77	5.93	7.34
Avg. haul distance—pulpwood (miles)	12.59	27.64	7.69
Avg. sawlog diameter (inches)	14.10	14.42	13.71
Grade 1 sawlogs (percent)	34.4	29.6	50.1
Grade 2 sawlogs (percent)	27.6	28.7	16.3
Grade 3 sawlogs (percent)	38.0	41.7	33.6

Diameter-Limit Cut

Table 8 summarizes descriptive information about the timber supplies estimated to be economically available for diameter limit harvest in the market area under current market conditions. If the inventory were subjected to a diameter limit cut that would remove all sawtimber trees ≥ 12 inches d.b.h., the economically available volume would be about 4.4 billion ft^3 on 3.1 million acres. Under current market conditions, estimated annual demand (Table 2, midpoint) represents only 3.7 percent of the economically available timber supply from all ownerships in the market area (Table 8), and only 68.7 percent of net annual growth. The estimated economically available stock of timber in the market area could sustain current annual demand consumption for nearly 27 years.

Supply-Demand Segmented by Resource Quality

The timber resources within the Green and White Mountain National Forests' 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 Green and White Mountain National Forests' market area were segmented into three quality classes – high, average, and low, and compared to the trend for each quality segment to define how resource quality affects the current supply-demand situations.

Segmented Supply

To segment the resource, each inventory plot was assigned a quality code based on the species and tree-grade mix, and value per acre of the sawtimber on the plot. The decision rule used in assigning the plot quality code is shown in Table 9. High-value species included the timberland "select" hardwoods — select red oaks, ash, sugar maple, and yellow birch.

Once a plot was assigned a quality code, the entire sawtimber volume on that plot was assigned the same code regardless of the actual species or grade of individual sawlogs. On the basis of this segmentation, approximately 14 percent (3.9 billion ft^3) of the sawtimber inventory in the market area (all ownerships) was classified as on high-quality plots, 21 percent (5.9 billion ft^3) on average-quality plots, and 65 percent (18.1 billion ft^3) on low-quality plots. On the Green Mountain National Forest, the timber resource was skewed more to the low-quality segment, with 11.5 percent of the forest's sawtimber value on high-quality plots, 34.4 percent on average-quality plots, and 54.1 percent on low-quality plots. On the White Mountain National Forest, the timber resource was also skewed more to the low-quality segment, with 21.3 percent of the forest's sawtimber value in high-quality plots, 18.8 percent on average-quality plots, and 59.9 percent on low-quality plots.

The majority (57 percent) of the high-quality plots was on nonindustrial private forest land. National Forest lands accounted for about 26 percent of the high-quality plots, versus 17 percent for the forest industry, corporations,

Table 9.—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 more than 5,000 board feet/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 more than 2,000 board feet/acre.
Low	All other plots.

Table 10.—Criteria for segmenting primary processing mills, by resource use

Resource quality	Criteria
High	Hardwood/softwood sawmills producing more than 1 million board feet per year.
Average	Hardwood/softwood sawmills producing 50,000 to 999,999 board feet per year.
Low	Hardwood/softwood sawmills producing less than 50,000 board feet per year.

and other public timberlands. Figure 9 shows the general distribution of the high-quality plots as a percentage of timberland by county.

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 procures the highest quality timber it can afford because higher grade lumber is worth 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. 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 10).

On the basis of this segmentation strategy, at the midpoint of consumption, approximately 95 percent of the current sawtimber consumption in the market area is by 55 sawmills that demand high-quality timber resources. Consumption of about 4.5 percent is by the 76 sawmills demanding average-quality sawtimber; the remaining .50 percent is by 16 sawmills that process low-quality sawlogs. The 36 fiber mills in the market area consume

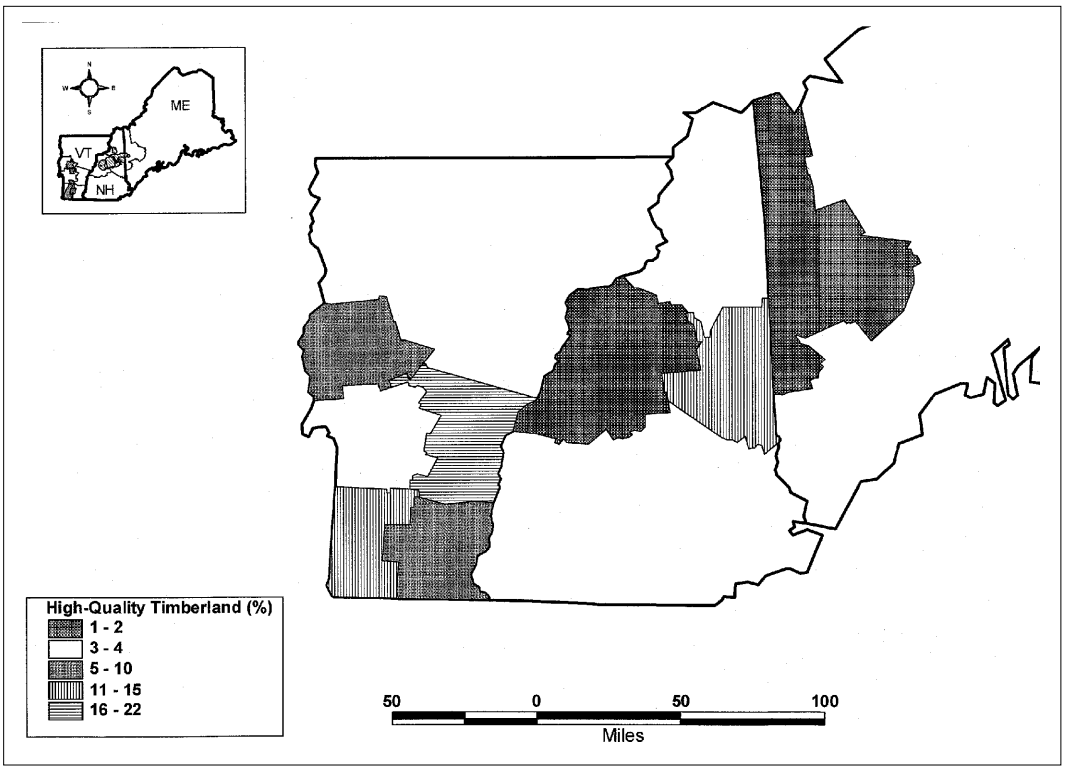

Figure 9.—Distribution of high-quality plots as a percentage of the timberland area, by county, Green and White Mountain National Forests' market area.

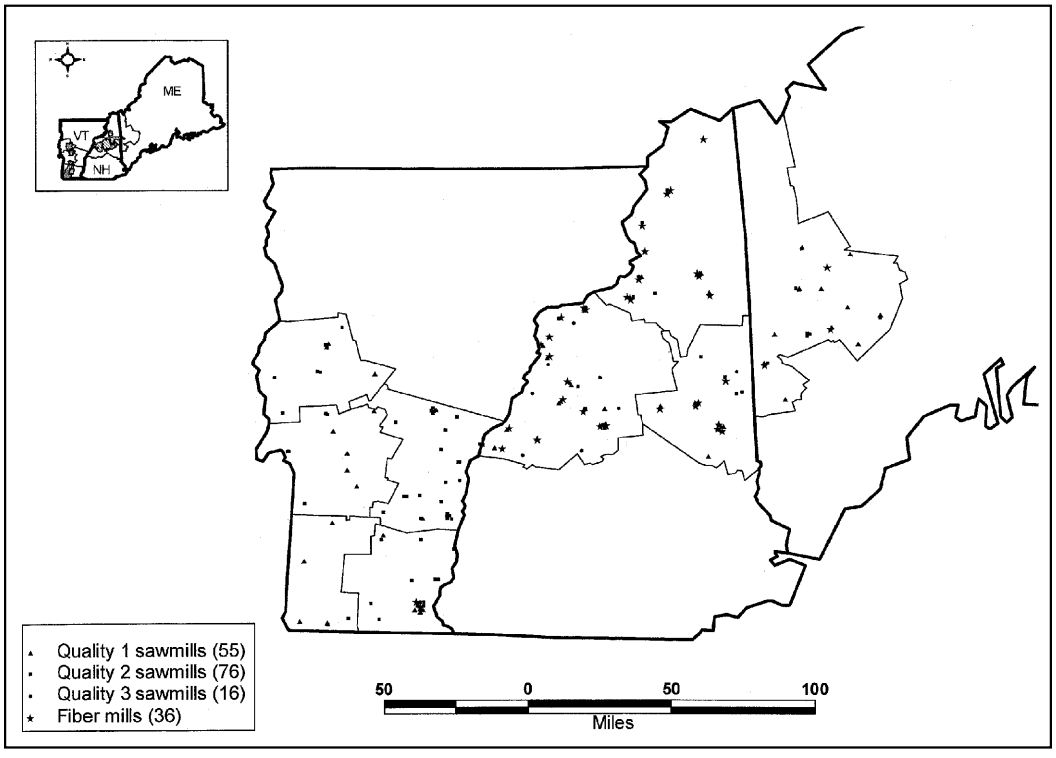

Figure 10.—Primary wood-processing mills segmented by resource quality, Green and White Mountain National Forests' market area.

Table 11.—Distribution of inventory and net growth by resource quality and current timber demand as a percentage of the "economically available" supply by resource quality, all ownerships

Roundwood consumption range	Demand/economically available inventory	Demand/net annual growth
High-quality sawlogs[a]	3317.21 million board feet	104.89 million board feet
Minimum (234.73)	7.1%	223.7%
Midpoint (400.43)	12.1%	381.8%
Maximum (566.13)	17.1%	539.7%
Average-quality sawlogs[a]	4918.83 million board feet	155.57 million board feet
Minimum (9.92)	0.20%	6.4%
Midpoint (20.53)	0.42%	13.2%
Maximum (31.15)	0.63%	20.0%
Low-quality sawlogs[a]	10685.82 million board feet	337.97 million board feet
Minimum (.10)	0.00%	0.03%
Midpoint (.19)	0.00%	0.05%
Maximum (.29)	0.01%	0.08%
Pulpwood[b]	3833.1 million ft^3	121.23 million ft^3
Minimum (28.55)	0.7%	23.5%
Midpoint (57.11)	1.5%	47.1%
Maximum (85.66)	2.2%	70.7%

[a]In million board feet/yr.
[b]In million ft^3/yr.

57.11 million ft^3 of roundwood per year. Figure 10 shows the distribution of these mills within the 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.

The volume of timber available at various revenue levels for each resource segment is shown in Figures 11-13 for the regeneration-cut scenario with the reserve and steep-terrain plots removed from the inventory. As expected, harvest economics has the greatest effect on the low-quality resource. Thirty-eight percent of the volume on the low-quality plots is unprofitable to harvest. For the average-quality plots, 2 percent of the volume is unprofitable; for high-quality plots, the entire inventory is profitable to harvest.

In Table 11, current annual timber consumption segmented by resource quality is contrasted with the economically available supply. The results indicate that 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 lower end, 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 resources 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.

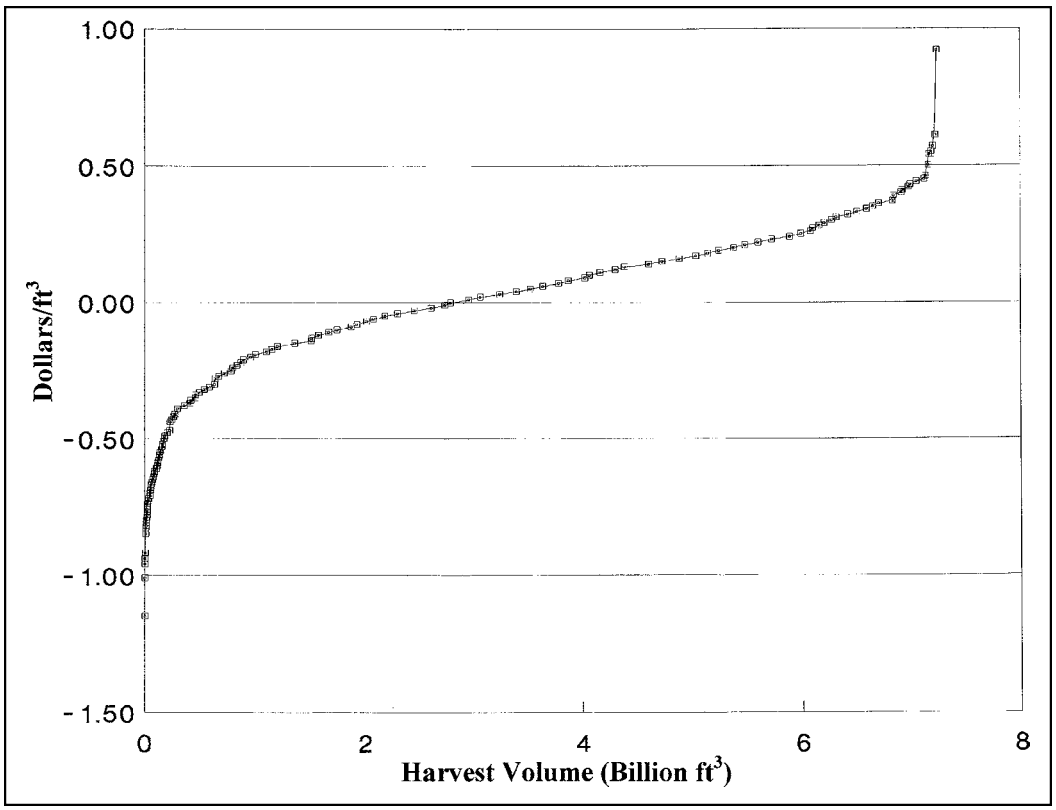

Figure 11.—Potential profit versus harvest volume for low-quality plots, Green and White Mountain National Forests' market area (reserve and steep-terrain plots removed).

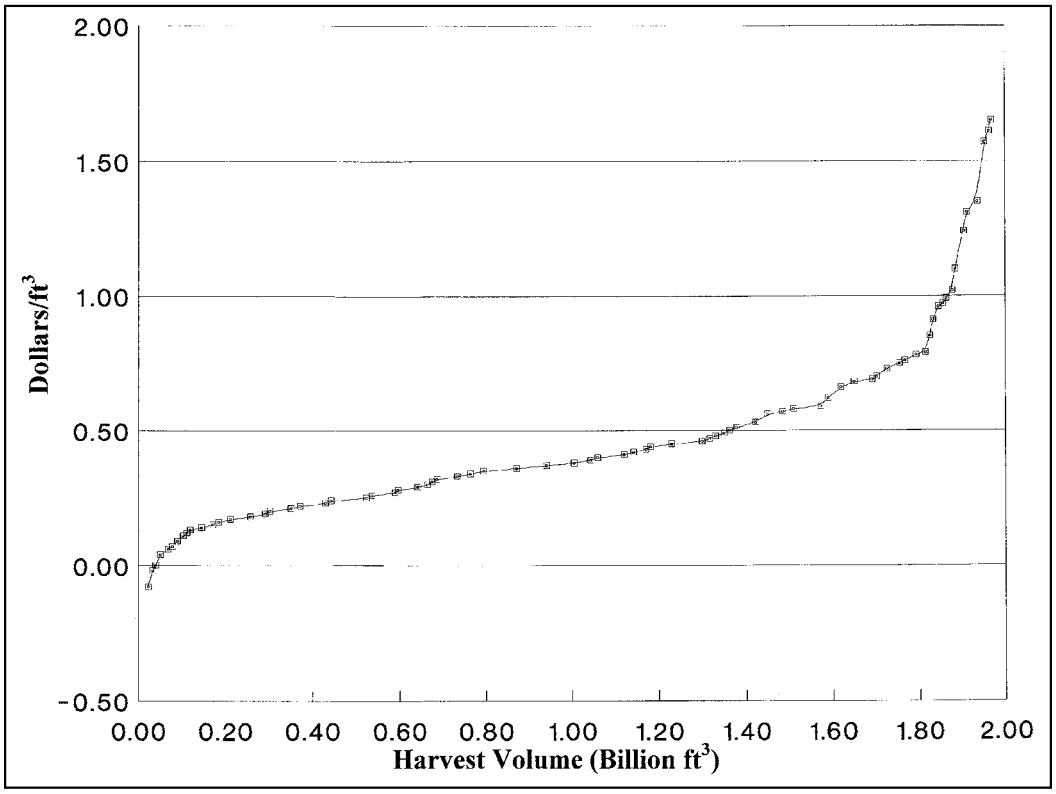

Figure 12.—Potential profit versus harvest volume for average-quality plots, Green and White Mountain National Forests' market area (reserve and steep-terrain plots removed).

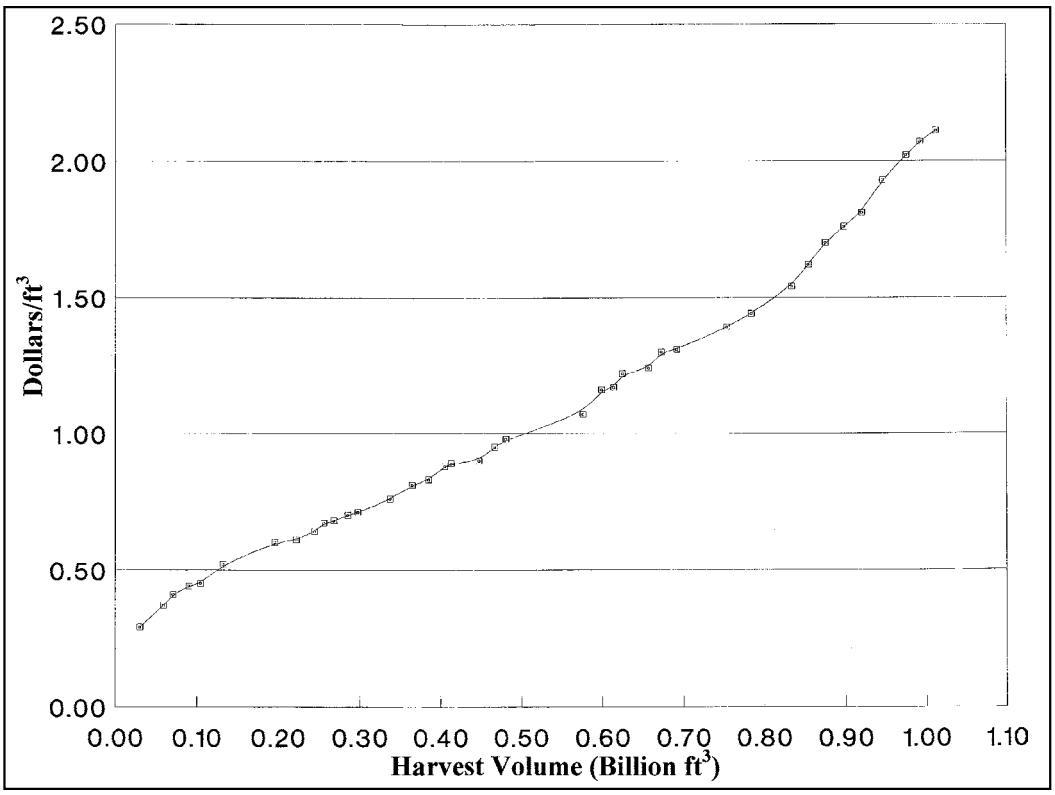

Figure 13.—Potential profit versus harvest volume for high-quality plots, Green and White Mountain National Forests' market area (reserve and steep-terrain plots removed).

Summary

The market area covers approximately 5.8 million acres, with about 95 percent of the land area (5.5 million acres) classified as timberland. Sixty-one percent of the timberland is in the NIPF ownership which includes individuals, farmers, and corporations other than forest industry. National Forest land accounts for 19 percent of the timberland area. The estimated total volume of live trees in the market area is approximately 11.8 billion ft^3. The total net annual growth of growing stock is about 373.11 million ft^3. The estimated total inventory of grade 3 or better sawtimber trees in the market area is 22.4 billion board feet.

There are 147 sawmills and 36 pulp- and fiber-producing mills within the market area. Combined, these mills consume 105.55 million ft^3 of sawtimber and 57.11 million ft^3 of pulpwood (at the midpoint of consumption). At current market prices and assuming a regeneration cut, about 87.5 percent (10.32 billion ft^3) of the timber inventory in the market area is economical to harvest. This economically available inventory stock of timber in the market area could sustain annual consumption for nearly 64 years.

Removing the economically available reserved timberlands from the economically available inventory reduces the land area by 3.9 percent or 168,263.3 acres. Most of the reserve timberlands were located on the Green and White Mountain National Forests with 82,313.3 and 151,710.3 acres, respectively. Eliminating the economically available reserve timberlands from the inventory reduces the economically available board feet volume by 2.9 percent to 25.21 billion board feet.

Eliminating steep slope lands ($\geq$ 35 percent) sideslope reduced the economically available timberland acreage by another 425,011.9 to 3,758,828.7 acres. The board-foot volume was reduced to 22.7 billion board feet. The impact of removing reserve and steep slope lands from the economically available inventory reduces the total acreage and board-foot volume by 31.7 and 19.0 percent, respectively. Reducing the total inventory for reserve and steep slope lands has a small impact on the availability and sustainability of the timber resources in the market area. Under these conditions, the market could sustain current annual consumption for nearly 55 years.

Under a simulated partial cut treatment where one-third of the volume per acre is removed equally across diameter

classes, the total economically available volume is 1.6 billion ft^3. Partial cutting removes less volume per acre, which means less value per acre resulting in fewer economically available resources.

If the inventory were subjected to a diameter limit cut that removed all sawtimber trees $\geq$ 12 inches d.b.h., the economically available volume would be about 4.4 billion ft^3 on 3.1 million acres. This inventory could sustain current annual demand consumption for nearly 27 years.

When the timber resources in the market area are segmented by quality, about 14 percent (3.9 billion ft^3) of the sawtimber inventory was classified as on high-quality plots, 21 percent (5.9 billion ft^3) on average-quality plots, and 65 percent (18.1 billion ft^3) on low-quality plots. Fifty-seven percent of the high-quality plots are on NIPF land. National Forest lands account for about 26 percent of the high-quality plots, while the forest industry, corporations, and other public timberland account for 17 percent of the high-quality plots.

When annual demand consumption was segmented by resource quality, about 95 percent of the current sawtimber consumption in the market is by 55 sawmills that demand high- quality resources. Seventy-six sawmills consume about 4.5 percent of the average-quality; the remaining .50 percent is by 16 sawmills that process low-quality logs. The 36 fiber mills consume 57.11 million ft^3 of roundwood per year.

The supply-demand comparison shows that harvest economics has the greatest effect on the low-quality resource. Thirty-eight percent of the volume in low-quality plots is unprofitable to harvest. For average-quality plots, 2 percent of the volume is unprofitable; the entire inventory of high-quality plots is profitable to harvest. As expected, the high-quality resource is under the greatest pressure.

It is important to note that a plot may be classified as high quality, but contain a mixture of high-, average-, and low-quality sawtimber. Thus, a "high-quality" sawmill would be using a range of sawlog material. Similarly, a low-quality plot also would contain both high- and average-quality sawtimber. Low-quality material is used for pulpwood, firewood, fuelwood, oriented strand board (OSB), and low-grade sawlogs. Average-quality material is used for props, rails, peelers, and medium- and low-grade sawlogs. High-quality material goes into peelers, sawlogs, and export veneer and sawlogs. In actual practice, the material end uses are not as distinct as defined previously. For example, material for OSB can be from the lower end of the medium-quality resource, peelers will be from the high end of the medium-quality resource and the low end of the high-quality resource, and single sawmills typically process logs from all resource qualities. Given these facts along with the economically available supply in the high-, average-, and low-quality sawlog portion of the inventory (Table 11), it appears that sawmills within the market area can be assured of sustainable supplies of wood for about 45 years. Pulp mills can be assured of sustainable supplies of fiber for about 67 years (Table 11).

The National Forests contribute significantly, representing 18.37 percent (14.82 percent for the WMNF, 3.6 percent for the GMNF) of the total economically available sawtimber inventory (reserve and steep terrain plots removed) in the market area. These forests contribute 16.43 percent of the pulpwood (13.57 percent for the WMNF, 2.8 percent for the GMNF). About 82 percent of the National Forests' timber inventory is economical to harvest under current market conditions.

Literature Cited

Hanks, L. F. 1976. **Hardwood tree grades for factory lumber.** Res. Pap. NE-333. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 81 p.

Hansen, Mark H.; Frieswyk, Thomas; Glover, Joseph F.; Kelley, John F. 1992. **The Eastwide Forest Inventory Data Base: users manual.** Gen. Tech. Rep. NC-151. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 48 p.

LeDoux, Chris B. 1985. **Stump-to-mill timber production cost equations for cable logging eastern hardwoods.** Res. Pap. NE-566. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

May, Dennis M.; LeDoux, Chris B. 1992. **Assessing timber availability in upland hardwood forests.** Southern Journal of Applied Forestry. 16(2): 82-88.

McWilliams, William H.; Rosson, James F., Jr. 1988. **Hardwood supply & availability in the Midsouth Highlands.** In: Availability of hardwoods in the Upland South. Coop. Ser. No. 7. Charlotte, NC: Hardwood Research Council: 47-95.

Sheffield, Raymond M.; Bechtold, William A. 1990. **Volume and availability of eastern hardwoods.** In: Proceedings, 18th annual hardwood symposium of the Hardwood Research Council; 1990 May 6-9; Cashiers, NC. Memphis, TN: Hardwood Research Council: 55-65.

Worthington, Virginia E.; LeDoux, Chris B.; McWilliams, William H.; Sloan, Hank; Jones, Toni. 1996. **Methodology for assessing current timber supplies and product demands**. Gen. Tech. Rep. NE-226. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 25 p.

LeDoux, Chris B.; Sendak, Paul E.; McWilliams, William H; Huyler, Neil; Malecek, Thomas; Muzzey, Worthen; Jones, Toni. 2001. **Timber supply and demand assessment of the Green and White Mountain National Forests' market area**. Gen. Tech. Rep. NE-280. Newtown Square, PA: Northeastern Research Station. 19 p.

This report describes a timber supply and demand assessment of the Green and White Mountain National Forests' market area using USDA Forest Service, Forest Inventory and Analysis data, production information provided by forest industry, and a stump-to-mill logging cost-prediction model. Nonavailable timberland that includes reserve and steep-terrain lands is analyzed, and the sustainability of regeneration, partial cut, and diameter-limit harvests is evaluated.

Keywords: Economics, sustainability, logging cost, sawmills, timber quality

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