New Hampshire's Vanishing Forests:

Conversion, Fragmentation and Parcelization of Forests in the Granite State

Report of the
New Hampshire
Forest Land Base Study

Sarah Thorne and Dan Sundquist
Society for the Protection of New Hampshire Forests
Concord, New Hampshire
April, 2001

Celebrating 100 Years

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Executive Summary

Forest conversion, parcelization and fragmentation have many ecological and social impacts. These include declining water quality, scenic and recreational degradation, and habitat loss and deterioration. The Society for the Protection of New Hampshire Forests has conducted the New Hampshire Forest Land Base Study to focus upon a specific set of forestry issues: the economic impacts of these land base changes on forest landowners, foresters, loggers and the forest products industry.

This analysis draws upon information from a variety of sources. Data were collected from surveys of five groups of key players in the forestry community. A geographic information systems analysis was conducted by SPNHF to study New Hampshire's changing forests. As explained in the report, extrapolations and projections have been founded on this information. Given these assumptions, the following conclusions can be drawn about the status and future of New Hampshire's forest land base:

- **The extent of New Hampshire's forests is shrinking.** From a high of 87% around 1980, the forest land base will decline to cover only 80% of the state by 2020.
- **New Hampshire loses about 13,000 acres of forest each year, about half the land area of an average sized town.** At this rate there will be about 3 acres of forest per resident by 2020, an all-time low.
- **Forest conversion is driven by population growth and the rising rate of land consumption per person.** By 2020 the state's population will rise to 1.6 million, adding the equivalent of Milford's population each year.
- **The impact of development on forestland is most pronounced in the southeastern counties, the Merrimack River Valley and the Lakes Region.** In the three most populous counties, 20% of the pre-colonial forests have been converted to developed uses.
- **An estimated 31% of the acreage being harvested in Rockingham and Strafford Counties is being "terminally harvested,"** that is, being harvested for the last time in preparation for development. A proportionately greater percentage of the forests of this region are being harvested. Approximately 1.8% of the region's forest land base is terminally harvested each year. At his rate, the forests in this region would be gone within 55 years.

- Statewide, about 10% of the harvested area, or and estimated .46% of the state's forested area, is being terminally harvested each year in preparation for development.
- New Hampshire is developing its more productive forests faster than its less productive forest land base. For example, excellent sites for growing pine have been lost at the highest rates — 42% of these pine lands have been converted to development and other non-forest uses.
- Forest fragmentation is most advanced where population and recreational development are greatest. Yet, New Hampshire is fortunate that most towns still have at least one large (500 acre) block of forestland. Only 16% of the forest land base is in blocks smaller than 500 acres. However, in towns that have been suburbanized, like Exeter, less than one third of the forest is in blocks over 1000 acres. In rural towns like Tamworth, two thirds of the forest land base is in blocks over 1000 acres.
- The average size of a parcel of private "commercial" forestland in the state has fallen from 114 acres in 1960 to 37 acres in 1997. The average parcel size for the 97% of the forest land base that is in parcels of more than ten acres is 76 acres. Once a town hits a population density of 130 persons per square mile, it is extremely rare for it to have any parcels over 500 acres, unless that land has already been protected from subdivision and development. The suburban town of Exeter has two thirds of its land base in parcels under 50 acres in size while rural Tamworth has two thirds of its land base in parcels over 50 acres. However, in high population towns, when population is more concentrated in villages or other growth areas, more forest cover and larger parcel sizes can be retained.
- New Hampshire forestland owners surveyed say they own their land primarily for aesthetic and recreational enjoyment, with timber harvesting being a secondary goal. In the north, tenure and parcel sizes are greater and owners are more inclined to put priority on income generation from their forests. Northern owners are more likely to predict that their land will remain forested and will be harvested again. In the south, development and rising land values push these landowner attitudes in the opposite direction.
- Declining parcel size impairs the profitability of forest management. Most forestland investors seek parcels of at least 500 acres in size for long-term, economic management. Foresters and loggers feel that it is not economic for landowners to hire professional foresters if they hold less than 10 to 20 acres.
- Owners of larger parcels experience significant economies of scale when they harvest. Unit stumpage prices reported by foresters rise 12% for a hypothetical white pine harvest and 27% for a northern hardwood harvest as parcel size rises from the 11to 50 acre size class to the 201 to 500 acre size class. Unit operating costs for 10-acre versus 50-acre parcels are 74% higher for roads and landings, 80% higher for equipment moving, and 62% higher for landowner communications, according to loggers.
- As forestland in a region is converted, local mills must reach farther and farther for their wood supplies, reducing profitability. Trucking costs increase, up to 100%, as distance to the mill increases from 10 to 100 miles. The average buying radius for the shrinking pool of New Hampshire mills is 63 miles.
- Owners of larger parcels are more likely to employ foresters and have written management plans. They also express the objective of improving the future quality of

their forest as a reason for their harvest more often than smaller owners. Land clearance cuts (not the same as clear cuts) are seldom used for parcels above 25 acres but are used 18% of the time for parcels under 25 acres. This high level of terminal harvesting may obscure the prevalence of better quality management methods on the part of the small owners who are not converting. The highest incidence of diameter limit cutting is in the 101–250 acre size class, a cause for concern because this is a significant proportion of the forest land base and this size class may be most affordable (on a per acre basis) for liquidators to purchase and subdivide.

- Approximately one quarter of the forest land base, or 1.2 million acres, is permanently protected from development and subdivision. Productive soils are proportionately less protected than the mountainous, shallow, wet or bouldery forest soils. On the other hand, large blocks of forestland have been fairly successfully protected, predominantly by the White Mountain National Forest. Fifty-six percent of the forest area in blocks over 25,000 acres has been protected. Yet, many opportunities for protecting large blocks remain. Forestland protection in the southeast will require urgent action if parcels of sufficient productivity and size are to be secured for economic forest management.
- The state's forestlands are vanishing, palpably in some areas and almost imperceptibly in others. At the same time, the extent of forestland available for forest management is declining at an even faster rate. Lands unavailable for forestry comprise at least 26% of the forestland base. They include: steep, wet and high elevation lands, wilderness areas, ecologically sensitive areas, and parcels under ten acres. Within 20 years, it is estimated that less than 3.4 million acres will be available for economically and ecologically sound forest management.

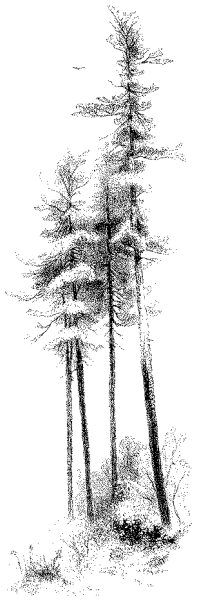
What does New Hampshire's forest sustainability report card look like? Clearly, the forest land base is not being sustained. The economically viable forest land base is being extinguished town by town. Overall forest volume is being sustained because the forest is maturing. However, in the north and for certain species, unsustainable harvest rates are consuming the supply. Although statewide the net growth to harvest ratio is 1.3 to 1, heavy cutting near the Maine border and of spruce and fir in the north warrant careful monitoring. The unsustainable harvesting now prevalent in certain regions could easily expand across the state.

Currently, New Hampshire is a net producer and exporter of forest products. We process and manufacture more than we consume. Currently we harvest approximately 1.5 times as much as we consume. Within 50 years, as population grows and the available land base shrinks, New Hampshire is likely to lose this distinction and become a net importer of forest products.

New Hampshire is fortunate in that there is still time to moderate these trends. Recommended actions include:

- improved research and monitoring of land base and harvesting trends,
- developing a ten year forestland protection plan to guide public and private investment in land conservation,
- refine the role for managed forestland within the Ecological Reserve System,
- create management and marketing strategies to improve economies of scale, and
- on the municipal level, master plan for forestry, designate forest conservation zoning districts and require the use of innovative zoning techniques to conserve important forestland.

Introduction



New Hampshire is endowed with a mantle of productive soil and a temperate climate that together hold great promise for growing forests. Many centuries of dynamic human settlement have left us with a forest, still resilient, covering 84% of the state's land area. Our inventories of growing stock and sawtimber have been swelling for several decades. Most of our wildlife populations have recovered from steep declines and extirpation of the last century. Scars from the rampant forest destruction of one hundred years ago have healed. Is there cause for concern in this second most forested state in the nation?

Yes. As this study documents, New Hampshire's forest land base is undergoing radical conversion, fragmentation and parcelization at a rate that will irrevocably change our state within a single human lifetime.

- What are the dimensions of this change?
- What are the causes?
- How are forests in different parts of the state being affected?
- What are the impacts of conversion, fragmentation and parcelization on the economics of forest management?
- How does the conversion of forestland to development affect the forestry community?

To help answer these questions, the *New Hampshire Forest Land Base Study* was undertaken by the Society for the Protection of New Hampshire Forests (SPNHF) on behalf of the New Hampshire Division of Forests and Lands. This research was carried out between 1999 and 2001. The study has several dimensions that have been integrated and presented in this final report. Five different mail surveys were conducted to gather information about forest conversion, parcel size, economics, and forest management. Complete results of these surveys are available in separate publications. An extensive analysis of these forest land base trends was conducted using SPNHF's geographic information system (GIS).

Forest conversion is defined as the turnover of forestland to other long-term uses such as roads, development and agriculture. *Forest fragmentation* is the division of blocks of contiguous of forest into smaller blocks by non-forest uses. *Forest parcelization* is the division of forest blocks into units of ownership through subdivision. Definitions used in this study are designed to identify conditions relevant to forestry and may differ from definitions of forest fragmentation used purely for wildlife ecology purposes.

Forest conversion, parcelization and fragmentation have many ecological and social impacts. These consequences include declining water quality, scenic and recreational degradation, habitat loss and deterioration, destruction of wilderness values, and loss of the productive forestland base. There are significant economic impacts from these land base changes on forest landowners, foresters, loggers and the forest products industry. The decisions made by these participants in the forestry economy have enormous repercussions for the other values and functions of the forest.

The report will examine the productivity of the forest land base, its availability for sound forest management, and its degree of protection from development. In addition, the analysis documents the extent of conversion, parcelization and fragmentation and makes projections for the future. The report also examines the impacts of these changes in the land base on the economics, quality and volume of harvests. Recent ownership data and trends will also be considered.

Why Does Forestry Matter?

As this report demonstrates, forestland conversion, fragmentation and parcelization hurt the profitability and sustainability of forest management. Why does this matter?

- Forestry contributes $3.9 billion in annual direct and indirect income to our economy, contributing 12% of the gross state product.[1]
- Forests provide thousands of jobs based upon a renewable resource.
- Landowners who are able to earn a good return from *retaining* their forests are less likely to sell them for development.
- Economically and ecologically sound forestry can help secure the forest land base for many of the other values for which our forests are cherished.

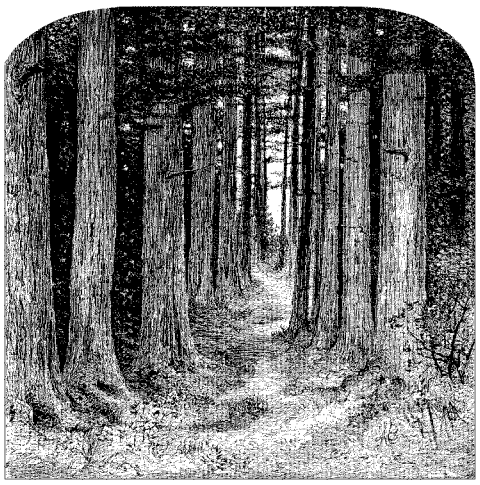
The extent of forest conversion, fragmentation and parcelization have already undermined many of the values of the forest in the Merrimack Valley, Seacoast, and rapidly growing tourist areas of the state in the Lakes Region and around the White Mountains. Here, the forest cover has dropped below 60% for at least 17 municipalities.[2] In these towns, only remnants of the forest remain. If this trend is to be forestalled in other areas of the state, a rapid and targeted response will be needed in addition to the many fine existing initiatives to conserve our forests. Recommendations for possible responses are contained in the final section of this report. Findings from this study can be used by municipalities, land conservation organizations and state and federal policy makers to evaluate options and take action.

New Hampshire's land base has been supporting the dynamic evolution of forests, wildlife and human communities for 12,000 years. In just one human lifetime this living forest ecosystem could be lost from the fabric of life for most of our residents.

[1] Resource Systems Group, 1999.

[2] Sundquist, 1999.

Background



Policy Framework

Several recent forest policy task forces have identified forest conversion to development and forest fragmentation as significant problems.

In 1990, the Northern Forest Lands Council was established in response to the sale of about one million acres in northern New England and New York. In 1994, the Council issued its recommendations, which included:

- Acquiring lands for public ownership based on clear public priorities, demonstrated need and fairness to landowners, and
- Recognizing that for the very long term, the use of conservation easements to protect lands from development will be needed to ensure sustainability of the forest resource in areas with significant development pressures.[3]

Under their principles of sustainability, the Council listed a "continuous flow of timber, pulpwood and other forest products," but did not set any goals for the retention of the forest land base to maintain that flow.

In the 1996 *New Hampshire Forest Resources Plan*, four of the eleven actions recommended relate to forest land base retention:

- "Encourage the maintenance of large contiguous parcels of forest lands in private ownership.
- Encourage careful siting of development to maintain ecologically significant land and large contiguous blocks of managed forest by providing communities with information and tools to assist them in making long range land use decisions.
- Support the Ecological Reserve System Steering Committee process to design a science-based system of ecological reserves as one approach to maintain and enhance New Hampshire's biological diversity.

[3] *Finding Common Ground*, 1994.

- Initiate a goal-oriented, public planning process to develop a state acquisition program for land and easements that builds upon the successful model of Land Conservation Investment Program and Trust for New Hampshire Lands."[4]

More recently, the Governor's Advisory Committee on Growth Management has recommended that state and local land use planning be overhauled to address the long-term, incremental, cumulative impacts of growth and development.[5] Their report noted that few communities are able to implement their master plan goals through their zoning ordinances and, in fact, most zoning ordinances promote the opposite—fragmentation and consumption of natural lands.

Forest Values

New Hampshire's forests provide many direct and indirect benefits to our state. Among these are:

- Forest products such as lumber and paper to meet consumer needs.
- Forest-based manufacturing, which contributes 8% of the statewide value for manufacturing and employs 9400 people.[6]
- A renewable, locally controlled source of energy, supplying about 6% of the state's electrical and heating energy.[7]
- Plant and animal habitat. New Hampshire is home to 1606 vascular plants, 34 of which are at risk globally, and 434 vertebrate animals, 8 of which are at risk globally.[8] Most of these species depend upon healthy forest habitat for at least part of their life cycle.
- Clean water for human consumption and aquatic ecosystem function. About 10% of the forest land base plays a vital role in supplying clean water for our public drinking supplies and thousands of private wells also benefit from the retention of forest cover. Forests also attenuate flood waters and moderate stream flow throughout the year, a service that otherwise requires costly engineering.
- Clean air. The forest filters out pollutants and moderates air temperature for shaded buildings and streets, improving health, energy conservation, and comfort.
- Carbon storage. Forest biomass and forest soils can play a significant role in carbon storage, particularly when wood products have a long lifespan and are substituted for other carbon-based, energy-intensive products such as steel and plastic. Conversion of forests to development releases significant amounts of carbon into the atmosphere. Strategies to increase carbon storage and reduce emissions based upon U.S. wood use, forest management, forest retention and replanting could equal between 20 and 40% of the carbon being emitted annually in the United States.[9]

[4] New Hampshire Forest Resources Plan, 1996.

[5] Managing Growth in New Hampshire, Changes and Challenges, New Hampshire Office of State Planning, Concord, December, 2000.

[6] "The Economic Importance of New Hampshire's Forests," North East State Foresters Association, March 2001.

[7] Ibid.

[8] Stein, Bruce A., ed., 2000.

[9] Sampson, R. Neil, 1996.

FIGURE1. SUMMARY OF ECONOMIC IMPACTS RELATED TO OPEN SPACE ACTIVITIES IN NH, 1996/7.[10]

Sector	% Attributed to Open Space	Direct and Indirect Income	State and Local Tax Revenues
Agriculture	56%	$376,915,800	$30,907,096
Forestry	100%	$3,921,182,894	$325,300,797
Tourism & Recreation	54%	$1,732,261,600	$249,417,502
Vacation Homes	100%	$816,983,565	$285,855,786
Total	69%	$8,182,234,524	$891,481,182

- Recreation, health and aesthetic enjoyment. Our forests provide scenery, exercise, and emotional and spiritual renewal for visitors and residents. They are part of the quality of life that New Hampshire residents value.
- Economic value. All of these products of the forest contribute economic value to the state, through personal income, real estate values, or tax revenue. The overall annual contribution of open space related activities in New Hampshire was $8.2 billion in 1996/7.[11] This comprised about 25% of the state's gross state product. On their own, forestry related activities contributed $3.9 billion. Much of the tourism, recreation and second home activity, is also forest-based (see Figure 1 above).

The future of all of these forest values will be affected by the land use changes being etched in the forest land base of New Hampshire. The health of the forest economy and the quality of management as they are affected by changes in the land base are the focus of the remainder of this report.

METHODS

The New Hampshire Forest Land Base (FLB) Survey consists of five different mail surveys. These surveys were designed to gather information about the extent and impacts of land conservation, fragmentation, and parcelization on forest management.

The following populations were surveyed:

1. Forestland investors, those who own multiple tracts of forestland in New Hampshire and other northeastern states primarily for the purpose of generating income from timber management over the long-term,
2. Field foresters licensed by the State of New Hampshire,
3. Loggers who are members of the New Hampshire Timber Harvesting Council and operate in New Hampshire,
4. NH Forest products industries that process raw wood from New Hampshire, and
5. NH Forestland owners who have conducted recent harvests.

[10] Resource Systems Group, 1999.
[11] Ibid.

FIGURE 2. SURVEY RESPONSE RATES

Group	Number Delivered	Number Returned	Response Rate %
Forest Investors	12	7	58
Foresters	250	75	30
Loggers	535	107	20
Forest Industry	84	50	59
Forestland Owners	1888	616	33

All data collected in the first four surveys were for calendar year 1999. Data for the last survey was for the April 1, 1998 through March 31, 1999 tax year. Data reported are not empirically documented. Respondents were asked for their best estimates.

The University of New Hampshire Survey Center advised on survey design and mailing procedures. The Survey Center tabulated the surveys and produced the tables and graphs used in this report that show the survey results. Full survey results are available in separate reports.[12]

The first four surveys were mailed out on March 8, 2000. The survey of landowners conducting recent harvests was sent out on November 16, 2000 to a random sample of 2000 landowners. The mailing list was drawn from those filing "Intent-to-Cut" forms with the New Hampshire Department of Revenue Administration. Copies of each survey are found in Appendix A. A map showing the locations of municipalities and counties used in this analysis is in Appendix B.

Numbers of surveys delivered to respondents (i.e. not returned as undeliverable) and response rates are shown in Figure 2. Results from each of the surveys are described in the following sections of this report.

[12] Thorne, Sarah, "New Hampshire Forest Land Base Survey," Society for the Protection of NH Forests, October 11, 2000; "New Hampshire Forest Land Base Survey, 2000," University of New Hampshire Survey Center, Durham, NH, August 2000; and "New Hampshire Recent Forest Harvest Survey," Survey Center, University of New Hampshire, 2001.

Forestland Conversion

When New Hampshire was first settled by the Europeans, it is estimated that expansive forests covered about 95% of the land area. Figure 3 depicts the dramatic change in forest cover over the last two and a half centuries.[13] By 1983 the state's forests had come nearly full circle and covered 87% of the state's land.

Although humans have wrought tremendous change to New Hampshire's forests during this period, the first cycle of forestland conversion was reversible. Most of the nineteenth century farmland had reverted back to forest by the end of the 20th century. The new cycle of forestland conversion, showing a net decline in the forest land base beginning in the 1980s, is likely *irreversible*. Forestland is now being converted almost entirely to roads and development rather than to agriculture. By 1997, the state's forest cover had declined to 84%.[14] Predictive modeling suggests that, in response to the development pressures of population growth, the extent of our forests will decline by 144,000 acres to 80% cover by 2020.[15]

New Hampshire's Forest in Context

Worldwide, forested area per capita has fallen by over 50% between 1960 and 1995 to .6 hectares (or 1.5 acres) of forestland per person. Because the United Nations' definition of forest is land with 10% canopy cover, this is an optimistic view of global forest per capita. Through continued deforestation and population growth, forest cover is projected to drop to .4 hectares (1 acre) per person by 2025.[16] Figure 4 puts New Hampshire's forest cover per capita into context with the rest of the world.

North America is well endowed with forests (13.2 % of the world's forests) and a comparatively low density population. However, in the United States as well as most of the rest of the

[13] Sundquist, 1999; forest cover as estimated by Henry Baldwin and Dr. John Litvaitis

[14] Frieswyk, 2000.

[15] Sundquist, 1999.

[16] Gardner-Outlaw, Tom and Robert Engelman. "Forest Futures," Population Action International, 1999.

FIGURE 3. ESTIMATED CHANGE IN FOREST AREA AND POPULATION GROWTH IN NEW HAMPSHIRE 1750 TO 2025

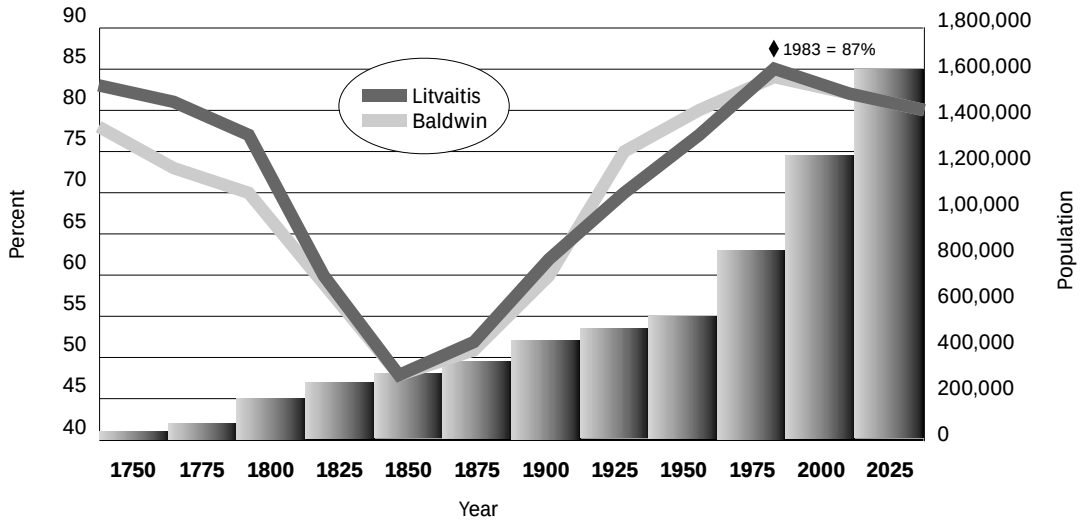


FIGURE 4. FORESTED AREA PER CAPITA

Region	Forest/capita
Global, 2000 (FAO)	0.6 ha (1.5 acres)
Global, 2025 projected	0.4 ha (1 acre)
US, 1995	0.8 ha (2 acres)
South Asia, 1995	0.08 ha (.2 acres)
Canada, 1995	8.26 ha (20.4 acres)
New Hampshire, 1997 (FIA)	1.6 ha (4 acres)
New Hampshire, 2020 projected	1.2 ha (3 acres)

FIGURE 5. PERCENT FOREST COVER IN NORTHEASTERN STATES[18]

State	% Forest Cover	Date
Maine	90	1995
New Hampshire	84	1997
Vermont	78	1997
Massachusetts	64	1985
New York	62	1993
Rhode Island	60	1985
Pennsylvania	59	1989
Connecticut	59	1985
New Jersey	42	1987

world, forestland is being rapidly converted to development. Recent Forest Service projections, anticipate that the United States' net forested acreage will decline by 3.1% between 1997 and 2050. Over the next 50 years, 15–20 million acres of the nation's forest land base will be urbanized.[17]

Figure 5 at left compares New Hampshire's current forest cover to that of selected northeastern states as reported by the most recent U.S. Department of Agriculture (USDA) Forest Service Forest Inventory and Analysis (FIA) data.

[17] Alig, 2000.

[18] USDA Forest Service website, 2001.

New Hampshire's Forest Cover

Forests currently cover 4,823,800 acres in New Hampshire. Although New Hampshire is the second most forested state in the nation, the state's forested area is declining steadily. The USDA Forest Service has conducted inventories of forested acreage in New Hampshire since 1948 (see Figure 6).

Figure 6. Percent N.H. Forest Cover 1948–1997 (extracted from FIA data[19])

Inventory Date	% of State Covered by Forest
1948	81
1960	85
1973	85
1983	87
1997	84

Between the 1983 and 1997 inventories, there was a net decrease of 134,500 acres of forestland or 0.2% (9607 acres) per year. Projected to 2020, the state's forest cover would be 79%, very similar to the projection of 80% referenced above. At the 1983-1997 rate of forestland decline, most of the state's unprotected 3.6 million-acre forest land base would be converted within 350 years. This is not a prediction, just a scenario based on current trends. For some of the state's southern towns, nearly complete conversion is already reality. In some northern towns, the more remote and difficult terrain may never be converted.

The decline in privately owned forestland capable of producing a commercial crop is even greater than the overall rate of forestland decline. Between 1983 and 1997, 290,700 acres of "timberland"[20] were lost, or an average of 20,764 acres per year. This represents 5.8% of the 1983 forest land base at an average decline of .42% per year. If this rate were to continue, the "commercial" forest land base would be gone in about 166 years, considerably faster than the total forest land base.

Another inventory of forestland conversion is conducted by the USDA National Resource Inventory. Between 1982 and 1997, they reported that New Hampshire's forested area declined by 4.7%, for an average loss of 13,066 acres per year. (This is about 30% higher than the rate of loss documented by the FIA.) During this same period, developed land increased by 55%. Development accounted for most of the loss of the forest land base.[21]

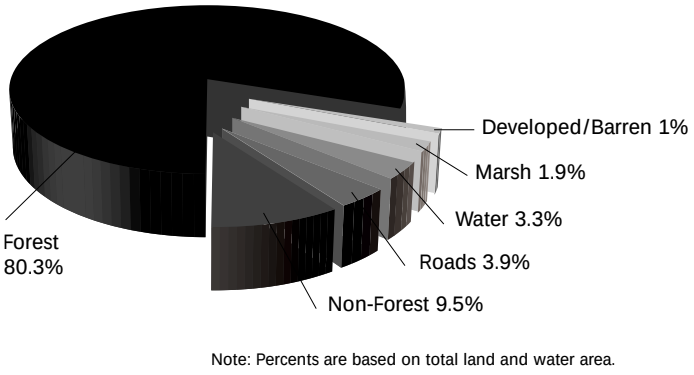
Figure 7 shows the current distribution of land cover types in New Hampshire, based upon 1992/93 satellite imagery. The *developed land* cover type includes barren areas such as gravel pits and rock outcrops as well as urbanized land covers such as pavement and buildings. The *roads* cover class is defined as a separate land cover feature because they are derived from another GIS datalayer rather than satellite imagery; this was done to identify travelled roadways that fragment forest blocks. The *non-forest land* cover type includes agricultural lands (croplands, hay fields, pastures, etc.), old fields regenerating into shrubs and tree saplings, golf courses, and larger lawn areas such as recreation fields. In southeastern New Hampshire, the non-forest cover class tends to be more associated with suburban land uses; elsewhere in the state, it trends toward rural open spaces, as with agricultural uses and old fields.

[19] Frieswyk, 2000.

[20] "Forest land producing or capable of producing crops of industrial wood (more than 20 cubic feet per acre per year) and not withdrawn from timber utilization." Frieswyk, 2000.

[21] 1997 Natural Resource Inventory, Summary Report, United States Department of Agriculture, revised December, 2000.

FIGURE 7. NEW HAMPSHIRE'S LAND COVER



Note: Percents are based on total land and water areas.
Source: 1992/93 Landsat TM imagery and mapping by UVM/Spatial Analysis Laboratory.

It is important to note that the satellite imagery used to create the land cover map does not typically "see" the presence of houses built under tree canopy. Development along road frontage that is largely forested will not be mapped as non-forest unless a sizeable opening exists. Therefore it is reasonable to assume that forest margins along most roads may include single family residences and other buildings.

DEVELOPMENT PRESSURES

The development that is consuming the state's forest land base is, in part, due to population growth. The state's population has doubled since 1950 and is projected to rise to nearly 1.6 million by 2020.[22] Although the rate of increase is projected to decline, it is expected that a net gain of at least enough people to populate a town the size of Milford will settle in New Hampshire each year from now until 2020.

Most of the population growth is occurring in the southern part of the state and this is where the forest impacts are most severe. Figure 8 shows population increases and projections by the Office of State Planning. Figure 9 depicts the geographic distribution of population in New Hampshire, with projections to 2020. Most of the growth, about 85%, will continue to occur in the southern and central portions of the state. However, new settlement will advance north and westward into more rural and forested areas.

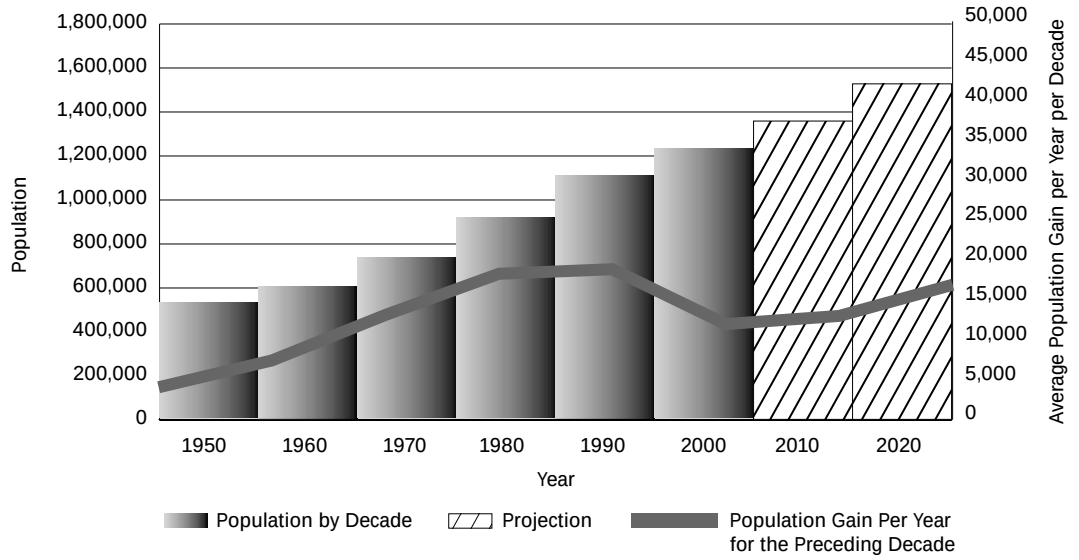
In New Hampshire, housing construction has outpaced population growth. Figure 10 showing new housing construction also reflects the impact of vacation and second home development on the forest not represented in resident population figures. Construction activity in the Lakes Region and towns around the White Mountain National Forest is notable, in addition to construction in the seacoast and Merrimack Valley. Much of the state's new construction will occur in rural areas — in other words, in areas that are now forested.

As important but less evident is that the rate of land development per person has been rising. Between 1987 and 1992, the nation developed 8/10ths of an acre for every net new person. Between 1992 and 1997, that figure rose to 1.7 acres per person.[23] The 1997 American

[22] NH Office of State Planning, NH Population Projections 2000–2020,1998.

[23] Sampson, Neil, "Implications for Sustainable Private Forests," Yale Forest Forum, vol.3 no.6, 2000, based on NRI data.

FIGURE 8. N.H. POPULATION CHANGE AND RATE OF CHANGE 1950 TO 2020



Source: N.H. Office of State Planning

Housing Survey indicates that during the 1950s, the average single family home lot covered 1.05 acres. By 1997 the average lot size had risen to 1.82 acres.[24] At the same time, the average number of people per household is falling, from 3.14 people in 1970 to 2.63 in 1990.[25]

According to a national study of sprawl, increases in developed area per capita accounts for about half of the land consumed by sprawl each year. Population growth accounts for the other half of the land base that is developed each year nationwide. The study also sites a U.S. Department of Housing and Urban Development report using 1994–1997 data that drew the same conclusion: overall, urban areas were expanding at about twice the rate of population. Per capita land consumption is even more significant in the Boston urbanized area (US Census data), which grew 34.1% in area between 1970 and 1990. Although the greater Boston population grew only 4.6% during this period, per capita land use grew 28.2%.[26]

New Hampshire's Changing Landscapes used population projections and existing forest cover and population density relationships to project forest decline for 2020. A map showing municipal losses is shown in Figure 11. Many towns may lose over 10% of their forests in just the next two decades. This projection assumes that land consumption per capita will remain constant. As can be seen from the example of the Boston area above, that probably will not be the case. Therefore, these projections of forest loss are *conservative* and may depend upon curtailing the rise in per capita road width, house lot size, retail space, parking areas, and so on.

The amount of forestland that has already been converted to development and other uses can be estimated. By overlaying satellite-derived land cover types with digital USDA Natural

[24] Peterson, Tom, USEPA, "What's Happening to the Land," Fragmentation 2000 Conference, Annapolis, MD, September 17–20, 2000.

[25] Alig, op.cit.

[26] Kolankiewicz and Roy Beck, "Weighing Sprawl Factors in Large U.S. Cities," Numbers USA.com, 2001.

Figure 9

Change in N.H. Population Density 2000 to 2020 (Projected)

Persons/Square Mile
- 0
- 1- 10
- 10 - 50
- 50 - 100
- 100 - 250
- 250 - 500
- 500 - 1000
- >1000

New Hampshire's Vanishing Forests

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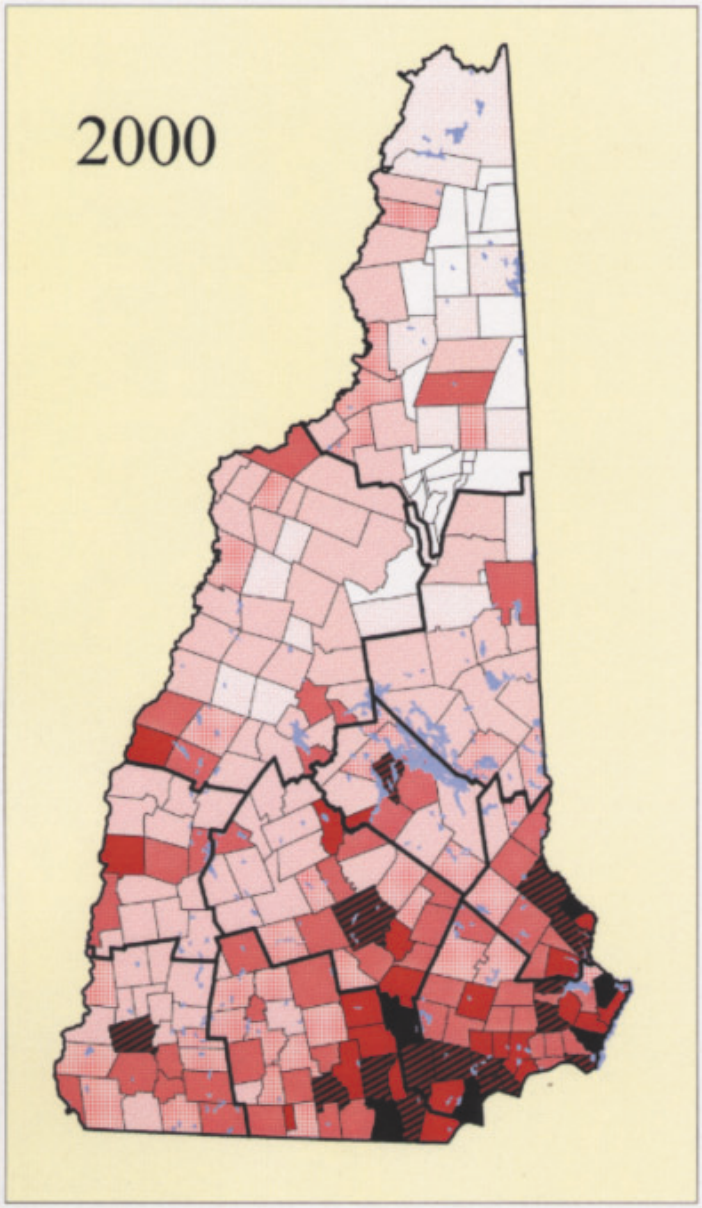
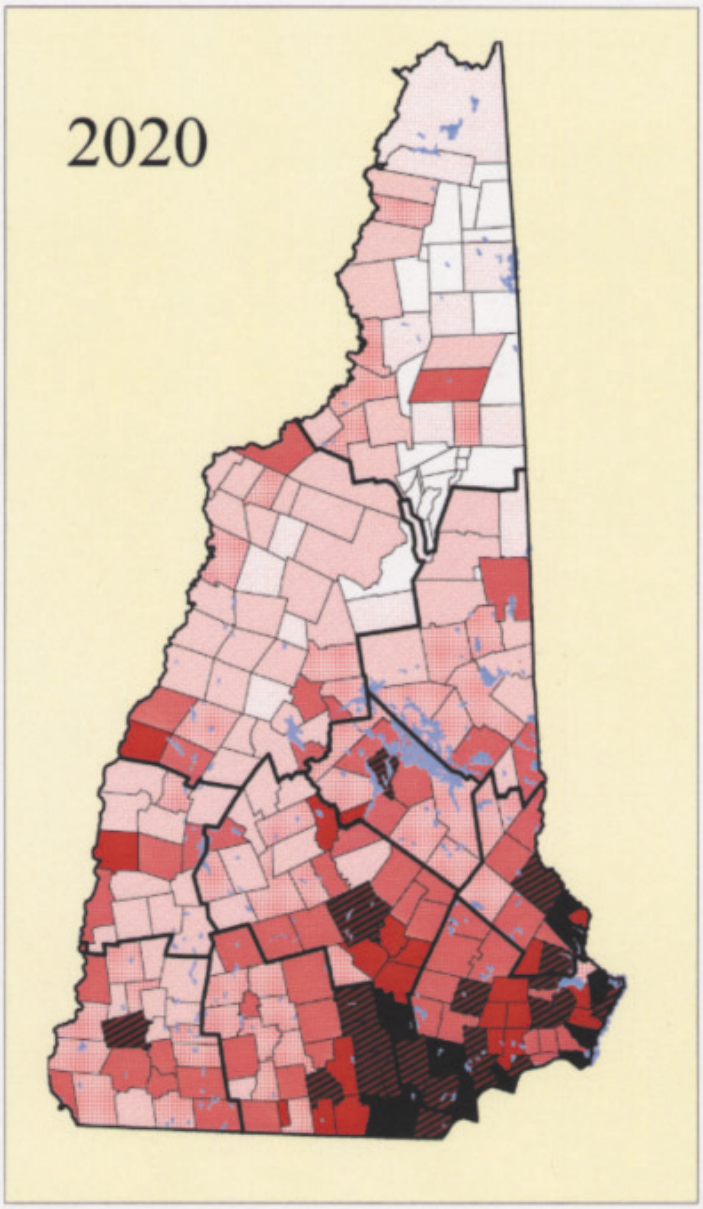
for the Division of Forests & Lands,
N.H. Dept. of Economic Resources & Development





0 20 Miles

Data Sources:

Hydrological information and political boundaries are derived from U.S. Geological Survey digital line graphs, 1:24,000 to 1:25,000 as archived in the N.H. GRANIT database.

Population data are derived from U.S. Census Bureau population estimates, updated through 1998, and population projections for cities and towns for 2000 to 2020 published by the N.H. Office of State Planning, 1999.

Funding for this project provided in part by the USDA Rural Development Through Forestry Program.

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Figure 10

New Housing Construction 1990 - 1999

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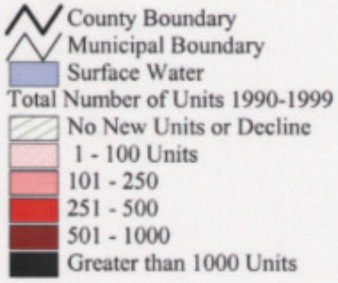
N.H. Dept. of Economic Resources & Development



Data Sources:

Hydrological information and political boundaries are derived from U.S. Geological Survey digital line graphs, 1:24,000 to 1:25,000 as archived in the N.H. GRANIT database.

Housing data are derived from Current Estimates and Trends in N.H.'s Housing Supply, updated through 1999 published by the N.H. Office of State Planning November, 2000.

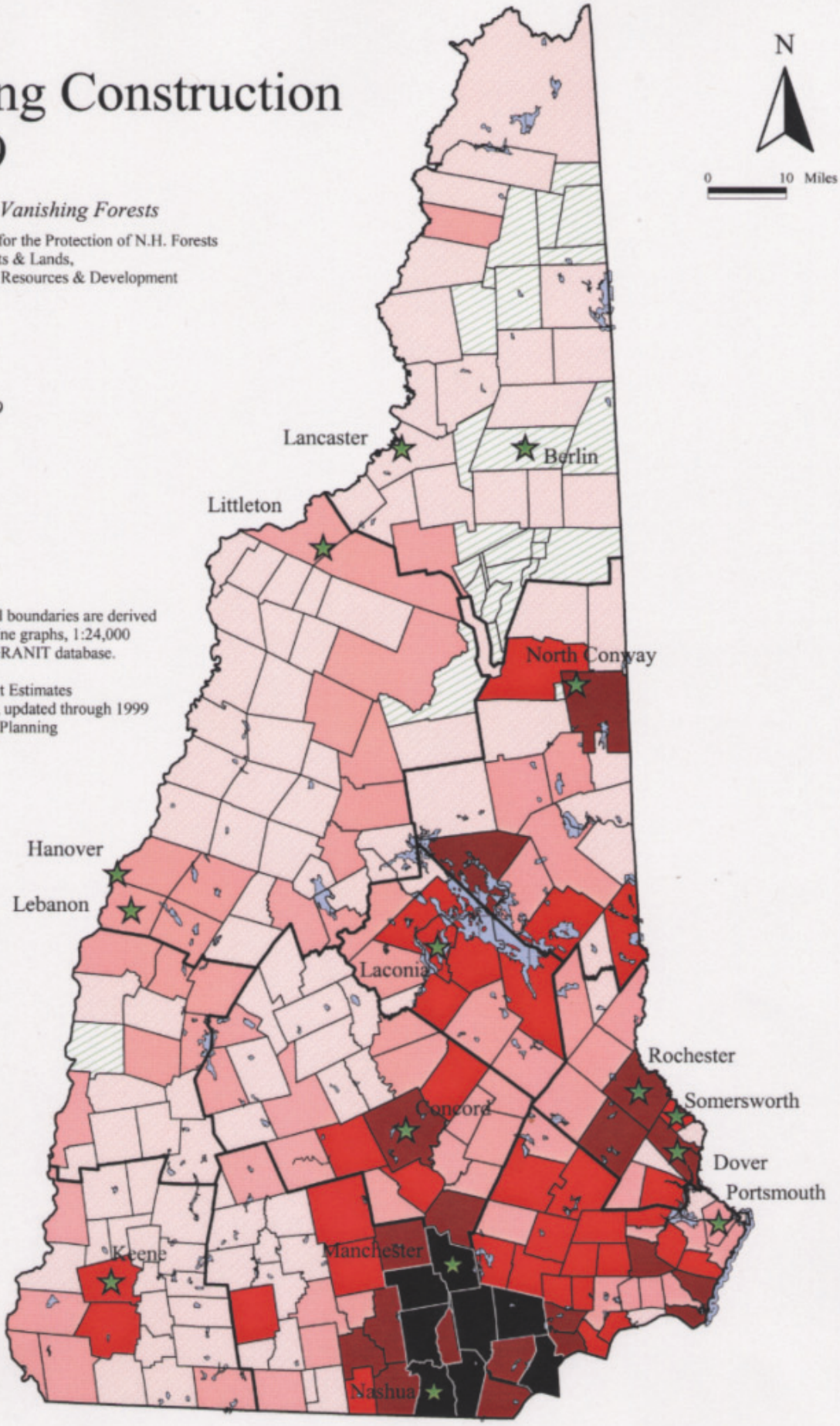


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Figure 11

Projected Decline in Forest Land Area 1993 - 2020

New Hampshire's Vanishing Forests

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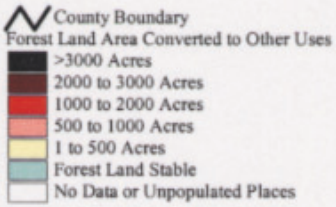
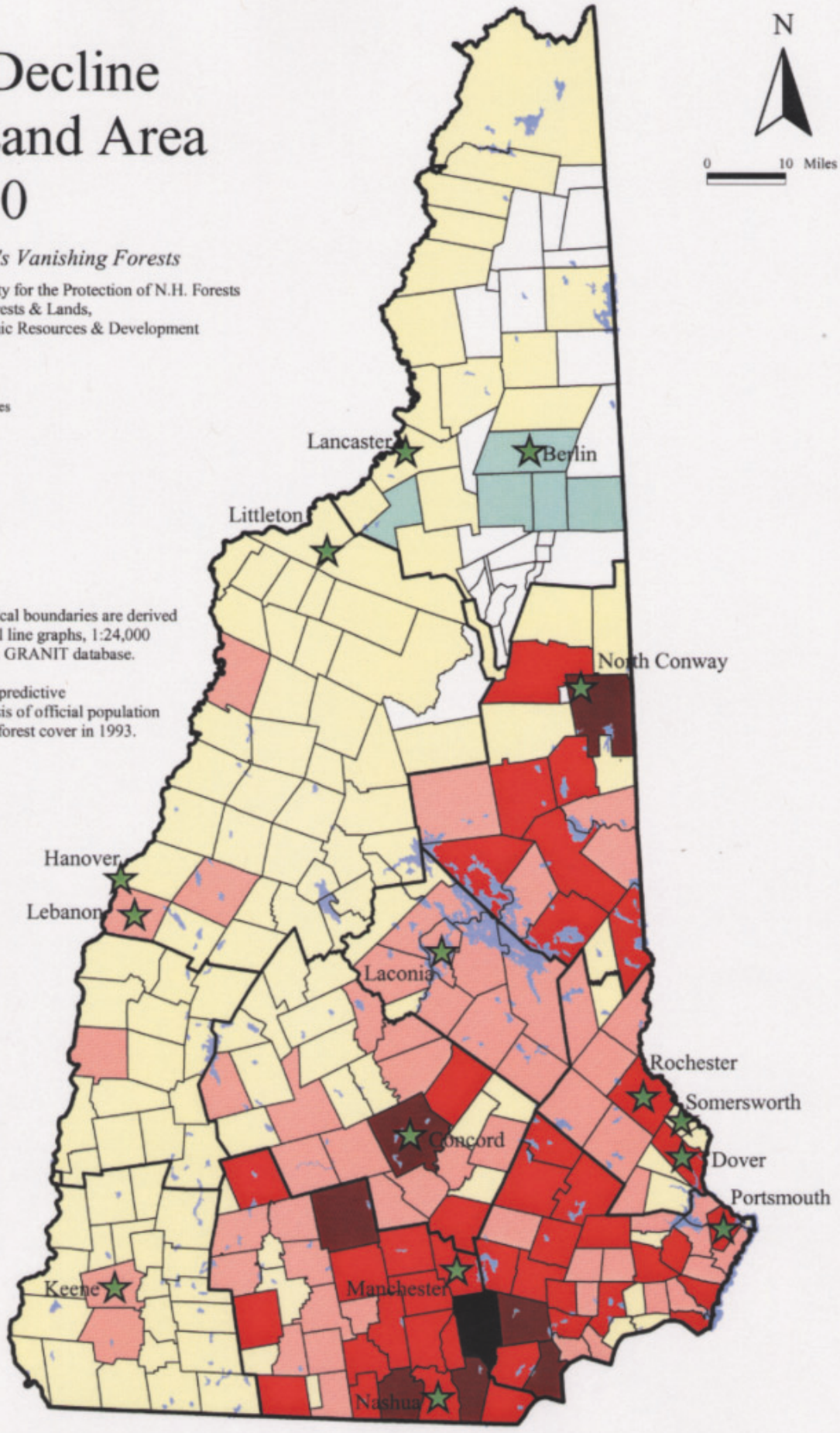
N.H. Dept. of Economic Resources & Development



Data Sources:

Hydrological information and political boundaries are derived from U.S. Geological Survey digital line graphs, 1:24,000 to 1:25,000 as archived in the N.H. GRANIT database.

Forest land decline is derived from predictive modeling based on statistical analysis of official population projections and existing percent of forest cover in 1993.



Funding for this project provided in part by the USDA Rural Development Through Forestry Program.

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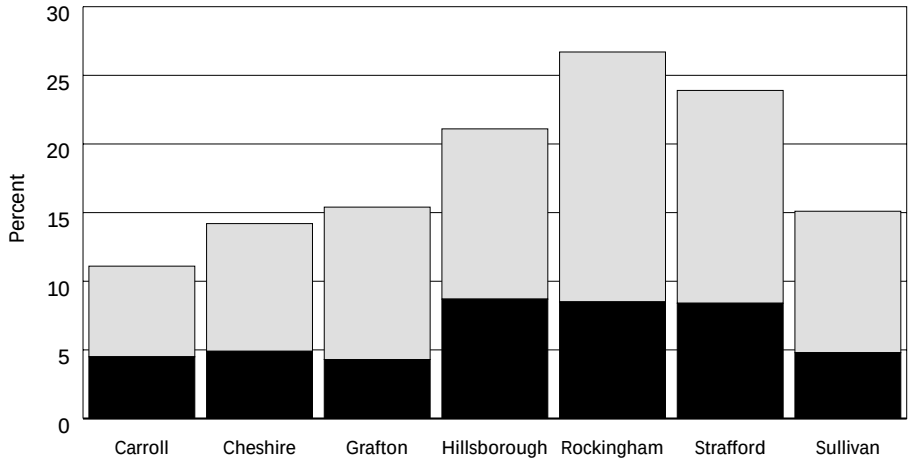
FIGURE 12. PERCENTAGE OF FOREST SOILS CONVERTED TO DEVELOPMENT AND NON-FOREST USES FOR SEVEN N.H. COUNTIES



Percentages are cumulative.
For example, in Rockingham County:
8.5% of land is covered by development and roads.
18.2% of land is in other non-forest uses, e.g., agricultural, lawns, and fields.
26.7% of total land area in development and non-forest uses.

Resource Conservation Service soil maps for the seven of 10 counties available, converted forest soils can be identified. Figure 12 shows that in each of the three most developed counties, more than 20% of the pre-colonial forests have already been converted to development. The dark portion of the bar represents buildings, parking lots and roads. The light portion represents lawns, golf courses, and cropland or farm fields (only about 4% of the state's land area is devoted to agricultural uses).

TERMINAL HARVESTS

Evidence of liquidation cutting to convert forests to house lots is ample along our roadsides, but how much of our annual cut really is coming from these "terminal harvests?" Data was gathered in the FLB surveys from loggers, foresters, and landowners to measure the extent of harvesting for the last time in preparation for development.

Among loggers responding, 64% reported that none of their harvests were "terminal" cuts. Approximately one quarter said that at least 10% of the acreage they harvested was being converted for development. The mean percentage of acreage harvested being terminally harvested was 31% in Rockingham and Strafford Counties, ranging down to 4% in southwestern New Hampshire (see Figure 13).

Proportionately more *volume* is coming from these "terminal harvests." Thirty per cent of respondents said that at least 10% of their volume came from "terminal harvests."

Landowners who conducted harvests and filled out intent-to-cut forms between April 1998 and March 1999 were also surveyed. Statewide, 10% of these respondents listed the most important purpose of their harvest as being clearing the land for development.

Some mills do not track the origin of their supply. However, when asked, they estimated that a median of 10% of the acreage yielding their supply was being harvested for the last time due to development. Forty percent said that *more* than 10% of the acreage that generated their supply

FIGURE 13. PERCENTAGE OF ACREAGE AND VOLUME HARVESTED FOR LAST TIME BY COUNTY

	Belknap / Carroll (Central)	Cheshire / Sullivan (SW)	Coos / Grafton (North)	Hillsborough / Merrimack (South Central)	Rockingham / Strafford (Southeast)
Mean Acreage:	15%	4%	7%	16%	31%
Mean Volume:	14%	17%	19%	18%	28%

had undergone a terminal harvest. Although the survey methods are different, it is interesting to compare this to the 1983 FIA data. In 1983, the FIA reported that only 3.6% of the harvesting was reported to be for land clearing for any purpose.[27] In 1998, Rockingham County mill owner Charlie Marden reported in the *Timber Crier* that, "last year, two million board feet, or nearly 90% of our production, came from logs harvested from land for the last time around." He cited his declining future log supply and mounting regulations as the reasons that he closed his southeastern New Hampshire mill.[28]

The 1995 Interim New Hampshire Forest Inventory, reported that 53% of the oak removals and 44% of pine removals came from harvests for the last time between 1983 and 1994.[29] This is of concern because oak and white pine are the state's most commercially valuable species. White pine is the state's number one species by volume.

Terminal harvests are problematic for a number of reasons. First, often they take the form of "liquidation harvests," which remove most of the merchantable timber and may render a forest uneconomic for several generations. Even if the anticipated development does not materialize for years, the land has been stripped of its value for forestry, aesthetic appeal, and many types of habitat. Not all terminal harvesting removes all the trees, but it is probable that the land, once populated by roads and buildings, will not be commercially harvested again.

Terminal harvesting also elevates the flow of wood in a way that masks the true sustainable supply. It may give the illusion that a region's wood supply is dramatically more abundant than it will be five or ten years down the road. Industry and public awareness of the forestland conversion problem could be obscured by the glut of terminally harvested wood. Eventually, the forest economy will wither after enough of the commercial forest land base has been terminally harvested and converted. If the terminal harvest survey data are accurate, and if current rates of forestland conversion continue, the commercial forest land base in Rockingham and Strafford Counties may be largely gone within fifty-five years.[30]

Population growth and escalating land consumption per person are both causing the rapid conversion of New Hampshire's forest land cover. If current policies are not changed, by 2020 forest cover will fall below 70% in many towns and below 80% statewide.

---

[27] Birch, Thomas, Resource Bulletin NE-108.

[28] Marden, Charlie, "Closing the Door on a Livelihood," *Timber Crier*, New Hampshire Timberland Owners Association, Winter, 1998.

[29] "Results of an Interim Forest Inventory of New Hampshire's Timber Resource," N.H. Forest Inventory Project Steering Committee, September, 1995.

[30] Terminal harvest rate (31%) x annually harvested acreage (40,000 acres)=12,400 acres/year. The two-county forestland base of 481,257 acres, would be consumed in 39 years at this rate.

Productivity of the Forest Land Base

The concept of "prime farmland" is familiar in agricultural and land conservation circles. This is the farmland that will yield more crops and sustain those crops through extreme weather conditions more successfully due to soil texture, slope, depth to bedrock, and drainage. A similar concept focusing on the productivity and forest management limitations has been developed for forest soils in New Hampshire by the Natural Resources Conservation Service.[31] It is the only system specifically keyed to New Hampshire that has been developed to give a general indication of forest soil productivity. In this study, the objective has been to determine the prevalence of soil productivity classes in New Hampshire and the differential impacts of development upon them.

The terrain features, topography and soils that provide the foundation for today's forests can be traced to the grinding, scraping and dumping action of glacial ice or to the action of meltwater as the last glacier retreated northward. As a result, considerable variability of soil types can be expected across the state and from unit to unit on a given site. Differences in available nutrients and moisture in soils account for most of the variability in tree species and forest composition across New Hampshire.[32]

Important Forest Soils

Soils mapped by the USDA Natural Resources Conservation Service for each county soil survey have been grouped into six categories — termed *Important Forest Soils Groups* (IFSG) — based on consideration of the inter-relationship among:

- Soil textures and moisture or wetness
- Inherent limitations of the soil for forest management — steep slopes, shallowness, boulders, rock outcrops, etc.
- Forest successional trends on certain soil types.

IFSG soils are coded as 1A, 1B, 1C, 2A, 2B. A few very wet soils and other site features included in soil survey mapping are not considered since they have low or no potential for productive forest management (see below).

---

[31] Jim Spielman, Sidney Pilgrim, and Richard Boulanger, "The Role of Soils Maps in Forestry," *Forest Notes*, Spring, 1984.

[32] William Leak & Jane Riddle, "Why Trees Grow Where They Do in N.H. Forests," USDA Forest Service, Northeastern Forest Experiment Station, Pub. NE-INF-37-79.

Brief descriptions of each soil group and its characteristics are as follows:

- 1A: Deeper, loamy soils, moderately- to well-drained
- 1B: Sandy or loamy soils, moderately- to well-drained
- 1C: Outwash sands & gravels
- 2A: 1A & 1B soils with limitations, e.g., very steep, shallow, or rocky
- 2B: Poorly-drained soils
- Not considered: Muck & peat soils, rock outcrop, gravel pits, marsh, and other soil types not considered productive for forest management.

Groups 1A, 1B and 1C contain the more productive soils in New Hampshire, with few limitations for forest management. 1A soils are considered prime northern hardwood forest sites, but in some soil series may be more conducive to management for hemlock. 1B soils are good growing ground for paper birch in the far northern part of the state, beech in central New Hampshire and oak in more southerly sites. 1C soils support the growth of the highest volumes of white pine. 2A soils can be quite productive, depending upon management, since this group contains many of the soils in the 1A and 1B classes, but severe site constraints limit accessibility and silvicultural activities.

Productivity of group 2B soils is generally less than the other groups and site conditions such as year-round wetness limit their use for forestry. However, these soils can be very productive spruce-fir sites, especially in northern New Hampshire, due to the ease with which these species regenerate.

By using GIS analysis of soils mapping for the seven of ten New Hampshire counties with digital information, the relative area and distribution of IFSG for a large majority of New Hampshire land area can be approximated. The acreages and percentages of each IFSG for the available counties are shown in Figure 14. It is interesting to note that about three-fifths of the soils in the state are rated more productive and conducive for forest management (see pie chart).

Figure 15 shows important forest soil groups mapped for Tamworth, New Hampshire. Tamworth is part of the great Ossipee outwash plain and possesses a large endowment of IC soils — some of the best land in the state for growing white pine on a volume basis.

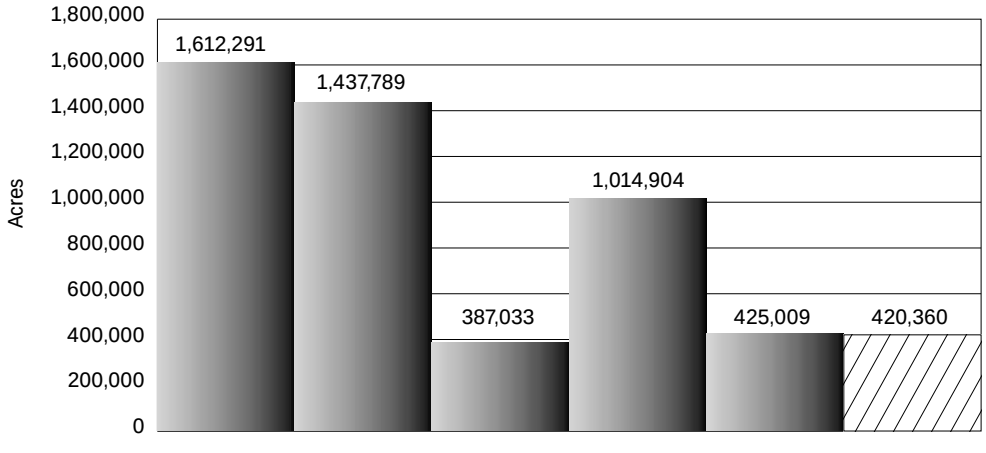
Some of the characteristics of productive forest soils include gentle slopes, absence of boulders, and absence of ledge outcroppings or cliffs. In other words, lower elevations, valley floors and deep soils are more favorable sites for forest growth and operability. These are the same sites that are more favorable for development and attendant roads, wells and septic systems. By overlaying the land cover data layer on the important forest soil group layer, it is possible to determine whether the more productive soils are disproportionately more developed.

Conversion of Important Forest Soils

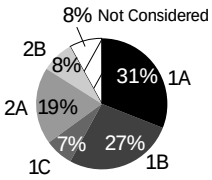
The findings for the seven counties for which digital data are available are shown in Figure 16. The excellent pine sites (1C) have been developed at a much greater rate than any other soil group — 42% of all original sites highly conducive to growing pine have been converted to development and other non-forest uses. This is particularly significant because white pine is the highest volume and one of the most valuable species in our forest. Not surprisingly the forest soils that are more steep, rocky, and shallow (2A) are proportionately less developed.

There are very real costs to the forestry economy for the loss of its most productive and operable sites to development. If forestry must retreat to the more marginal lands, operating costs will be higher and stumpage prices to the landowner will be lower. The attractiveness of retaining forestland as an investment for forestry will be reduced. Low profitability may cause even more conversions of forestland to development.

FIGURE 14. ESTIMATED ACRES OF IMPORTANT FOREST SOIL GROUPS IN N.H.



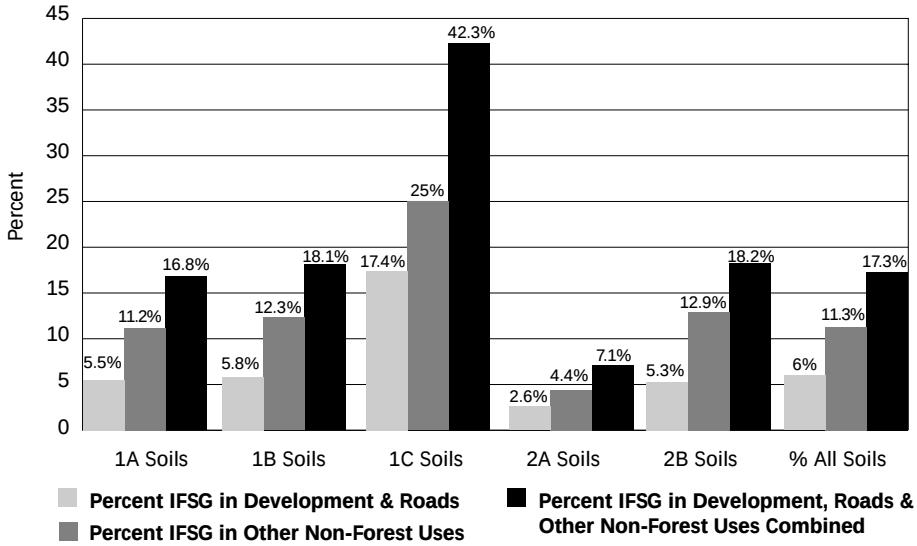
Percent of Land in IFSG Classes



Key
1A = Deeper loamy soils, moderately- to well-drained
1B = Sandy or loamy soils, moderately- to well-drained
1C = Outwash sands & gravels
2A = 1A & 1B soils with limitations (very steep, shallow or rocky)
2B = Poorly drained soils
Not Considered = Muck & Peat, rock outcrop, gravel pits, marsh, etc.

Source: Published and unpublished soil surveys, USDA Natural Resources Conservation Service

FIGURE 16. PERCENTAGE OF IMPORTANT FOREST SOILS GROUPS IN DEVELOPMENT, ROADS AND OTHER NON-FOREST USES FOR (7) N.H. COUNTIES



Percent IFSG in Development & Roads
Percent IFSG in Other Non-Forest Uses
Percent IFSG in Development, Roads & Other Non-Forest Uses Combined

Key
1A = Deeper loamy soils, moderately- to well-drained
1B = Sandy or loamy soils, moderately- to well-drained
1C = Outwash sands & gravels
2A = 1A & 1B soils with limitations (very steep, shallow or rocky)
2B = Poorly drained soils
Not Considered = Muck & Peat, rock outcrop, gravel pits, marsh, etc.

Figure 15

Forest Soils Groups Tamworth, N.H.

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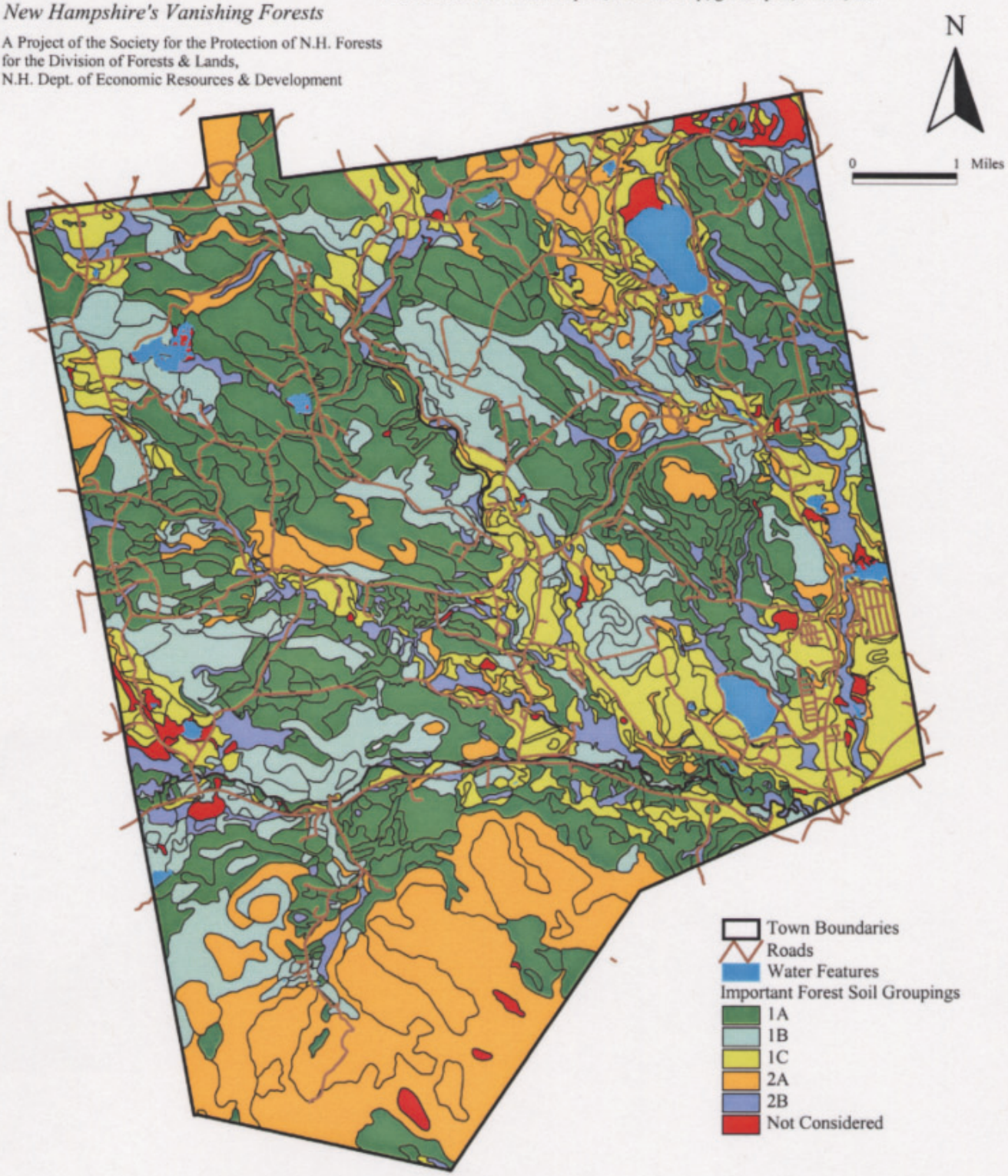
Soil Group Definitions

1A: Deeper loamy soils, moderately- to well-drained; prime northern hardwood sites.
1B: Sandy or loamy soils, moderately- to well-drained; oak & beech depending on sites
1C: Outwash sands & gravels; white pine sites.
2A: 1A & 1B soils with limitations, e.g., very steep, shallow, or rocky; northern hardwood sites.
2B: Poorly drained soils; spruce/fir sites in northern N.H.
Not Considered: Muck & peat, rock outcrop, gravel pits, marsh, etc.



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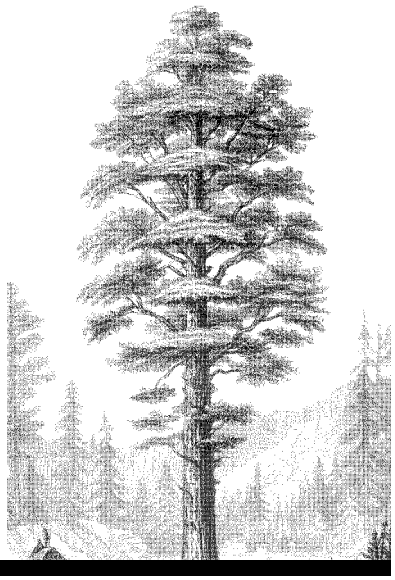
Fragmentation of Forest Blocks



Forest fragmentation is defined as the dividing of contiguous blocks of forestland by roads, development and other non-forest uses. Block size is important because many biological and social values are diminished or negated as block size falls. It is not the purpose of this study to analyze the full range of forest values. However it is useful to consider how these values interrelate with forestry. In general, larger blocks:

- Host interior habitat essential to many species (e.g. certain songbirds),
- Provide home ranges and habitat diversity necessary to conserve biodiversity, particularly for, larger mammals and carnivores,
- Deter the invasion of exotic species,
- Offer more remote recreational opportunities,
- Maintain high water quality for human consumption and aquatic ecosystems,
- Reduce abutter and neighborhood conflicts with management activities, and
- Have lower per acre land values, which make the land more affordable to purchase or protect for forest management and other purposes.

Block Size Distribution

A map of forest blocks in New Hampshire by size classes is shown in Figure 17. A block is defined on its perimeter by non-forest land uses, including publicly maintained roads, development, agriculture, and large rivers. This definition of forest blocks was chosen specifically to depict those characteristics that are relevant to forestry. Forest block studies being conducted primarily for habitat purposes, for example, would be defined by other boundaries, depending upon the habitat needs of the species.

Intensively developed areas are depicted in red on the map. Urbanization in the lower Merrimack Valley, Seacoast, and Lakes Region is clearly visible. The progressive reduction of unfragmented area as minimum block size grows is shown in Figure 18.

Figure 17

Distribution of Forest Blocks by Size Class 1992-1993

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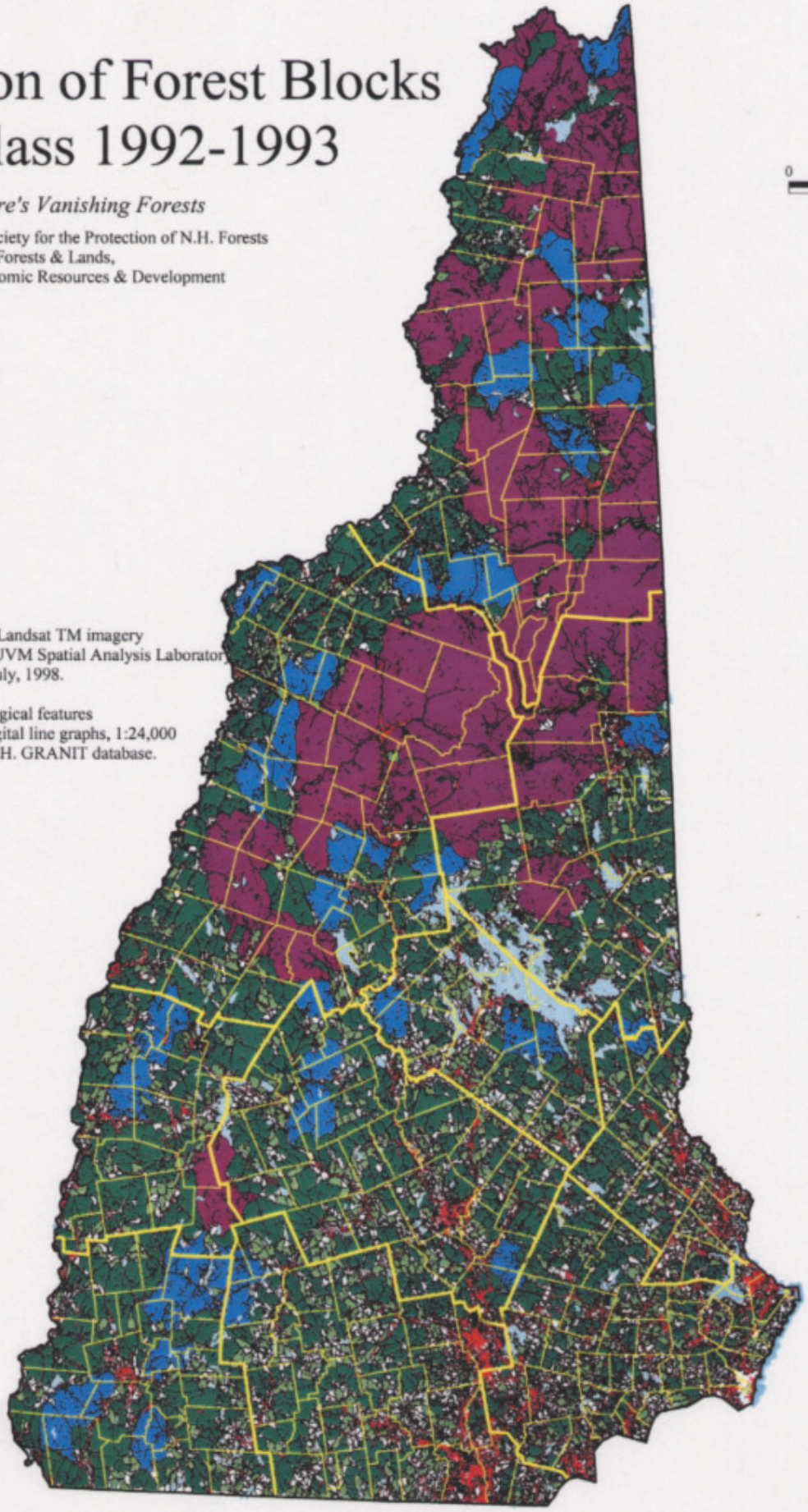

County Boundaries
Municipal Boundaries
Developed Lands
Water Features

Forest Blocks
<500 acres
500 - 1000
1000 - 10,000
10,000 - 25,000
>25,000

Data Sources:

Forest cover type data based on Landsat TM imagery
ca. 1992/1993 and mapping by UVM Spatial Analysis Laboratory
University of Vermont, issued July, 1998.

Political boundaries and hydrological features
from U.S. Geological Survey digital line graphs, 1:24,000
to 1:25,000 as archived in the N.H. GRANIT database.

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Figure 18

Comparison of Forest Blocks by Size Class

N

0 20 Miles

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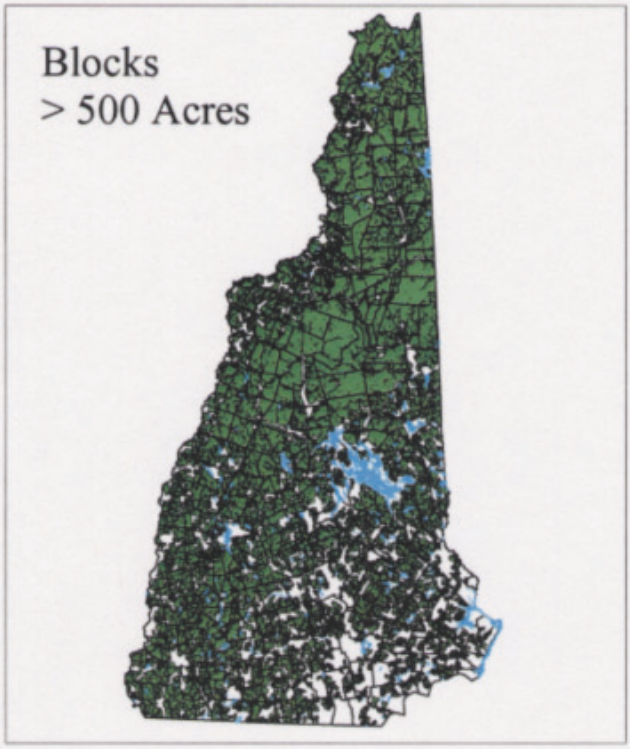
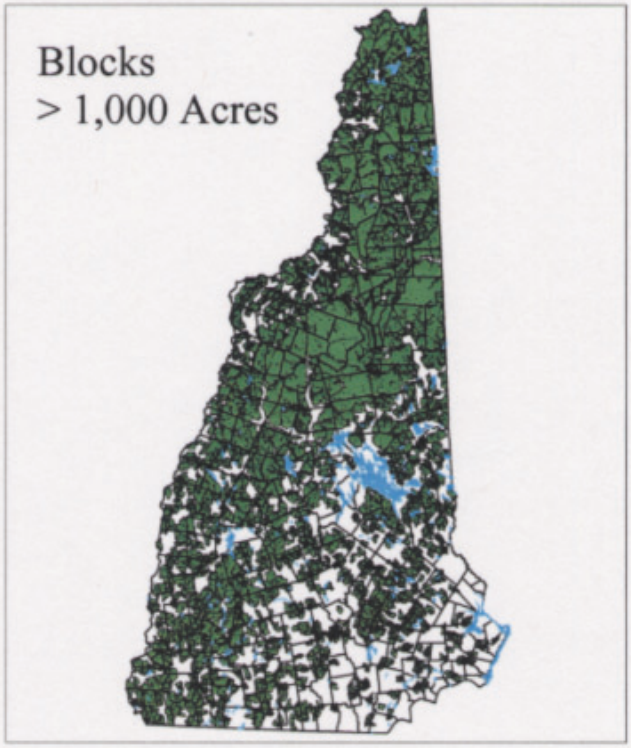
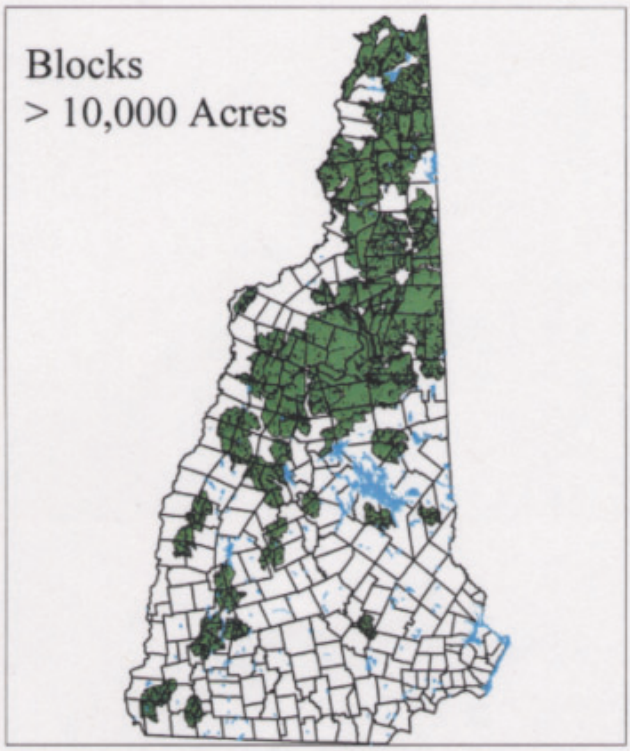
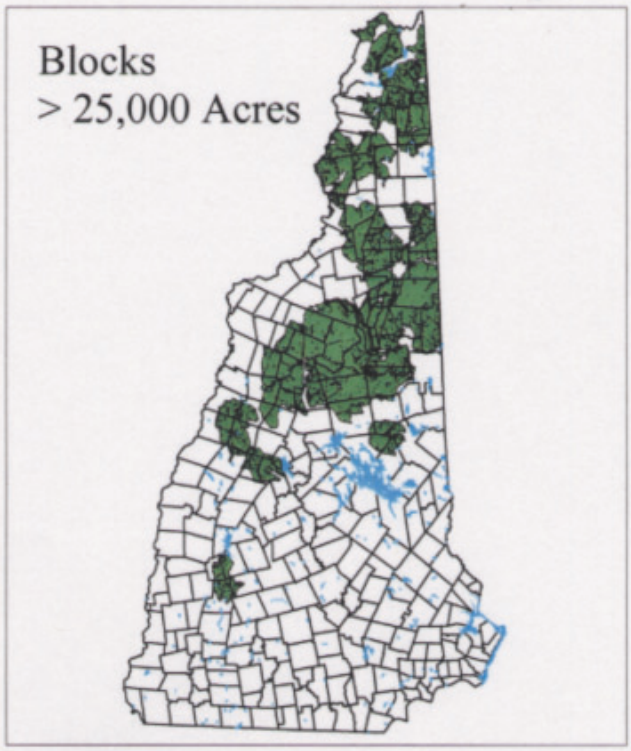
N.H. Dept. of Economic Resources & Development









Data Sources: 1992/93 land cover mapping by UVM Spatial Analsyis Laboratory, issued 1998.

Funding for this project provided in part by the USDA Rural Development Through Forestry Program.

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Figure 19

Percent of Land in Forest Blocks >500 Acres

New Hampshire's Vanishing Forests

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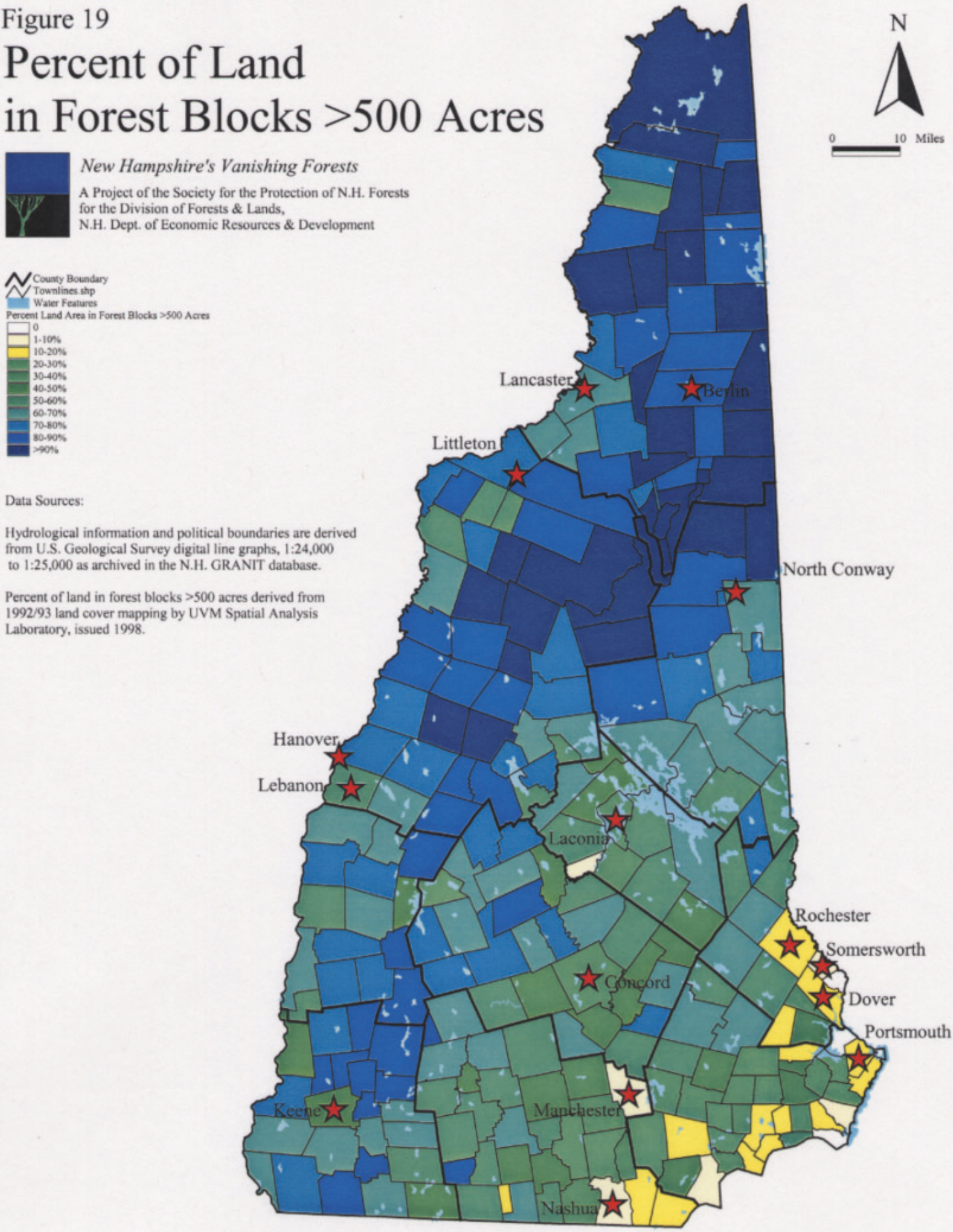

Data Sources:

Hydrological information and political boundaries are derived from U.S. Geological Survey digital line graphs, 1:24,000 to 1:25,000 as archived in the N.H. GRANIT database.

Percent of land in forest blocks >500 acres derived from 1992/93 land cover mapping by UVM Spatial Analysis Laboratory, issued 1998.

Funding for this project provided in part by the USDA Rural Development Through Forestry Program.

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There are only a few towns in the state that do not have at least one block of forest that is over 500 acres in size (see Figure 19). These 500-acre blocks are still prevalent, although less numerous in the south central and southeastern parts of the state. The fragmenting effects of urbanization can be seen more readily in Figure 18 when comparing the map of blocks greater than 500 acres to the map of blocks greater than 1000 acres. Many towns in the southeast and Lakes Region have few or no 1000+ acre blocks remaining. Some towns are only a few housing developments away from losing their last remaining large blocks of forest.

Moving to the map of blocks more than 10,000 acres, the geographic distribution of extensive forest blocks in the north and along the western highland spine of the state is striking. Public conservation lands and conservation easement ownerships in the Belknap Mountains, Bear Brook State Park, Sunapee-Pillsbury area, Cardigan, Mt. Monadnock and Pisgah areas are all evident. Had these investments in conservation not been made decades ago, the pattern of forest fragmentation would be much more advanced. In the south central portion of the state, only the forests extending outward from Bear Brook State Park constitute as much as 10,000 acres.

In the 25,000+ acre size class, the White Mountain National Forest protects our largest expanse of forest from further fragmentation by development and public roads. It covers about half of the forest blocks greater than 25,000 acres in size. Industrial lands to the north and large private family, state, Dartmouth College, conservation group and investor holdings to the west and south of the national forest are responsible for the other huge blocks. The Mt. Sunapee/Pillsbury State Park area, including several large private holdings is the prominent, southern-most 25,000+ acre block.

Figure 20 shows the distribution of the forest block sizes for the state. Twenty eight percent of the state's forests exists in blocks of more than 25,000 acres. This is an enviable percentage for our neighboring states to the south. Only 16% of the state's forestland is divided into blocks of under 500 acres.

Vast areas of our forests remain intact to provide a myriad of valuable services. However, the maps demonstrate that the balance of the large forest blocks is heavily skewed to the north and west and the fingers of fragmentation are advancing. There is a paucity of forestland, particularly in large blocks, in close proximity to where most people live.

FIGURE 20. PERCENT OF FORESTED LAND BY BLOCK SIZE CLASS

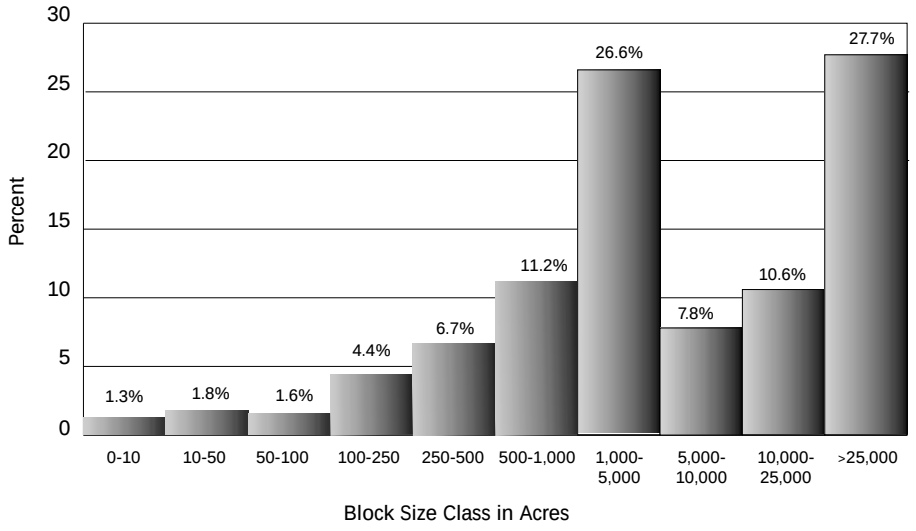
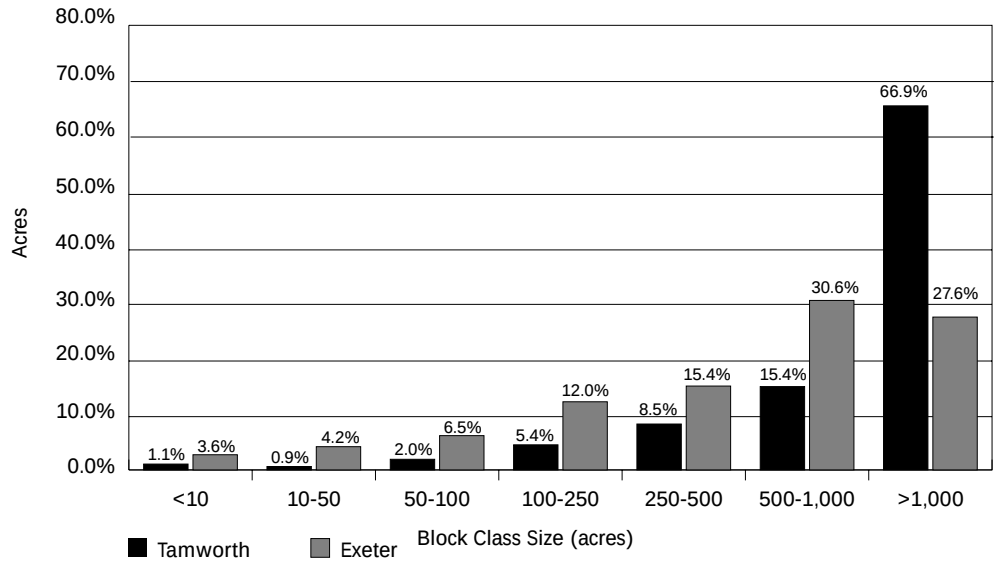


FIGURE 22. COMPARISON OF FORESTED LAND BY BLOCK SIZE CLASS FOR TAMWORTH AND EXETER, N.H.



Figures 21 and 22 illustrate this disparity in block sizes between a rural, northern town (Tamworth, 37 persons/square mile) and a southern, suburban town (Exeter, 676 persons per square mile). Tamworth has two thirds of its forest land in 1000+ acre block size classes whereas Exeter has only 28%. Tamworth has less than 10% of its forest land base in blocks of less than 250 acres whereas Exeter has 26%.

ABUTTER EDGE EFFECT

Most forest fragmentation in New Hampshire is caused by development and roads rather than agriculture. One of the benefits of having large blocks of forestland is that any given ownership will be more likely to be surrounded by forests, rather than development. Given their choice, most forest managers would prefer to have forests as abutters rather than houses. When the chainsaws start up and the skidders begin hauling out wood, residential abutters often complain to local authorities and the forest landowner. This may not be a problem when there are only a few neighbors who have lived a long time in a rural area and are accustomed to occasional timber harvesting. But for dozens of new subdivision residents whose homes may abut managed forest land, there may be little tolerance or understanding of forest management.

Aside from aggravation and delays, abutters can create pressure for regulations that make forestry more difficult and less economic.[33] Tighter load limits on roads, noise ordinances, and harvesting restrictions can all impede even the most ecologically sound forest management. Forest managers often recommend setting aside buffers of unmanaged woodland along their boundaries

[33] Egan, A.F. and A.E. Luloff, "The exurbanization of America's Forests," *Journal of Forestry* 98(3):26-30.

Figure 21

Comparison of Forest Blocks by Size Class for Tamworth & Exeter, N.H.

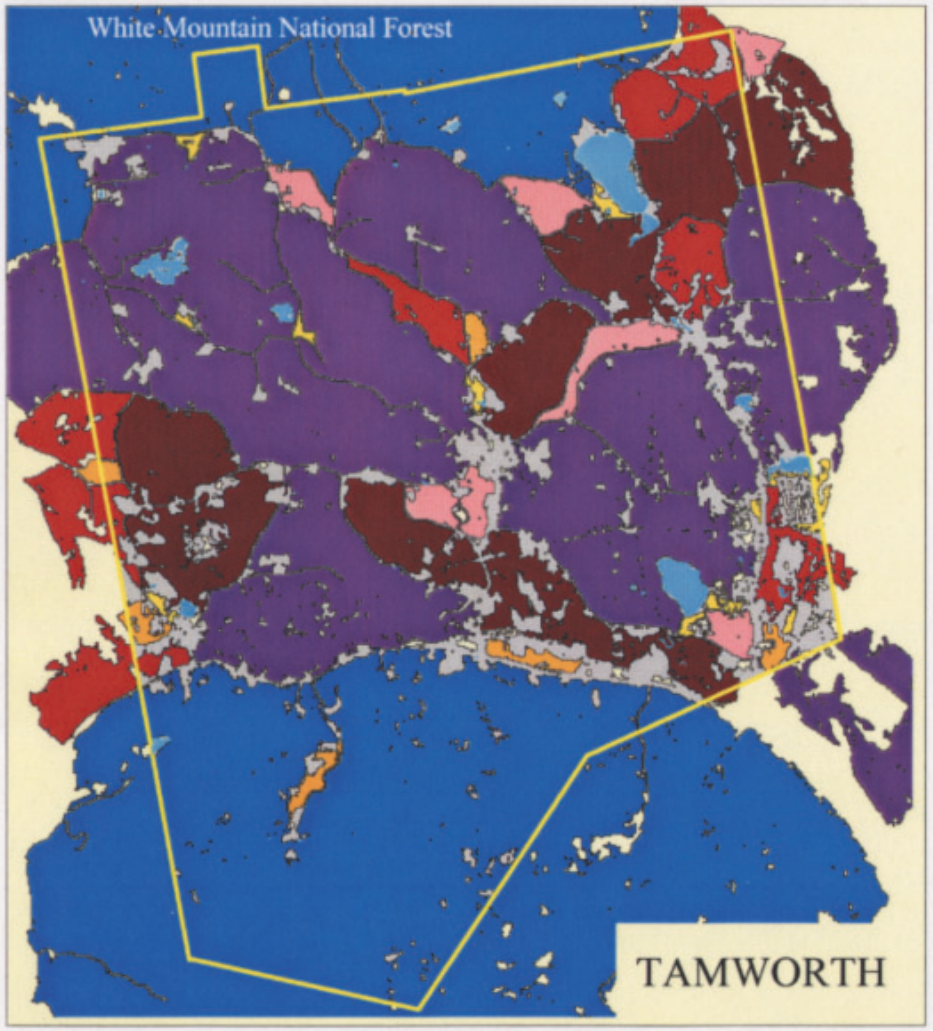
New Hampshire's Vanishing Forests

A Project of the Society for the Protection of N.H. Forests
for the Division of Forests & Lands,
N.H. Dept. of Economic Resources & Development

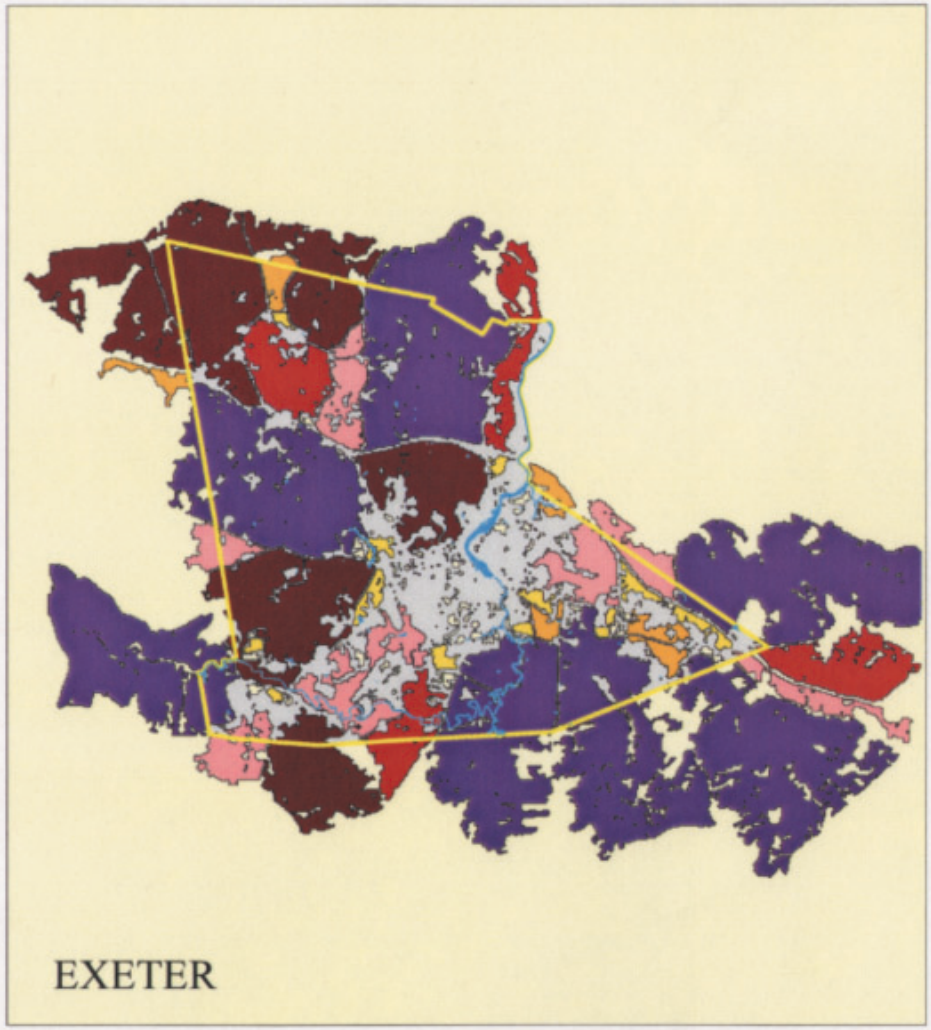
Forest Blocks by Size Class
- <10 Acres
- 10-50
- 50-100
- 100-250
- 250-500
- 500-1000
- 1000-5000
- >5000
- Water Features
- Non-forested Lands

N

0 1 2 Miles



0 1 2 Miles



Data Source: 1992/93 land cover mapping by UVM Spatial Analysis Laboratory, issued 1998.

April 2001

to minimize abutter complaints. This can be a significant economic sacrifice to the forest owner because the perimeter to volume ratio is larger for smaller tracts, so the losses of harvestable area due to buffers would be greater.

The "abutter edge effect" caused by land development and fragmentation can discourage forest investors from purchasing forestland in rapidly developing areas. Rising land values, taxes and abutter conflicts caused by the development of abutting land may also compel some landowners to sell their forestland, making it more vulnerable to development.

Biodiversity and the Forest Land Base

Since forested ecosystems are predominant in New Hampshire, biodiversity conservation is almost entirely dependent upon the forest land base. For the survival of many species, large unfragmented blocks of forest are essential. The New Hampshire Ecological Reserve System Steering Committee submitted their blueprint for biodiversity conservation in 1998. In it they recommended that the state establish an Ecological Reserve System. The report calls for the permanent protection of globally rare or concentrations of rare natural communities, plants and animals, exemplary and matrix communities, large unfragmented blocks of core forest, areas adjacent to existing conservation lands, and connections between these lands, especially riparian corridors and ridgelines.

The report finds that, *"except in the White Mountain ecoregion, current conservation lands are not well connected to one another and they do not reflect scientific principles for designing biodiversity conservation lands. The isolation and small size of many conservation lands decreases the likelihood of the resident species and natural communities remaining viable over the long term."*[34] Moreover, the isolation and small size of remaining forests caused by development damages population viability and ecosystem function. For example, research indicates that a black bear density index decreases ten fold with a ten fold increase in road density and resulting habitat fragmentation.[35]

The report continues, "the recommended approach to conserving natural communities over the long term is to preserve viable examples of matrix communities which have concentrations of small and large patch community types embedded within them. The recommended size for preserving matrix communities ranges from a minimum size of 5,000 acres to 25,000 acres." Matrix communities are the common dominant forest types that cover large areas and provide vital habitat to wide ranging species and those requiring remote or forest interior habitat. Matrix forests are not rare themselves, but they provide vital ecological support to the embedded rare populations including healthy aquatic ecosystems, transportation corridors for migrants, food sources, and habitat for mutualistic species.

What is not discussed in the biodiversity assessment is the extent to which forest management is compatible with the other goals of the Ecological Reserve System. In the matrix areas, in particular, there is considerable potential for managing forests according to ecosystem-based principles such as those outlined in *Good Forestry in the Granite State*.[36] Biodiversity conservation and ecosystem-based forest management can be compatible at the landscape scale. Preserving large unfragmented blocks of forest land is essential to achieving both goals.

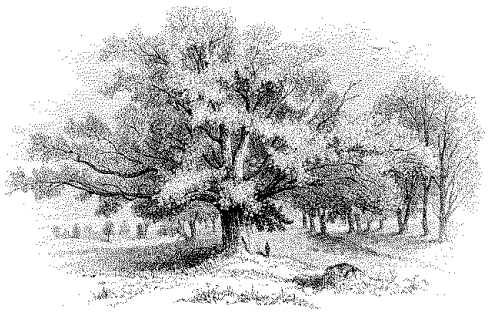
[34] Stevens, ed. 1998.

[35] "Is Forest Fragmentation a Management Issue in the Northeast?" 1988.

[36] *Good Forestry in the Granite State*, 1997.

New Hampshire still has an impressive proportion of large forest blocks. Returning to Figure 20, it can be seen that nearly half the state's forested area (46%) is in blocks greater than 5,000 acres in size. This meets the definition for matrix forest used above. This is an impressive figure, but must be analyzed geographically. Figures 17 and 18 show that the northern forest land base, if retained and well managed, can support diverse biota and healthy ecosystem function. The story is far different, however, in the south. Here, the forest matrix is significantly dissected by development. As this study has found, opportunities in southern New Hampshire to conserve large forest blocks or connect networks of smaller blocks will vanish soon if present patterns and rates of growth persist.

PARCELIZATION



PARCEL SIZE

The USDA Forest Service has tracked parcel size for private commercial forestland in New Hampshire since their first Forest Inventory and Analysis (FIA) in 1948. Since then the average parcel size (for private commercial forestland in excess of one acre) has fallen from 114 acres to 37.5 acres. Figure 23 shows this decline in concert with the reduction of forest cover and forested acreage. (Note, the definition of forestland and owner has changed over time.)

In New Hampshire's 1983 FIA survey, ownerships under 50 acres comprised 17% of the private land base and accounted for 81% of the forest ownerships. There were 17,100 ownership units in parcels over 50 acres.

The distribution for all New Hampshire forestland owners from the 1994 Birch survey of Northern U.S. owners, based on a smaller sample with less accurate results, is shown in Figure 24.

The average parcel size for all owners, public and private, was 50 acres. The average parcel size for the 97% of the forestland base that is in parcels over 10 acres is 76 acres.

Declining parcel sizes are an issue in many states. In 1994, the average size for a tract of commercial private forestland in the northern U.S. was 33 acres, slightly below the New Hamp-

FIGURE 23. PRIVATE COMMERCIAL FORESTLAND IN NH, OWNERS AND ACREAGE (DERIVED FROM FIA DATA)

	1948	1960	1973	1983	1997
# owners	5,000	37,000	87,500	88,100	84,000
# acres	3,999,800	4,211,000	4,082,100	4,144,000	3,626,600
Ave. parcel size (acres)	114	114	47	47	37.5
% state forested	81	85	85	87	84

FIGURE 24. DISTRIBUTION OF PRIVATE OWNERSHIPS AND ACREAGE BY SIZE CLASS, N.H., 1993.[37]

Size Class	#Owners in NH	% all owners	Thousands of Acres	% of all Forestland
1–9	28,900	34.5	117	3
10–19	27,700	33	382	9
20–49	5,300	6	171	4
50–99	14,900	18	947	23
100–199	3,700	4	511	12
200–499	2,200	3	682	16
500–999	600	.7	365	9
1000–4999	500	.6	365	9
5000+	witheld	.1	605	15
Total	83,700	100	4144	100

shire average. This average parcel size is projected to fall to 17 acres nationwide by 2010.[38] More than 92% of private ownerships in the northern U.S. were in tracts of less than 100 acres of forestland.[39] For example, in Virginia, 51% of the non-industrial private forest land base was in ownerships of 11–50 acres, and only 38% of was in parcels over 100 acres.[40] In South Carolina, 43% was in the 11–100 acre size class and 46% was over 100 acres.[41] In Massachusetts, the average ownership size for a private, non-industrial owner was 10.6 acres in 1985.[42]

Parcel size is relevant to forest management for many reasons, as will be discussed in ensuing sections of this report. One important effect of parcel size is on the landowner's decision to manage. In an Oregon study, Row found that parcel size is inversely related to the landowner's propensity to manage for forest products.[43] The Economics section of this report offers evidence of the negative impact of parcel size on profitability of forest management.

OWNERSHIP SIZE CLASSES IN 12 N.H. TOWNS

Information about ownership sizes can be derived from maps of tax parcels maintained by municipalities for property taxation purposes. Unfortunately, most towns have not yet digitized their tax maps, so it is impractical to determine parcel sizes for the entire state using GIS. However, digital data for twelve municipalities representing a range of population and development are available. Figure 25 shows town population, population density, and average parcel size. Note that these parcels are not necessarily forested and include residential house lots. These averages are useful to compare one town to another, but not to the average sizes of forested parcels discussed above.

[37] Birch, 1994 Northern U.S.
[38] Sampson and DeCoster, 2000.
[39] Birch, Thomas, Private Forest-land Owners of the Northern United States, 1994.
[40] Thompson, Michael, 1998.
[41] Thompson, Michael, 1997.
[42] Kittredge, 1996.
[43] Row, C. "Economies of tract size in timber growing," *Journal of Forestry* 76(9):576–579.

FIGURE 25. MUNICIPAL POPULATION, DENSITY AND AVERAGE PARCEL SIZE
(TOWN ORDER CORRESPONDS TO FIGURE 26 BELOW)

Town	Population, 2000*	Population/Square Mile	Average Parcel Size
Dublin	1554	55.1	16.9
Tamworth	2486	41.6	14.3
Temple	1338	60.2	24.4
Wilton	3443	134.2	9.2
Madbury	1588	135.8	10.1
Northwood	3616	128.9	6.8
Lee	4161	208.8	7.9
Exeter	14,497	730.3	3.3
Kingston	6453	326.7	5.1
Merrimack	24,601	750	2.4
Windham	10,598	397.2	3.2
North Hampton	4333	311.5	3.8

*U.S. Census, 2000

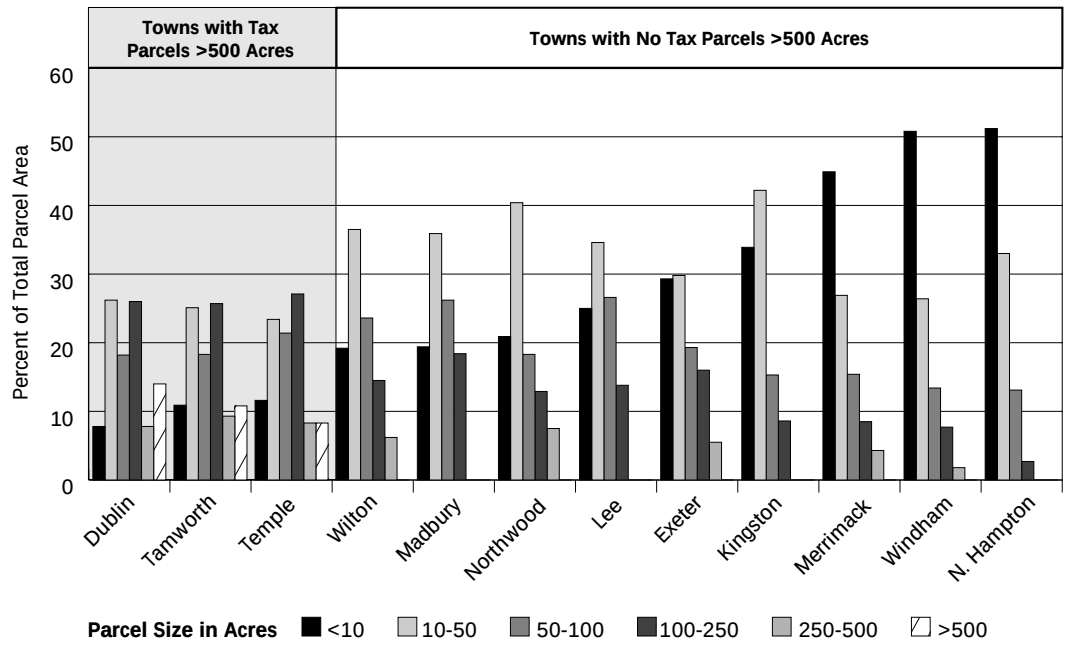
The distribution of parcels by size class is shown in Figure 26. The towns are ranked from Dublin, with the smallest percentage of land area in parcels under 10 acres, to North Hampton, with the largest proportion of parcels under 10 acres.

In general, the towns with a smaller population have proportionately less of their land base in the under 10 acre parcel size class. The three most sparsely populated towns have more than 60% of their land area in parcels over 50 acres.

Given typical development patterns, once towns reach the density of Wilton, Northwood and Madbury, approximately 130 persons per acre, there are no large parcels (over 500 acres) remaining. In fact, there are very few parcels over 250 acres unless they have already been protected.

It is interesting to compare towns with a similar population density but different settlement patterns and land protection profiles. Although Exeter and Merrimack have double the population densities of North Hampton and Windham, they have proportionately more large parcels. Higher population does not always result in less forest and smaller parcels. If significant portions of that population are concentrated on small lots and in village patterns, large forested areas can be retained and protected.

FIGURE 26. ANALYSIS OF TAX PARCELS AS A PERCENTAGE OF LAND AREA FOR 12 NEW HAMPSHIRE TOWNS



PARCEL SIZES IN TAMWORTH AND EXETER

A more detailed comparison of the relationship between parcel size and population is shown in Figure 27. (It should be noted that sometimes one owner holds two or more abutting tax parcels.) Again, comparing the more rural town of Tamworth and the suburban town of Exeter, the impact of growth and development on parcel size is evident. The scale for the two town maps is the same for purposes of comparing relative parcel sizes and patterns. Note that Exeter at 20 square miles is considerably smaller in area than Tamworth, which covers 60 square miles. Exeter has no tax parcels over 500 acres and only two in the 250-500 acre class, one of which has been protected in recent decades. The bar graph in Figure 28 shows that nearly two-thirds of Exeter's land base is in parcels *under* 50 acres in size. In contrast, about two-thirds of Tamworth's land base is in parcels *over* 50 acres.

This section documents that New Hampshire private commercial forest parcel sizes have declined to an average of 37 acres. Population growth, increases in per capita land consumption, and tourism will continue to parcelize New Hampshire's land base. As many of our towns surpass the population density of Exeter, we can expect the majority of their forest land base to be split into parcels of less than 50 acres. This will have important implications for the future of forest management in the state. As will be discussed in the remaining sections of this report, parcels in excess of 50 acres or so probably do not suffer significant diseconomies of scale in forest management. Some foresters feel that the rise in ownerships in the 50–250 acre class, through parceliza-

Figure 27

Comparison of Parcels by Size Class for Tamworth & Exeter, N.H.

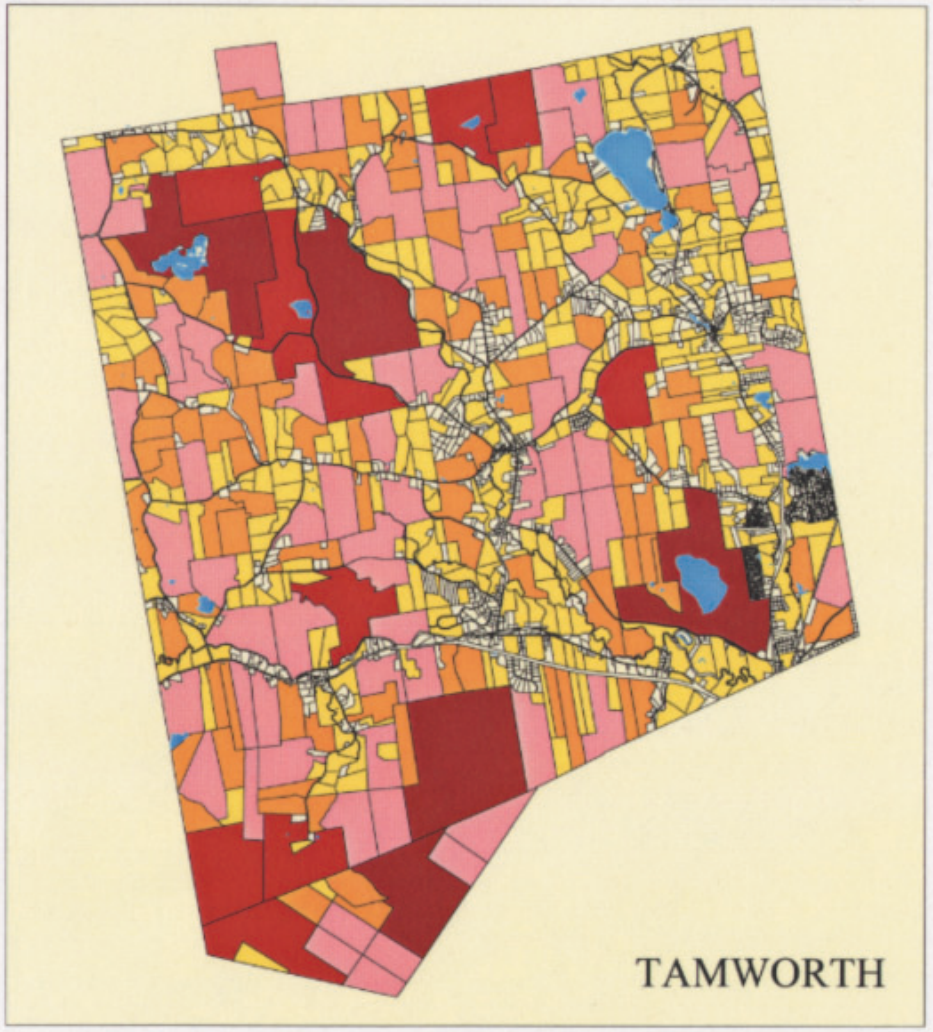
New Hampshire's Vanishing Forests

A Project of the Society for the Protection of N.H. Forests
for the Division of Forests & Lands,
N.H. Dept. of Economic Resources & Development

N

Land Ownership by Parcel Size Class
- <10 Acres
- 10- 50
- 50- 100
- 100- 250
- 250- 500
- > 500
- Water Features

0 1 2 Miles



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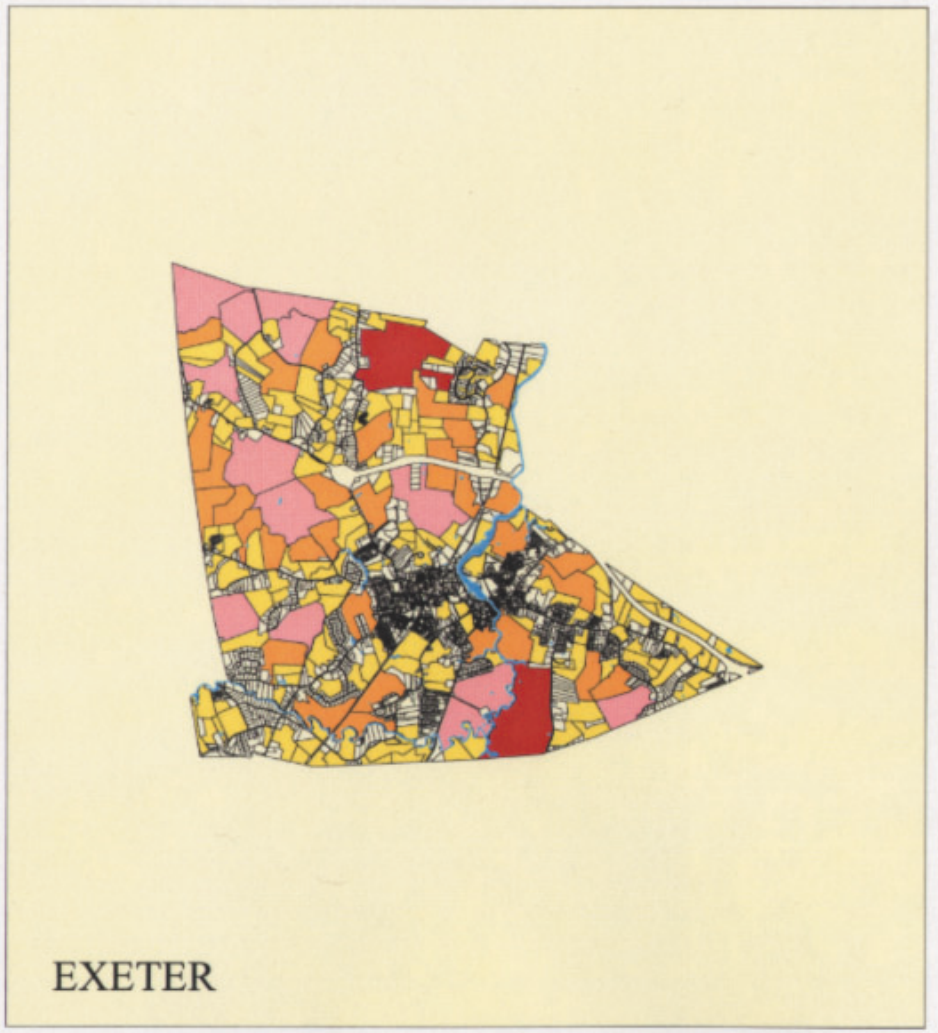
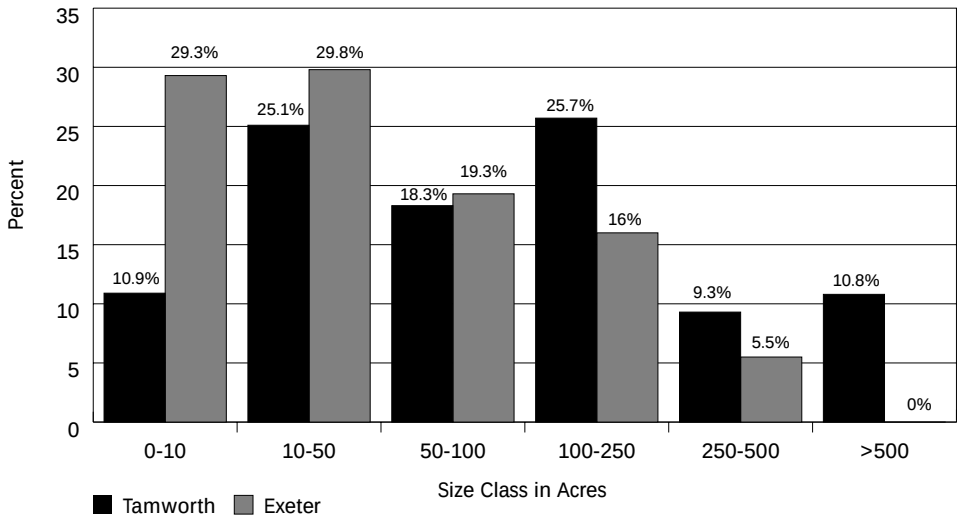


Data Source: 1992/93 land cover mapping by UVM Spatial Analysis Laboratory, issued 1998.

April 2001

tion, may, have a positive impact upon forestry. Diversifying the ownership of the land base can help guard against abusive management within the hands of just a few owners. It could theoretically enhance the connection between people and land that is so important to New Hampshire culture and character. It is the proliferation of parcels in the smaller size classes, under 50 acres, that could have the most serious implications for forestry.

FIGURE 28. COMPARISON OF PERCENT OF LAND AREA BY PARCEL SIZE CLASS FOR TAMWORTH AND EXETER, N.H.



Forestland Owners

There are approximately 83,700 owners of forestland in New Hampshire in parcels of 1 acre or greater.[44] The majority of these owners are private, non-industrial owners. According to the 1997 FIA, 70% of the state's forestland base was held by non-industrial private owners, 10% industrial, and 8% state and local and 12% National Forest.[45] During the past decade, there has been a significant transfer of forestland ownership from forest industry to forest investors such as pension funds and pooled private investors. The long term implications of this shift are not yet understood.

Reasons for Owning Forestland

Of the landowners responding to the FLB landowner survey, 90% were private individuals or families, 4% were corporate, non-industrial, 3% were non-profit organizations, 2% were forest industry and 1% were public agencies. Respondents stated their reasons for owning their forestland as shown in Figure 29.

Scenery and wildlife were the most important reasons for owning forestland. There was some regional variation in responses with Grafton and Coos County (northern) owners being more likely to give a high importance to the production of forest products and land investment.

It is interesting to note that only 33% consider the production of forest products to be very important and 34% consider it to be not important. Even those respondents who *have* conducted harvests value a wide range of qualities in their land.

Typically, in surveys of forest land owners, timber production is not highly ranked. In the 1993 Forest Service survey of northern U.S. landowners, responses were given for the most important reason for owning forestland (see Figure 30).

[44] Birch, 1994.

[45] Cullen, J.B. "Inventory of New Hampshire's Forest Released," press release from NH Department of Resources and Economic Development, (undated).

FIGURE 29. REASONS FOR OWNING N.H. FORESTLAND (SPNHF, 2000)

Reason	Very Important	Somewhat Important	Not Important
Scenic Enjoyment, Wildlife	69	27	5
Part of Residence/Farm	66	12	22
Protecting it from Development	59	24	16
Recreation	41	40	18
Production of Forest Products	33	33	34
Land Investment	31	43	26

New Hampshire forestland owners seem more intentional in their ownership of forests and place a much greater emphasis on esthetic enjoyment than those from other northern states. Nationwide, although only 1% of the owners had timber production as their primary reason for owning land, these owners held 19% of the land base.

FIGURE 30. MOST IMPORTANT REASON FOR OWNING FORESTLAND IN NORTHERN U.S., N.H.[46]

Reasons	No. U.S.	N.H.
Esthetic enjoyment	22	52
Part of residence/farm	41	22
Recreation	7	4
Timber production	1	1
Land investment	2	4

NEW HAMPSHIRE HARVESTS

In the 1998–1999 tax year, an estimated 5754 of New Hampshire forestland owners conducted harvests (that exceeded 10,000 board feet (10 MBF) of sawlogs or 10 cords of wood for personal use).[47] Approximately 616 landowners responding to the FLB survey (10.7% of all those harvesting) reported harvesting 22,200 acres. If these landowners are representative, the total harvested area for the state could be estimated to be 220,000 acres, or 4.6 % of the forest land base.

Figure 31 shows the harvested area by region extrapolated from the survey data in comparison to the percentage of total land area found in that region. The right hand column shows the percent of the region's land base that has been harvested. If the respondents are representative, there is proportionately more harvesting occurring in the Rockingham/Strafford region and proportionately less in the Hillsborough/Merrimack region and Grafton/Coos regions. (The White Mountain National Forest was not in the survey.) Since Rockingham/Strafford has a lower percentage of forest cover to begin with, the harvest rate is considerably higher than average for the state. This could be accounted for in part by terminal harvesting.

Many questions can be posed about the relationship between timber harvesting and the status of the forest land base. Is there less harvesting in towns that are more heavily developed? Is there more harvesting where there are high rates of forestland conversion? How can we expect harvesting levels to change as municipalities grow and develop? These questions will be explored in the sustainability section.

[46] Birch, Thomas W., "Private Forest-land Owners of the Northern United States, 1994," NE Forest Experiment Station, USDA Forest Service, November, 1996, NE 136.

[47] Debra Gage, NH Department of Revenue Administration, personal communication, 2000.

FIGURE 31. EXTRAPOLATED 1998/9 HARVESTED AREA BY REGION COMPARED TO AREA OF FOREST IN REGION (SPNHF, 2000)

Region	Harvested area (acres)	% of region's land base that has been harvested
Rockingham/Strafford	40,000	5.9%
Hillsborough/Merrimack	33,000	2.9%
Cheshire/Sullivan	36,000	4.5%
Grafton/Coos	70,000	3.1%
Belknap/Carroll	37,000	4.3%

TENURE OF OWNERSHIP

The length of ownership by one individual, family, or corporation is shown in Figure 32. There is large variation in land tenure by region. For the state as a whole, about 26% of the owners have held their land less than 10 years. This percentage is highest in the southeast at 38% and lowest in Grafton/Coos at 18%. Similarly, northern landowners have a higher percentage of owners and families that have held their land for over 100 years — 10%. By way of comparison, the majority of landowners have held their forestland over twenty years. In contrast, Massachusetts forest landowners had a 50% turnover in just 10 years between 1973 and 1984.[48]

Land tenure and parcel size are also related. In general, the longer an owner has held land, the larger the parcel tends to be. Since land tends to be subdivided at the time of sale to new owners, it is not surprising that larger parcels tend to be held by owners with greater tenure (see Figure 33).

Tenure is important because a forest requires many decades to mature. Good management must be sustained throughout this period.

SIZE OF OWNERSHIPS

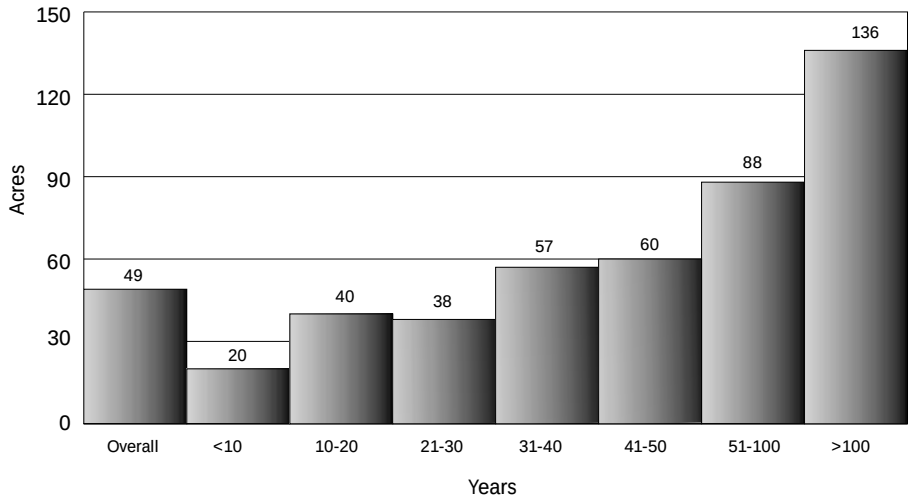
The average size of a parcel of private commercial forestland in New Hampshire is approximately 37 acres. Among landowners conducting recent harvests, the statewide median size of the

FIGURE 32. LAND TENURE OF NH LANDOWNER RESPONDENTS (SPNHF, 2000)

Tenure	Rock/Straf	Hills/Mer	Ches/Sul	Bel/Carr	Graf/Coos	State
<10 years	38	23	25	30	18	26
10–20	15	24	19	19	23	20
21–30 years	11	15	16	11	15	14
31–50 years	17	16	24	15	16	15
51–100 years	14	16	13	21	17	16
>100 years	6	6	4	3	10	6

[48] T.W. Birch, Forest-land owners of southern New England, USDA Forest Service Resource Bulletin, unpublished manuscript, 1989.

FIGURE 33. MEDIAN SIZE OF FOREST PARCEL BY NUMBER OF YEARS OWNED



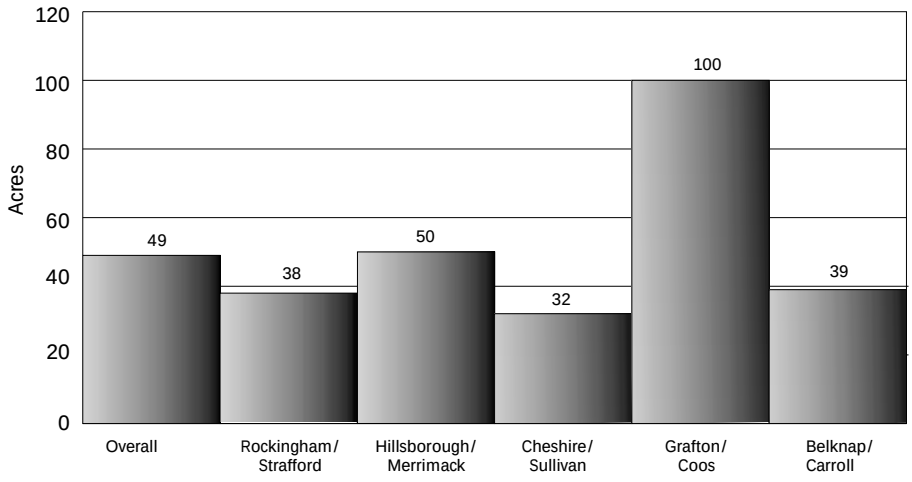
Source: N.H. Survey of Landowners Conducting Harvests 4/98–4/99, SPNHF/UNH Survey Center, 2000.

parcel harvested is 49 acres (median was used rather than average or mean because of a very small number of outliers). The results are shown by region in Figure 34. Again, there is considerable regional variation with Grafton/Coos having parcels with a median of 100 acres and, surprisingly, Cheshire/Sullivan with 32 acres.

The distribution of sizes of the forest parcels and the harvested areas are compared in Figure 35. Thirty-five percent of the harvests took place on parcels of less than 25 acres. However, 60% of the harvests had harvested areas of less than 25 acres. Only 2% of the harvests covered more than 250 acres each.

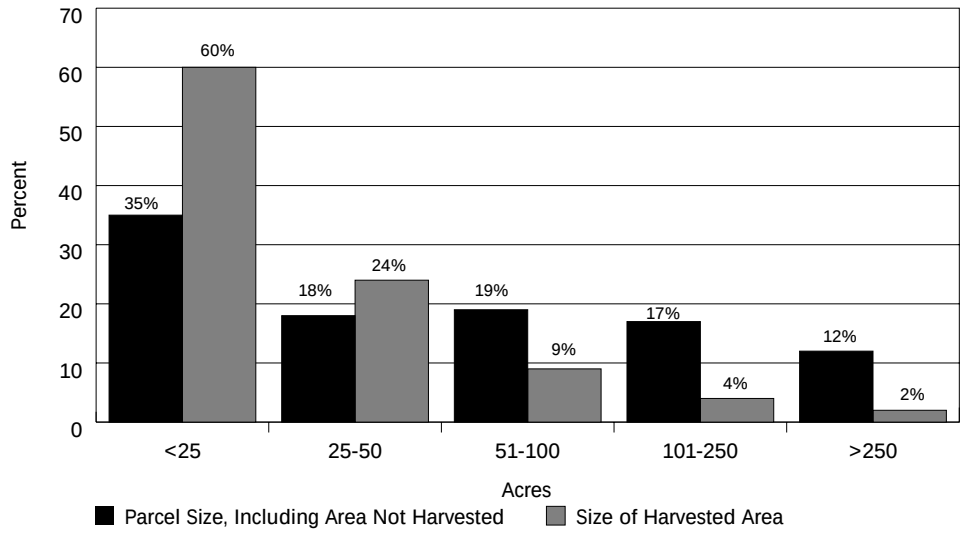
The fact that a harvested parcel is part of a larger block of forestland in one ownership may improve the economics and ease of the harvest. Potential abutter conflicts are fewer and access and road infrastructure may be better than if the harvested area were a stand-alone ownership, as was discussed in the fragmentation section. Therefore, one should not necessarily assume that a 49-acre ownership is as conducive to forestry as the 49-acre harvested area that is part of a larger parcel.

FIGURE 34. MEDIAN PARCEL SIZE BY REGION (INCLUDING ACRES NOT HARVESTED)



Source: N.H. Survey of Landowners Conducting Harvests 4/98–4/99, SPNHF/UNH Survey Center, 2000.

FIGURE 35. SIZE OF FOREST PARCEL



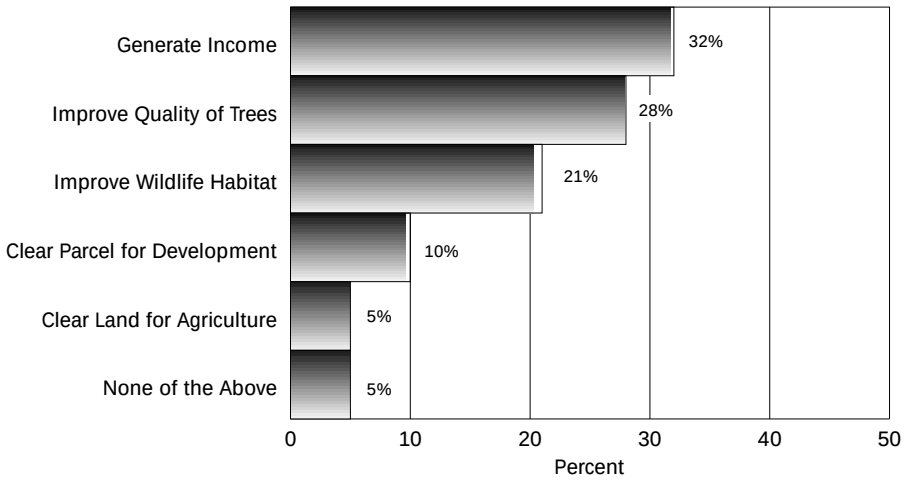
Source: N.H. Survey of Landowners Conducting Harvests 4/98–4/99, SPNHF/UNH Survey Center, 2000.

PURPOSE OF HARVESTS

Landowners were asked to identify and rank the purposes of their harvest (see Figure 36). The most important purpose for 32% of respondents was to generate income. The importance of income generation is related to parcel size. For parcels over 250 acres, owners rated income generation as very important 79% of the time, whereas owners of parcels under 25 acres rated it very important 30% of the time. Income generation was an important secondary purpose, however, for the smaller parcels.

This is a significant finding. **Owners of larger parcels place greater importance on income generation.** In the absence of a profitable forest products economy, large forest ownerships may be sold for non-forestry uses to generate income.

FIGURE 36. MOST IMPORTANT PURPOSE OF HARVEST

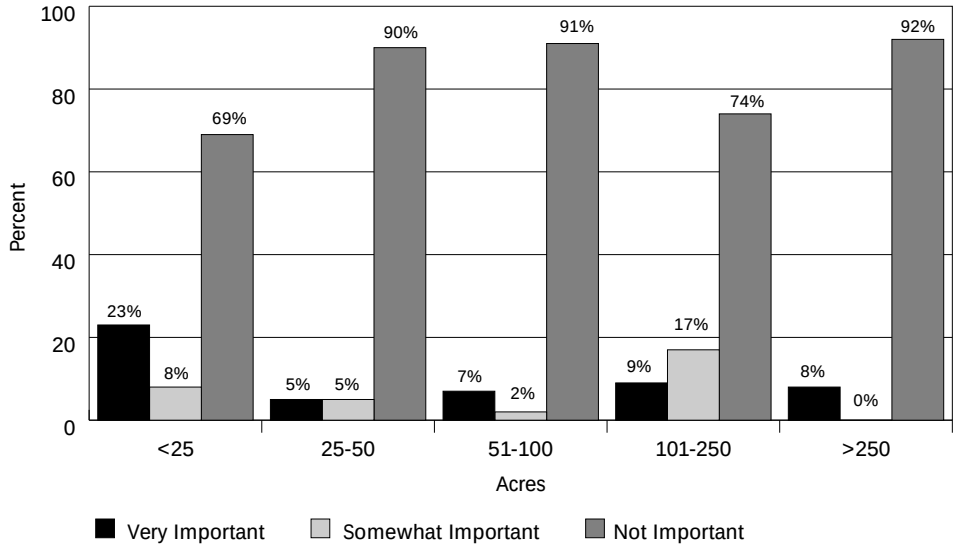


Source: N.H. Survey of Landowners Conducting Harvests 4/98–4/99, SPNHF/UNH Survey Center, 2000.

Clearing the parcel for development was rated most important by 10% of the harvesting landowners statewide. This is consistent with the terminal harvesting estimates made by foresters, loggers and mills reported in the forestland conversion section of this report. Clearing for development was very or somewhat important to 22% of the landowners statewide. This is a strong indication of the future intentions of these landowners. In Rockingham and Strafford, clearing for development was very or somewhat important to more of the owners harvesting than in any other region — 33%.

Clearing for development was very or somewhat important for 31% of the parcels under 25 acres and declined for larger parcel sizes, with an interesting exception for the 101–250 acre size class (see Figure 37).

FIGURE 37. PURPOSE OF HARVEST: CLEAR PARCEL FOR DEVELOPMENT BY SIZE OF HARVESTED AREA



Source: N.H. Survey of Landowners Conducting Harvests 4/98–4/99, SPNHF/UNH Survey Center, 2000.

Purposes of the harvest varied by region, as shown in Figure 38. Income generation was more important in Grafton/Coos than in any other region. Surprisingly, in the southeast, where 17% of landowners said that the most important purpose of their harvest was to clear the parcel for development, other owners in that region rated improving the quality of trees more highly than owners in any other part of the state. Clearly, one profile does not fit all landowners within a region.

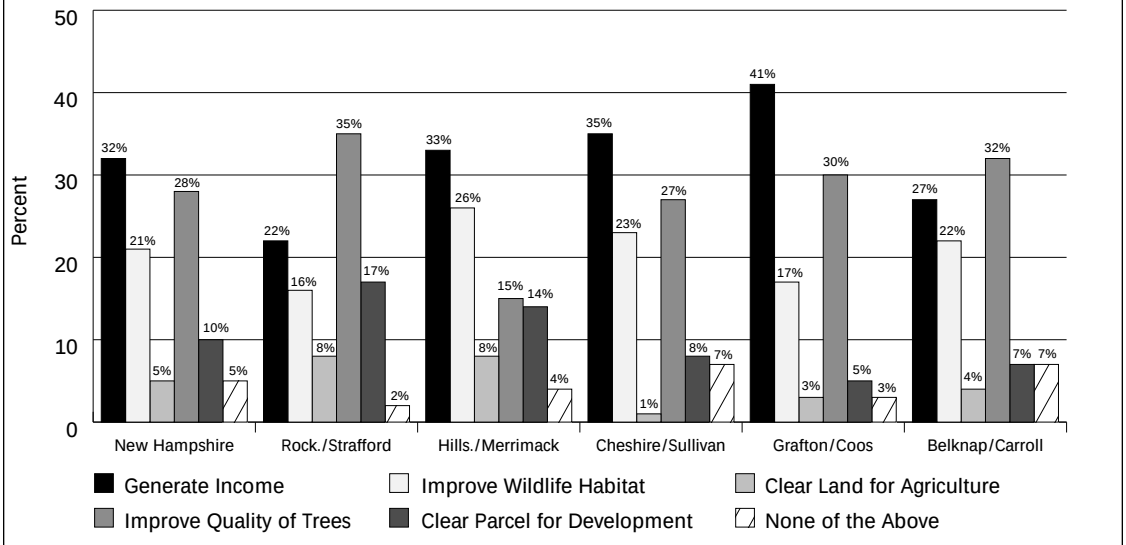
LIKELIHOOD OF FUTURE HARVESTING

In the nation as a whole, 90% of the timber removals are from private land.[49] Therefore, the attitudes of private landowners toward harvesting are very important.

In the 1983 USFS survey of New Hampshire forestland owners, 56% of the private owners holding 82% of the land said that they had conducted harvests in the past. When asked if they

[49] Sampson, Neil in Forest Fragmentation 2000.

FIGURE 38. MOST IMPORTANT PURPOSE OF HARVEST

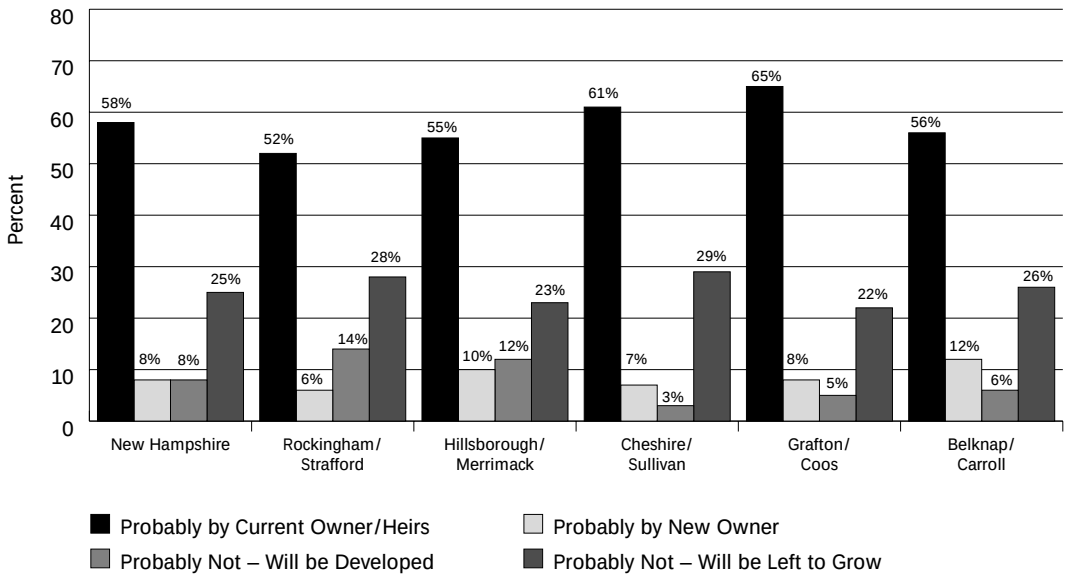


Source: N.H. Survey of Landowners Conducting Harvests 4/98–4/99, SPNHF/UNH Survey Center, 2000.

intend to harvest in the next ten years, 54% said yes and 26% said they intended to harvest in more than ten years. This accounted for 90% of the private commercial forestland base.[50]

In the FLB survey of New Hampshire landowners harvesting in 1998/9, 66% said that they expected themselves or their successors to harvest again within the next 25 years or so. **Owners of larger parcels were more likely to expect to harvest again.** In fact, only 54% of owners of less than 25 acre parcels expected that their land would be harvested within 25 years. In contrast, 100% of the owners of parcels over 250 acres expected them to be harvested within 25 years.

FIGURE 39. EXPECT PARCEL TO BE HARVESTED AGAIN OVER NEXT 25 YEARS



Source: N.H. Survey of Landowners Conducting Harvests 4/98–4/99, SPNHF/UNH Survey Center, 2000.

[50] Birch, Thomas, 1988.

Statewide, 33% of the owners expected that their land would not be harvested again in the next 25 years — 8% due to conversion to development and 25% due to leaving it to grow. Responses varied regionally, especially in the expectations about future conversion to development, as shown in Figure 39.

Likelihood of Conversion

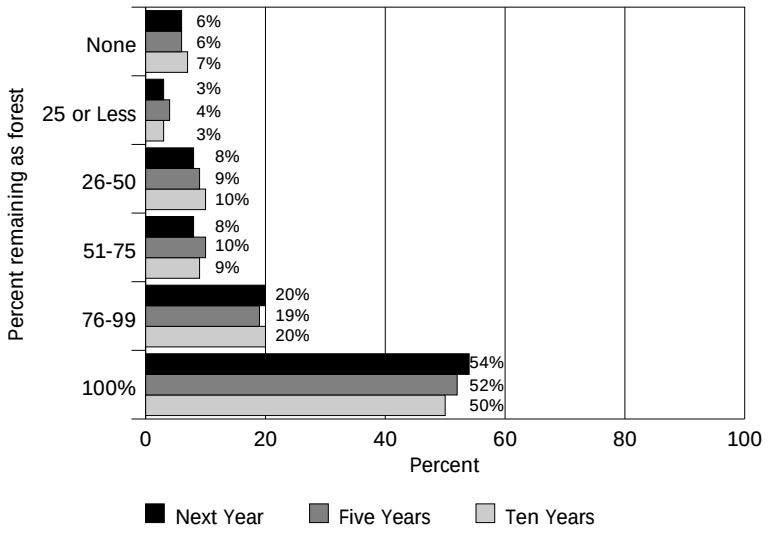
Larger parcels are more likely to remain as forest in the future according to their landowners. For parcels less than 25 acres, owners project that 75% of the parcel will remain as forest next year. For owners of over 250 acres, owners project that 98% will remain as forest next year.

Half the owners expect their forest to remain entirely as forest in 10 years (see Figure 40). Five percent expect their forest to be predominantly developed, seven percent predominantly converted to agriculture, and the remainder predominantly forest with some conversion to development and field. It appears that this question confused respondents, as they gave similar answers for their plans next year, in 5 years and in 10 years. Or, perhaps, landowners could predict their behavior next year but could not anticipate circumstances 5 or 10 years out. If these responses represent the likelihood of conversion next year rather than in 10 years, the results are alarming. At this rate, the land base could be consumed rapidly, although it is not known how much of the land base these likely converters own.

Landowners' responses were also analyzed by the size class of the area they harvested. The owners of parcels over 250 acres said they expect that 98% of their harvested area will remain as forest after one year. The owners of harvested areas of less than 25 acres said that they expect to keep only 75% of the area as forest.

In this section it has been demonstrated that New Hampshire forestland owners own their land primarily for aesthetic reasons rather than timber income. However, a significant amount of

Figure 40. How Parcel Will Be Used: Percent Remaining as Forest



Source: N.H. Office of State Planning

harvesting still occurs. As the ownership profile changes in New Hampshire, harvesting decisions could change as well. Owner survey data show that as parcel size falls,

- length of tenure drops,
- income generation is less important and wildlife and aesthetics are more important
- likelihood of harvesting in the future drops
- likelihood of converting the forest to development rises.

Declining parcel size is not necessarily the direct cause of these changes on owner decision-making. For example, people in urbanizing areas may move more often, may have higher incomes, may be less interested in harvesting and have weaker ties to the land. However, parcel size needs to be considered as a factor in landowner decisions about forest management. One of the most important reasons that parcel size may be a causal factor is economics, addressed in the next section.

Economic Impacts of Conversion, Fragmentation and Parcelization

The foregoing sections have described rapid rates of forestland conversion to development, fragmentation into smaller blocks and parcelization into smaller ownerships. This section will consider the impacts of these land base changes on the economics of forest management. Economic impacts considered by survey respondents range from the profitability of a single harvest to the profitability of long term investments in land and mills.

Minimum Economic Parcel Size

As was reported in the previous section, the median size of the harvested area in the FLB survey of landowners was 49 acres. Thirty-five percent of all harvests were conducted on parcels of less than 25 acres. However, this does not indicate that all of these harvests are economic. Landowners also reported that for 22% of all harvests, clearing or preparing the parcel for development was very or somewhat important as the purpose of the harvest.[51] Therefore, some of these harvests could have produced little economic gain. In addition, they may have yielded more volume than advisable for frequent, sustainable management.

All respondents in the forest investor survey indicated that parcels under 100 acres in size are uneconomical to purchase for long-term forest management, with most responses falling between 500 and 5000 acres. Because the number of investors and respondents is low, it is difficult to narrow this range.

When deciding whether to purchase a tract of land, investors ranked parcel size and volume second in importance to purchase price. Neighborhood population density, site productivity and stocking were also rated highly (see Figure 41).

Although less than 2% of the logger-operated acreage was in parcels of 10 acres or less, this represented 42% of all harvests conducted by loggers. In contrast, foresters managed few lots (8%) in the 10 acre and under class. It is not known whether foresters managed these lots for com-

[51] Harvests studies in the FLB survey of landowners occurred before the statute was changed to exempt harvests of less than 10 MBF sawtimber and 20 cords for land conversion purposes.

FIGURE 41. FACTORS AFFECTING INVESTOR DECISIONS TO PURCHASE LAND FOR LONG-TERM MANAGEMENT (SPNHF, 2000)

	Access to public roads	Zoning and Forestry Regulation	Parcel size / volume	Close to market	Land price	Site productivity	Existing stocking, species	Neighborhood density, attitudes	Terrain	Other
Very Important	43%	50%	86%	25%	100%	63%	63%	75%	50%	100%
Somewhat Important	43	38	14	75	0	25	38	0	50	0
Not Important at All	14	13	0	0	0	13	0	25	0	0
# Respondents	N=7	N=8	N=7	N=8	N=8	N=8	N=8)	N=8)	N=8	N=6)

FIGURE 42. PARCEL SIZE BELOW WHICH HARVEST IS UNECONOMICAL FOR ONE-TIME MARKING (SPNHF, 2000)

	Loggers	Foresters
5 Acres or less	46%	33%
6–10 Acres	14	45
11–25 Acres	18	17
26–50 Acres	14	0
More than 50 Acres	10	6
	(N=22)	(N=18)
	Median: 10 Acres	Median: 10 Acres

mercial or non-commercial purposes. Approximately 40% of foresters and loggers responded that there is a parcel size or volume below which a one-time marking by a forester is uneconomic. Their median minimum parcel size was 10 acres. Respondents were much more likely to respond "yes" to this question if they practiced primarily in southeast and central New Hampshire, where parcel sizes are smaller (see Figure 42).

In the FLB survey, mill owners reported that approximately half of their supply originated from parcels in the 11–100 acre size classes and another quarter from the 100–500 acre range (see Figure 43). Less than 10% came from parcels over 500 acres. It appears that small to mid-sized parcels (11-100 acres) are very important in supplying forest products.

Minimum economic size varies depending on the owner's objectives and harvest methods. However, all sectors surveyed recognized the management limitations of parcels under 10 acres.

STUMPAGE PRICES

Stumpage price paid to the landowner is generally the most important factor in determining the profitability of forest management for the landowner. It reflects the delivered price paid by the mill minus harvesting and management costs and their economies of scale. Two thirds of investors felt that both parcel size and sale volume affect unit stumpage prices.

As in the forest investor survey, logger and forester responses show a strong relationship between parcel size and stumpage prices. The survey postulated a hypothetical harvest holding

FIGURE 43. PERCENTAGE OF WOOD SUPPLY ORIGINATING FROM PARCEL SIZE CLASS (SPNHF, 2000)

	0–10 Acres	11–50 Acres	51–100 Acres	101–200 Acres	201–500 Acres	501–1000 Acres	More than 1000 Acres
None	46%	24%	22%	40%	42%	74%	82%
Less than 10%	24	4	6	2	16	14	12
10–25%	28	36	24	44	30	10	2
26–50%	2	24	40	10	10	2	4
More than 50%	0	12	8	4	2	0	0
Mean %	5.3	24.7	26.3	14.5	10.9	3.4	2.8
	(N=50)	(N=50)	(N=50)	(N=50)	(N=50)	(N=50)	(N=50)

constant road and landing costs, topography, loggers' chance, and stand type and volumes. Respondents were asked to report likely stumpage prices for various parcel size classes.

For the white pine stand example (applying to the 9 southern counties), unit stumpage prices reported by foresters rise 12% as parcel size increases from the 11-50 acre size class to the 201–500 acre size class (see Figure 44).

The prices reported by loggers rise 6% for this same parcel size span. For parcels larger than 500 acres, unit stumpage prices seem to stabilize. A similar question was asked for northern hardwood harvests in Coos County. Even greater economies of scale were reported, although response rates were lower (see Figure 45). In the northern hardwoods case, foresters estimated that stumpage prices would rise 27% as parcel size increased from the 11-50 size class to the 201-500 acre size class. Loggers surmised a 26% increase in stumpage prices for the same increase in parcel size class.

FIGURE 44. AVERAGE PER ACRE STUMPAGE PRICE PAID FOR WHITE PINE STAND (Q7A: LOGGERS — Q4A: FORESTERS)

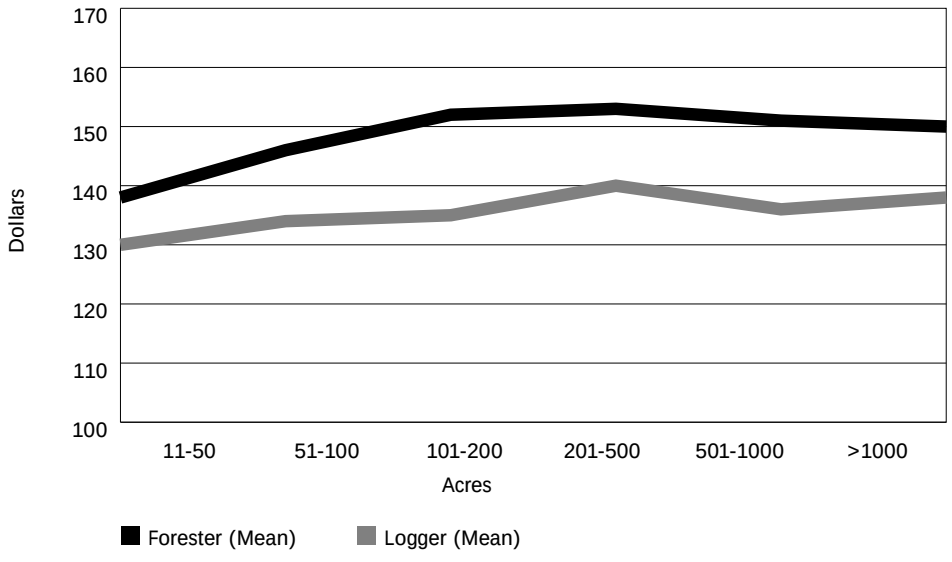
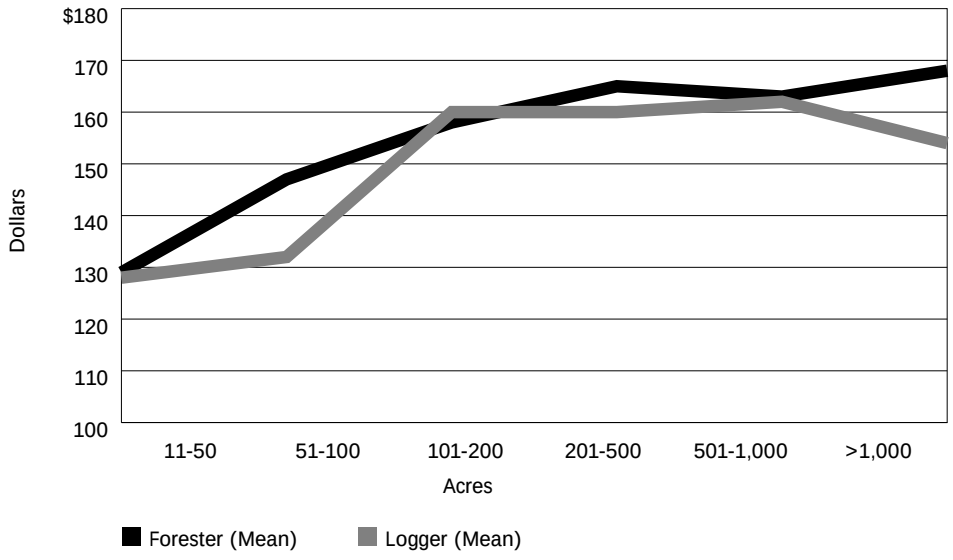


FIGURE 45. AVERAGE PER ACRE STUMPAGE PRICE PAID FOR NORTHERN HARDWOOD STAND (Q8A: LOGGERS — Q5A: FORESTERS)



The effect of parcel size on stumpage price may be dampened by the amount of liquidation and terminal harvesting on smaller parcels. These harvests can be conducted in conditions when sustainably managed woodlots should not be entered, they don't require the same care, and they have lower operating costs than might otherwise be the case on small parcels.[52]

Most mills responding (64%) said that they would not pay a higher delivered price for a larger volume. They may, however, pay a higher unit price to a reliable and continuous supplier that would, by nature, be large.

OPERATING COSTS

Operating costs are a major determinant of stumpage prices. All forest investors responding to the FLB survey agreed that parcel size affects certain unit operating costs such as road construction and management planning. The majority also identified marking, cutting and yarding and sales administration as being affected by parcel size. These economies of scale for operating costs are shown in Figure 46.

Loggers were asked to evaluate the following operating costs for a hypothetical harvest by parcel size class: cutting and yarding, moving their equipment to the site, locating boundaries, communicating with the landowner, and constructing roads and landings. Foresters were asked about costs for marking and job layout, sales administration, boundary location, and landowner communications. For both groups, unit operating costs fell most dramatically between the 10 and 50 acre benchmarks (see Figures 47 and 48).

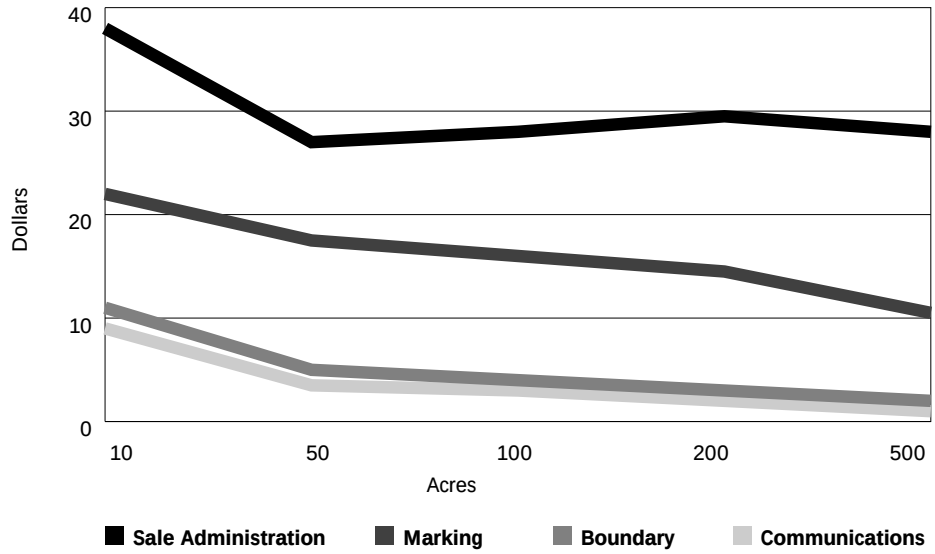
For loggers, these unit costs also continued a slow rate of decline out to about 500 acres. The exception was for cutting and yarding, which actually showed a slight increase for larger

[52] Bryce, Phil, State Forester, NH Department of Resources and Economic Development, personal communication, September, 2000.

Figure 46. Size of Parcel Affects per Acre Operating Costs (SPNHF, 2000)

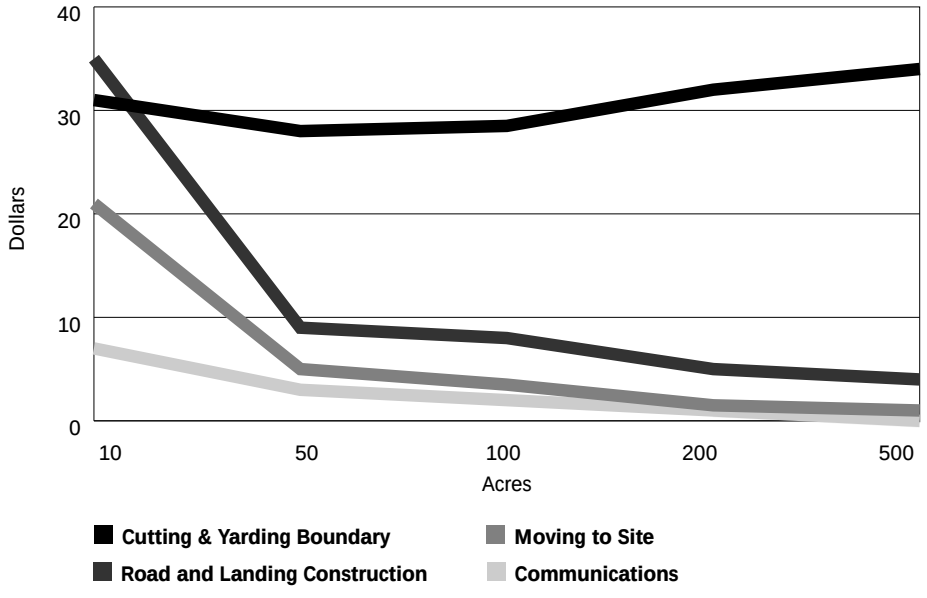
	Marking	Road and Landing Construction	Cutting/ Yarding	Sales/ Admin.	Management Planning	Other
Yes	57%	100%	71%	86%	100%	100%
No	43	0	29	14	0	0
	(N=7)	(N=7)	(N=7)	(N=7)	(N=7)	(N=2)

FIGURE 47. FORESTERS' AVERAGE PER ACRE COSTS FOR WHITE PINE STAND HARVEST



NH Forest Land Base Survey, 2000

FIGURE 48. LOGGERS' AVERAGE PER ACRE COSTS FOR WHITE PINE STAND HARVEST



NH Forest Land Base Survey, 2000

parcels, probably because of the increased skidding distance. For foresters, rates of decline in per acre operating costs are also small for parcels larger than 50 acres.

Unfortunately, we do not have data points for parcel sizes between 10 and 100 acres other than 50 acres. So, it is not possible to identify 50 acres as the break point. However, this does give us the important information that operating costs are highly sensitive to parcel size for parcels less than 50 acres in size.

Loggers reported that as parcel size drops from 50 to 10 acres, per acre costs for roads and landings increase 74%. Per acre equipment moving costs increase 80%, and landowner communications costs increase 62% for this same drop in parcel size.

In a 1994 survey of loggers in Massachusetts, Kittredge found that loggers were willing to bid on a 20 acre timber sale, regardless of the volume. As distance from the sale increased, willingness of loggers to bid decreased. Nearly 90% of the respondents would be willing to travel 5 miles from home for a 20 acre sale but only about 30% would travel 50 miles for the same 20 acre sale.[53] The mean smallest-acreage timber sale that the respondents had purchased was 7.8 acres. Willingness to bid on smaller sales also declined as wood quality decreased.

Apparently it is economic to log even very small parcels if sufficient volume is present in today's forest economy. In another study done for the New Hampshire Timberland Owners Association, "lots as small as 5-10 acres could be economically harvested (for biomass) by a small sized logging crew if the lot produced at least 35 tons per acre."[54] What is not known is whether logging crews could sustain themselves if many or most of their jobs were this size.

One last indicator of the impact of parcel size on the economics of forest management was measured in the FLB survey of mill owners. Those mills that own forestland were asked how likely it would be for them to sell various sized parcels following a harvest. Figure 49 shows that they expressed a much stronger inclination to sell small parcels than large ones. This is an indication that mill owners recognize the economy of scale in owning larger parcels.

Buying Radius

Buyers report that the overall mean trucking distance to the mill was 63 miles. Distances are smaller for sawmills (mean of 54 miles) and largest for pulp logs (mean of 84 miles, see Figure 50). Competition and stumpage prices were cited as the most important influences on buy-

Figure 49. Likeliness to Sell Land After Harvest Based On Parcel Size (SPNHF, 2000)

	0–10 Acres	11–50 Acres	51–100 Acres	101–200 Acres	201–500 Acres	501–1000 Acres	More than 1000 Acres
Very Likely	50%	33%	25%	27%	18%	18%	18%
Somewhat Likely	25	17	8	9	0	0	0
Somewhat Unlikely	0	17	25	18	18	18	18
Very Unlikely	25	33	42	46	64	64	64
	(N=12)	(N=12)	(N=12)	(N=11)	(N=11)	(N=11)	(N=11)

53 Kittredge, 1996.

54 Klemarczyk, 1994.

FIGURE 50. DISTANCE FROM MILL WHERE MAJORITY (80%) OF WOOD WAS PURCHASED (SPNHF, 2000)

	Pulpchip Mill	Biomass Mill	Pulplog Mill	Sawlog Mill	Total
Less than 25 miles	0%	0%	9%	10%	8%
25-50 miles	50	17	27	56	51
51-75 miles	17	33	18	17	16
More than 75 miles	33	50	46	17	25
Mean Distance (miles)	65.8	75.8	84.1	54.0	62.8
	(N=6)	(N=6)	(N=11)	(N=41)	(N=49)

ing radii. Loss of the forestland base was cited as important to very important in its effect on buying radius by 53% of respondents. This effect is likely to be more pronounced in parts of the state where forest conversion is more extensive. Parcel and sale size were only somewhat important influences on buying radii. This is consistent with the responses about the impact of parcel size on delivered prices paid. Buying radii determine trucking costs, discussed below.

Forest products buyers are fewer and farther apart than they were in decades past. In New Hampshire, many smaller mills have closed and many of the remining mills have expanded. The overall production volume is higher and the remaining mills are generally much more efficient and may be able to offer a better price than the closed mills, despite the increased trucking distances. As more land is converted to development, mills will need to reach farther to bring in the same volume of wood, thereby increasing trucking costs. A map of present mill locations is shown in Figure 51.[55] Only mills producing over 250 MBF (250,000 board feet) per year are included. The average buying radii for these mills of 60–80 miles may stretch halfway across the state and into neighboring states. They draw wood from a huge area. The scarcity of mills in the more developed part of the state is evident. Forest owners in this more fragmented and parcelized region must face longer trucking distances and higher costs, in addition to the other disincentives to forest management.

TRUCKING COSTS

Survey results indicate how trucking costs increase with distance to market (see Figure 52). Costs reported by loggers and foresters were very consistent and began at a median of $30/MBF for a haul distance of up to 10 miles and double to $60/MBF for a distance of 100 miles or more. For an average load of sawtimber valued at $125/MBF, this would represent a decrease of 24% in profits due to the longer haul distance. More research needs to be done on the impact of land base loss upon mill profitability and mill closures due to larger buying radii. Forestland conversion causes mills to reach farther for wood and trucking costs increase as shown on page 71.

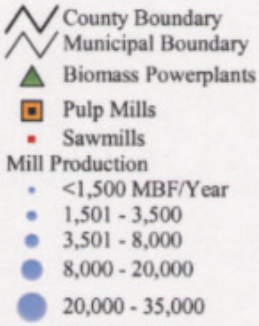
[55] Mill locations supplied by UNH Cooperative Extension, Sarah Smith, March, 2001.

Figure 51

Sawmill & Biomass Power Plant Locations in N. H.

New Hampshire's Vanishing Forests

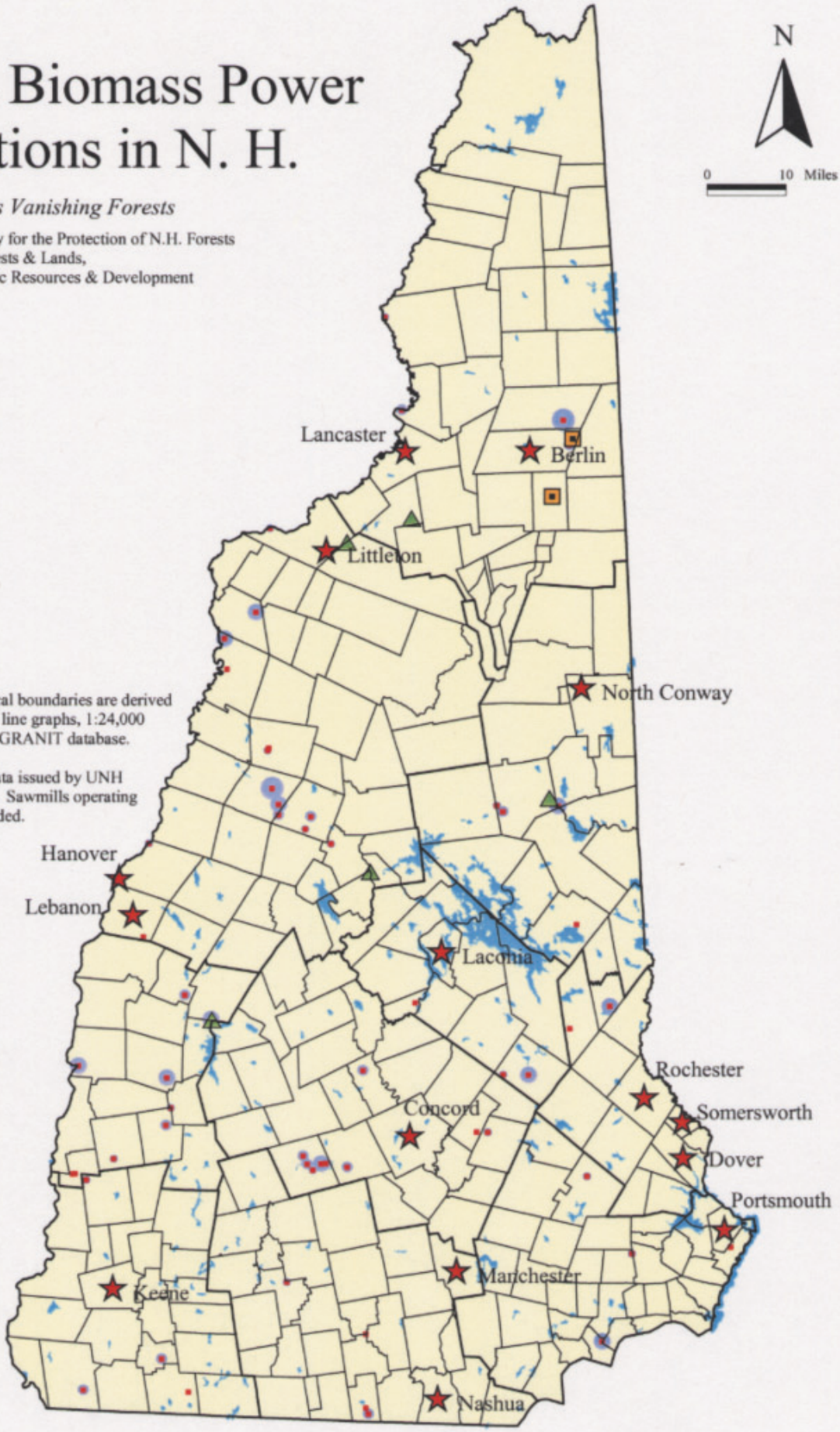
A Project of the Society for the Protection of N.H. Forests
for the Division of Forests & Lands,
N.H. Dept. of Economic Resources & Development



Data Sources:

Hydrological information and political boundaries are derived from U.S. Geological Survey digital line graphs, 1:24,000 to 1:25,000 as archived in the N.H. GRANIT database.

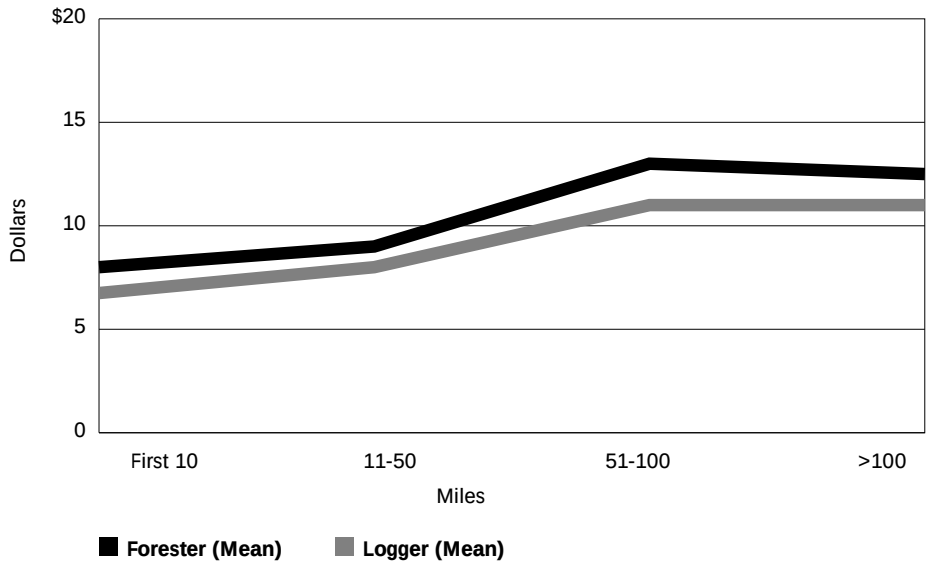
Sawmill and biomass power plant data issued by UNH Cooperative Extension March 2001. Sawmills operating at less than 250 MBF/year are excluded.



Funding for this project provided in part by the USDA Rural Development Through Forestry Program.

April 2001

FIGURE 52. TRUCKING COSTS FOR DELIVERY OF SAWLOGS: AVERAGE $/TON
(Q6: LOGGERS — Q3: FORESTERS)



SUMMARY OF ECONOMIC IMPACTS OF SMALL PARCEL SIZE

Declining parcel size and forest land conversion do reduce the profitability of forest management in the following ways:

- **There is a parcel size below which purchasing land for forest management is uneconomical for long-term forest investors.** Declining parcel size statewide may be limiting opportunities for long-term forestland investment for forest management.
- **Smaller parcels do have higher unit operating costs for most services of loggers and foresters.** Diseconomies of scale are most pronounced for parcels under 50 acres in size and are probably negligible for parcels over 500 acres.
- **Unit stumpage prices paid to the landowner rise as parcel size increases.**
- **Smaller parcels, under 10–20 acres or so, are usually uneconomical for marking or long term management planning by a forester,** even when certain subsidies are available.
- **Trucking costs increase, up to 100%, as distance to the mill increases from 10 to 100 miles.** This will significantly undermine profitability as fuel prices rise and the forest lands base close to the mills shrinks.

As the profitability of forest management on smaller parcels declines, it can be anticipated that some landowners may be induced to further subdivide or develop their land, particularly if they cannot pay the property taxes. The opportunity to practice economically and ecologically sound forest management is a vital force in retaining the forest land base — for forestry and so many other purposes.

Quality of Forest Management

In the last section, it was demonstrated that forest land base characteristics do affect the economics of forest management. How do conversion, fragmentation and parcelization affect the *quality* of forest management and the forest that remains? Quality was not assessed through field observations. Instead, the New Hampshire Forest Land Base Survey evaluated quality indirectly through questioning foresters, loggers, and landowners about harvest supervision, methods and objectives.

Employing a Forester

In his 1983 FIA survey of New Hampshire forestland owners, Birch found that most landowners using a forester had parcels over 50 acres in size. In the FLB survey, both loggers and foresters agreed with the FIA data, responding that larger parcel size does increase the landowner's likelihood of hiring a forester (see Figure 53).

Among foresters, 77% said parcel size "often" or "sometimes" affects the landowner's likelihood of hiring a forester. Most foresters (73%) also felt that merchantable volume "often" or "sometimes" affects the landowner's likelihood of hiring a forester.

Of the responding loggers, 50% said that none of their jobs were supervised or marked by a licensed forester. At the other end of the spectrum, 22% said that more than 75% of their jobs were marked and supervised by a forester (see Figure 54). These results indicate that as parcel size continues to decline, foresters may be involved less frequently and management quality may suffer.

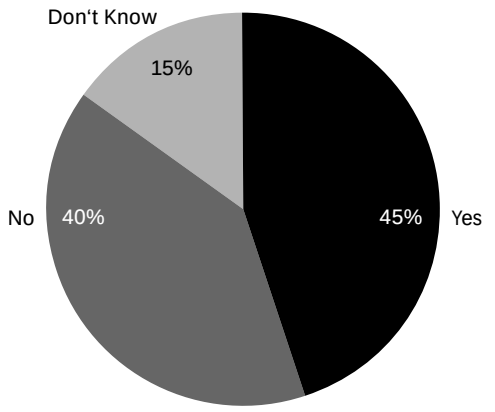
Figure 53. Parcel Size Affects Landowner's Likelihood of Hiring A Forester (SPNHF, 2000)

	Loggers	Foresters
Often	27%	30%
Sometimes	48	47
Hardly Ever	15	17
Never	10	6
	(N=88)	(N=70)

FIGURE 54. PERCENTAGE OF JOBS LAST YEAR MARKED AND SUPERVISED BY FORESTER (SPNHF, 2000)

	Loggers
No Jobs	50%
Less than 10%	7
10–25%	7
26–50%	7
51–75%	6
More than 75%	22
	(N=121)

FIGURE 55. HARVEST SUPERVISED BY LICENSED FORESTER?



Source: N.H. Survey of Landowners Conducting Harvests 4/98–4/99, SPNHF/UNH Survey Center, 2000

Among FLB landowners surveyed, 45% said that they employed a forester to supervise their harvest, 40% said they didn't and 15% didn't know (see Figure 55). There was not a striking relationship between region and hiring foresters.

When comparing rates of hiring foresters with parcel size, some interesting results are reported by harvesting landowners. For parcels over 500 acres, there is a much greater likelihood of having a forester supervise the harvest (76%). For parcels under 25 acres, a large percentage of the landowners are uninformed about whether or not they have a forester supervising their logging job. Likelihood of having a forester appears to be lower with smaller parcels, but this could be attributed, in part, to landowner uncertainty about whether they have hired a logger or a forester. National data show that the likelihood of having a written management plan and forester supervision increase with parcel size.[56]

Similarly, owners who have less tenure are either less likely to hire a forester or more likely not to know whether they have hired a forester.

Employing a Certified Logger

The New Hampshire Timber Harvesting Council has recently initiated the professional loggers' program of continuing education in an effort to improve practices. It is estimated that about half of the loggers operating in New Hampshire are certified.[57] Whether harvests conducted by certified loggers are higher in quality is not documented. Landowners were asked whether their harvests were conducted by certified loggers. Thirty-six percent said yes, 14% said no, and 49% said they don't know. This indicated that more landowner education needs to be done about the logger certification program and its benefits. Knowledge of logger certification is greatest in Grafton/Coos. More landowners were aware that harvests were conducted by certified loggers in Grafton/Coos (43%) and Belknap/Carroll (41%) than in other regions.

Management Planning

In the northern U.S., only about 5% of owners had written management plans as of 1993.[58] In the New Hampshire, the FLB surveys asked whether parcel size affects the landowner's likelihood of having a written management plan. Eighty-five percent of the foresters said "often" or "sometimes" (see Figure 56).

In New Hampshire, landowners have an economic incentive to hire foresters to write management plans. They receive a property tax reduction under current use assessment if they are following a management plan. During the survey period, some landowners may have been eligible

[56] Birch, US, 1994.

[57] Hunter Carbee, personal communication, 3/01.

[58] Birch, 1994.

FIGURE 56. PARCEL SIZE AFFECTS LIKELIHOOD OF HAVING A WRITTEN MANAGEMENT PLAN (SPNHF, 2000)

	Foresters
Often	41%
Sometimes	44
Hardly Ever	11
Never	3
	(N=70)

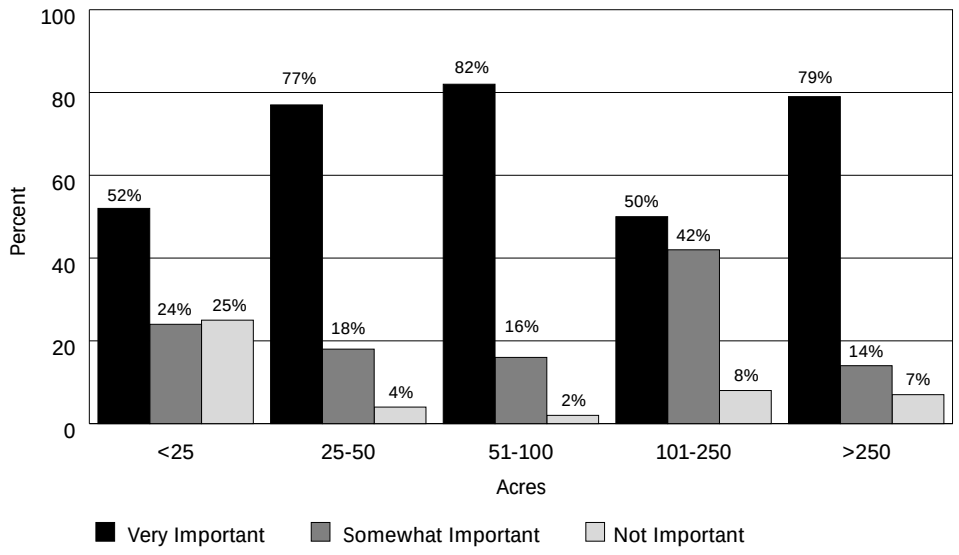
for federal Stewardship Incentive Program (SIP) funds to help pay for the plans. These subsidies for management planning make it more economical for landowners to hire foresters to write plans for twenty-acre parcels than it otherwise would be.

Loggers and foresters were asked whether there was a parcel size and volume below which a property is uneconomical for long term planning and management. Here, unlike the question above, the majority of respondents said "yes," with a stronger majority for foresters (61%) than loggers (52%). The median threshold parcel size cited by loggers was 20 acres and by foresters was 11 acres. The volume thresholds were 75 MBF for loggers and 30 MBF for foresters (however the response rate was low). It is interesting to note that the threshold cited by loggers is considerably higher than that cited by foresters. It is possible that the loggers were not considering the aforementioned management plan subsidies, whereas the foresters were.

PURPOSE OF HARVEST

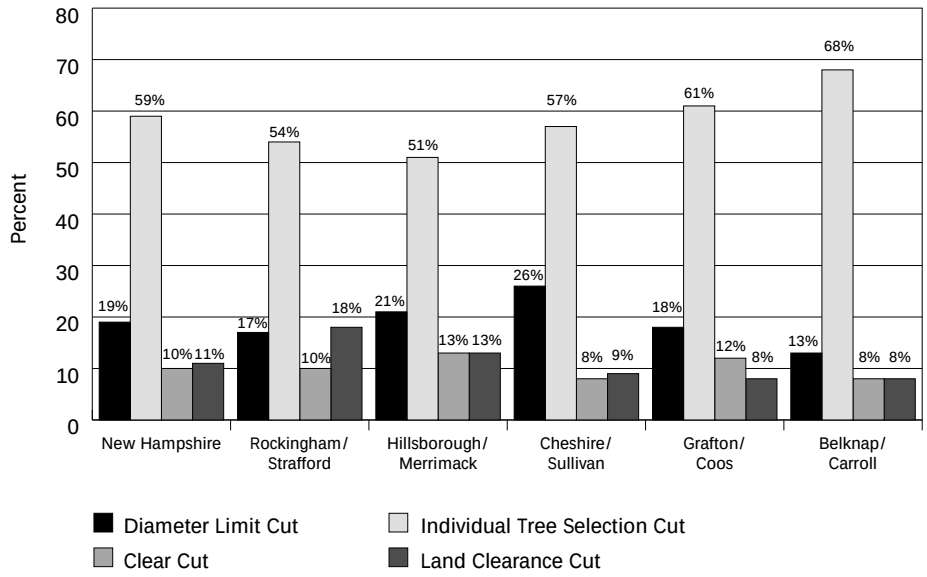
Landowners were asked whether improving the quality of their forest in the future was a purpose of their recent harvest. **Improving the quality of their forest was a less important purpose for small parcel harvesters than for large.** For landowners of parcels under 25 acres, this was a markedly less important purpose than for larger landowners (see Figure 57). In fact, for 25% of these small owners, improving forest quality was not an important purpose at all. The responses

FIGURE 57. PURPOSE OF HARVEST: IMPROVE QUALITY OF FUTURE FORESTS BY SIZE OF HARVESTED AREA



Source: N.H. Survey of Landowners Conducting Harvests 4/98–4/99, SPNHF/UNH Survey Center, 2000

FIGURE 58. PREDOMINANT HARVESTING METHOD USED



Source: N.H. Survey of Landowners Conducting Harvests 4/98–4/99, SPNHF/UNH Survey Center, 2000

for the 101–250 acre size class is anomalous and corresponds to the heavier use of diameter limit cutting for this class. This may be a popular size class for logging contractors to purchase and liquidate.

HARVEST METHOD

The predominant harvesting methods used by landowners harvesting in 1998/9 are shown in Figure 58. Although some harvests combine these and other methods, to avoid confusion, respondents were asked to generalize. Individual tree selection was the predominant method used in 59% of the harvests. Diameter limit cutting was most prevalent in the southwest. Land clearance cuts and clear cuts comprised 28% of the harvests in the southeast and 26% of the cuts in the south-central region.

The relatively uniform level of clear cutting by region is surprising. Although speculative, it is likely that land that is clear cut in the southern part of the state will be developed before it reverts to mature forest. It could be that the surrounding climate of land development induced the landowner to clear cut since land values for development far outpace future timber values. In effect, these may be terminal harvests.

Land clearance cuts are seldom used for parcels above 25 acres. They are used 18% of the time for parcels under 25 acres. Land clearance often occurs simultaneously with subdivision to make way for development. The majority (56%) of loggers said that there was a minimum parcel size below which they start charging for land clearing. The median value was 3.5 acres and 187 MBF of sawtimber. Two thirds of loggers said that they don't cut more per acre on smaller tracts "to come out whole" for logging jobs that are not land conversions, although half of the loggers that operate in the southeast said that they *do* cut harder on smaller tracts.

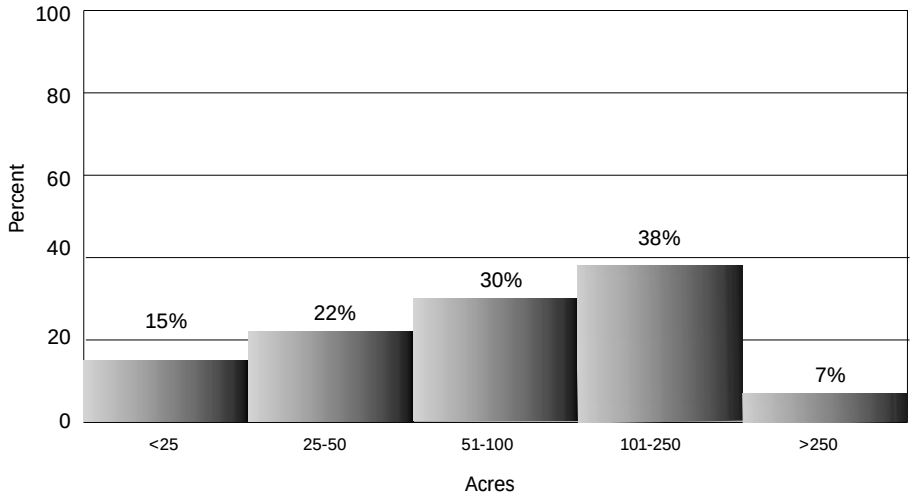
Conventional diameter limit cutting is not considered to be a sound silvicultural practice. It is conducted without regard to the species, quality, and spacing of the removed and residual trees, or other site conditions. Loggers reported that 49% of their collective harvests were con-

ducted using diameter limits. Thirty two percent of all acreage operated by responding loggers was cut according to diameter limits.

The FLB landowner survey results indicate that diameter limit cutting increases with parcel size until the 250 acre mark (see Figure 59). The size class that has the highest level of diameter limit cutting, 38%, is 101–250 acres. The rate falls dramatically to 7% for parcels over 250 acres. Could this be because the owners that tend to be engaged in diameter limit cutting feel that the larger parcels will be difficult to develop and resell as quickly as the 101–250 acre range?

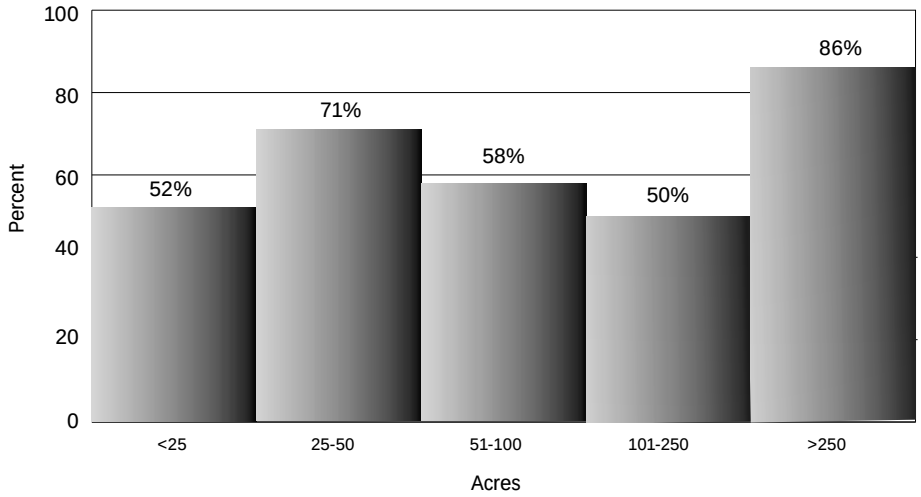
Individual tree selection harvesting is more often used on parcels over 250 acres than in any other size class, as seen in Figure 60. This is consistent with the greater likelihood of hiring a forester for these larger parcels.

FIGURE 59. PREDOMINANT HARVESTING METHOD USED: DIAMETER LIMIT CUT



Source: N.H. Survey of Landowners Conducting Harvests 4/98–4/99, SPNHF/UNH Survey Center, 2000

FIGURE 60. PREDOMINANT HARVESTING METHOD USED: INDIVIDUAL TREE SELECTION CUT



Source: N.H. Survey of Landowners Conducting Harvests 4/98–4/99, SPNHF/UNH Survey Center, 2000

Timber Stand improvement

An important determinant of future forest quality is whether timber stand improvement is conducted either as part of a commercial harvest or on its own. Trees that are diseased, damaged, misshapen, or crowded can be culled so that the residual stand increases in value and vigor. It may be harder to find markets for pulpwood from small jobs. When pulp prices are low, it may only pay to conduct mechanized harvests, which can be prohibitive on small parcels due to equipment moving costs.[59] Therefore, it may be harder to practice good silviculture on the smallest lots with an emphasis on the quality of the forest decades from now.

In fact, timber stand improvement on small parcels may only be feasible if conducted by the owners themselves or by hiring foresters to do "woodscaping." Defined as "…the art and science of enhancing aesthetics, recreational opportunities, and wildlife habitats by using forest management principles and practices," woodscaping is a developing opportunity for foresters in parts of the country that have become heavily fragmented and parcelized.[60]

Seventy-eight percent of all loggers said that they are not able to afford to harvest strictly pulpwood quality woodlots. What this tells us is that unless there is sawtimber, an improvement cut or thinning operation may be uneconomic. It is not known whether parcel size would have an effect on this response.

Summary of Impacts on Quality

There are several negative influences of small parcel size on the quality of management, most asserted through the diseconomies of scale of managing small parcels. Foresters are much more likely to be hired by larger harvesting landowners than small (76% with parcels over 500 acres). Landowners with longer tenure, who tend to have larger parcels, are more likely to hire a forester. Larger harvesting landowners are more likely to have a written management plan and say they place greater emphasis on improving the quality of their forest when harvesting. Very large owners (above 250 acres) are more likely to use the individual tree selection method than any other size class.

Small parcels and fragmented forests do not cause poor management. Many owners of small parcels care deeply about their forests. However, due to the rapid turnover in ownership relative to the time it takes to grow a forest, a generation of good management can be obliterated overnight. The diseconomies of scale facing small woodlot owners can dissuade them from hiring a forester and chosing a harvest method that will sustain the biodiversity, health and value of their forest.

[59] Moreno, Charles, personal communication, January 6, 2000.
[60] Campbell, 1998.

Protection of the Forest Land Base

Approximately 22.7% of the state's land base is permanently protected from development.[61] An estimate of the portion of the forest land base that is protected was derived from overlaying the GRANIT *Conservation and Public Lands* data layer on top of the UVM forest land coverage data layer for New Hampshire. Results indicate that 25% of the (1992/93) forest land base is protected amounting to 1,209,093 acres. See Figure 61 for the locations of protected forest land in New Hampshire. The types of owners or conservation easement holders for this protected land are shown in Figure 62. About 13% of the protected forest land base consists of the White Mountain National Forest. State agencies, municipalities and private conservation organizations hold most of the balance, in descending order of magnitude.

Protection of Productive Soils

It is important to know how effectively the state's productive forest soils are being protected. Are productive soils more or less protected than the average? By overlaying the important forest soil groups for counties for which digital data are available with the conservation and public lands data layer, this question can be answered. The analysis, reported in Figure 63, shows that the more productive soils (1A, 1B, & 1C) are proportionately *less* protected. It is important to note that soils for the White Mountain National Forest are not included.

This disparity is not surprising since protection efforts have tended to focus upon the prominent mountain peaks that are valued for scenic beauty, recreation and habitat. Identifying and protecting forests for their productive potential has not been a high priority of most public and private land protection programs. This may change, however, if citizens can sustain and increase current funding levels for the Forest Legacy and New Hampshire Land and Community Heritage Investment programs to purchase conservation easements on productive, working forest land.

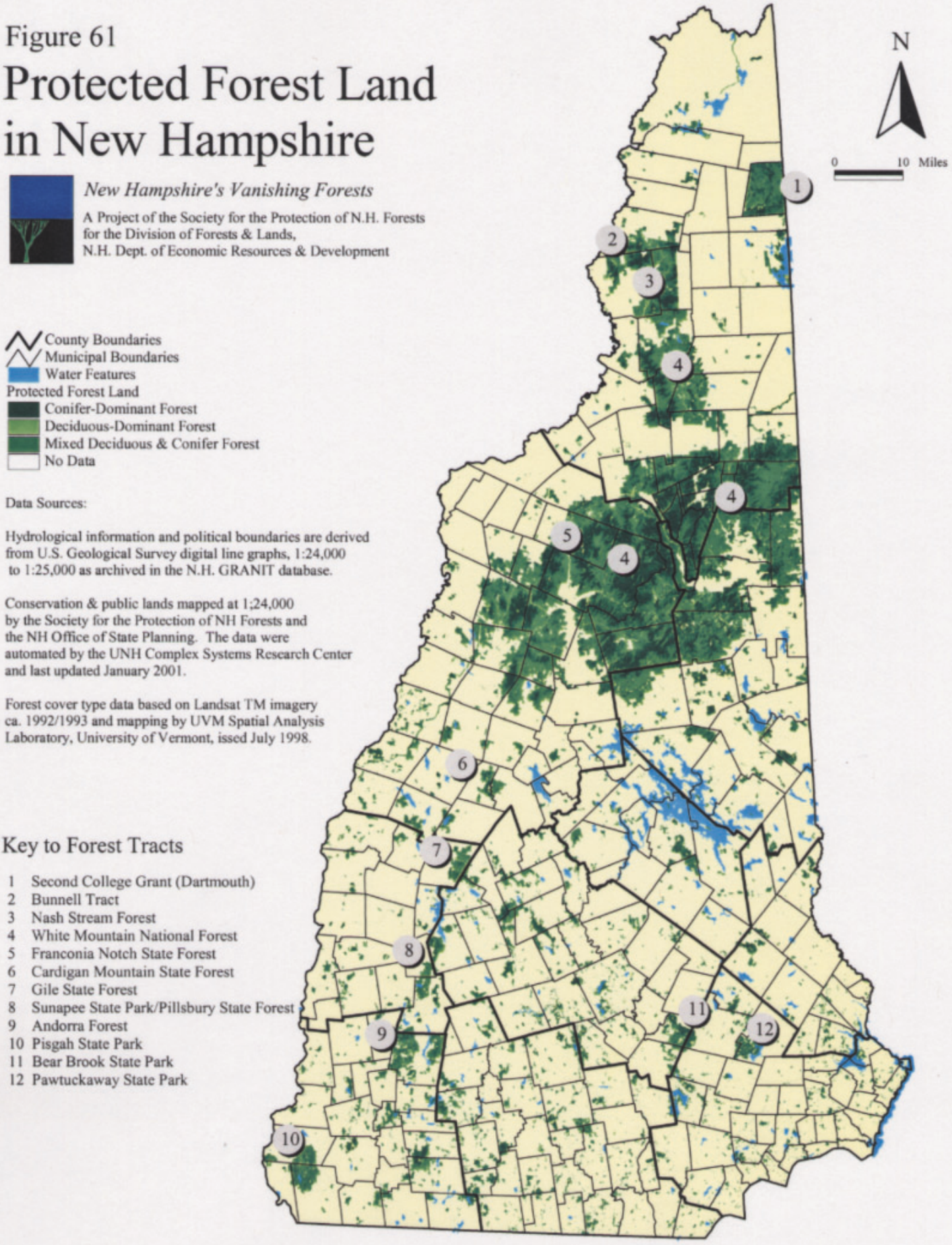
[61] GRANIT Conservation and Public Lands Data Layer, 1998 identified 1,293,565 acres of protected land. Since then, SPNHF estimates that at least 25,000 acres have been permanently protected.

Figure 61

Protected Forest Land in New Hampshire

New Hampshire's Vanishing Forests

A Project of the Society for the Protection of N.H. Forests
for the Division of Forests & Lands,
N.H. Dept. of Economic Resources & Development



County Boundaries
Municipal Boundaries
Water Features
Protected Forest Land
Conifer-Dominant Forest
Deciduous-Dominant Forest
Mixed Deciduous & Conifer Forest
No Data

Data Sources:

Hydrological information and political boundaries are derived from U.S. Geological Survey digital line graphs, 1:24,000 to 1:25,000 as archived in the N.H. GRANIT database.

Conservation & public lands mapped at 1;24,000 by the Society for the Protection of NH Forests and the NH Office of State Planning. The data were automated by the UNH Complex Systems Research Center and last updated January 2001.

Forest cover type data based on Landsat TM imagery ca. 1992/1993 and mapping by UVM Spatial Analysis Laboratory, University of Vermont, issed July 1998.

Key to Forest Tracts

1 Second College Grant (Dartmouth)
2 Bunnell Tract
3 Nash Stream Forest
4 White Mountain National Forest
5 Franconia Notch State Forest
6 Cardigan Mountain State Forest
7 Gile State Forest
8 Sunapee State Park/Pillsbury State Forest
9 Andorra Forest
10 Pisgah State Park
11 Bear Brook State Park
12 Pawtuckaway State Park

Funding for this project provided in part by the USDA Rural Development Through Forestry Program.

April 2001

Figure 62

Conservation & Public Lands in New Hampshire

New Hampshire's Vanishing Forests

A Project of the Society for the Protection of N.H. Forests
for the Division of Forests & Lands,
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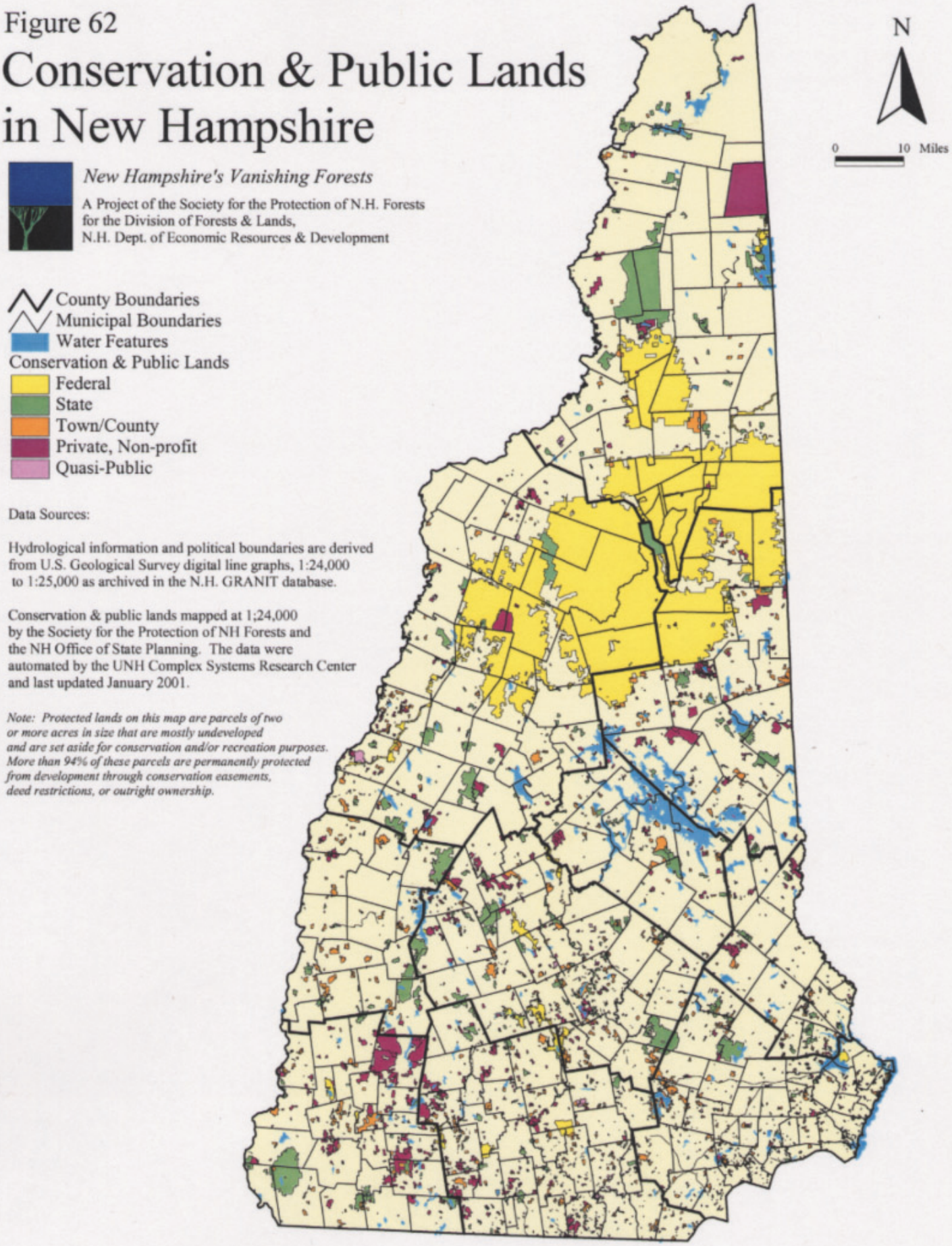


County Boundaries
Municipal Boundaries
Water Features
Conservation & Public Lands
Federal
State
Town/County
Private, Non-profit
Quasi-Public

Data Sources:

Hydrological information and political boundaries are derived from U.S. Geological Survey digital line graphs, 1:24,000 to 1:25,000 as archived in the N.H. GRANIT database.

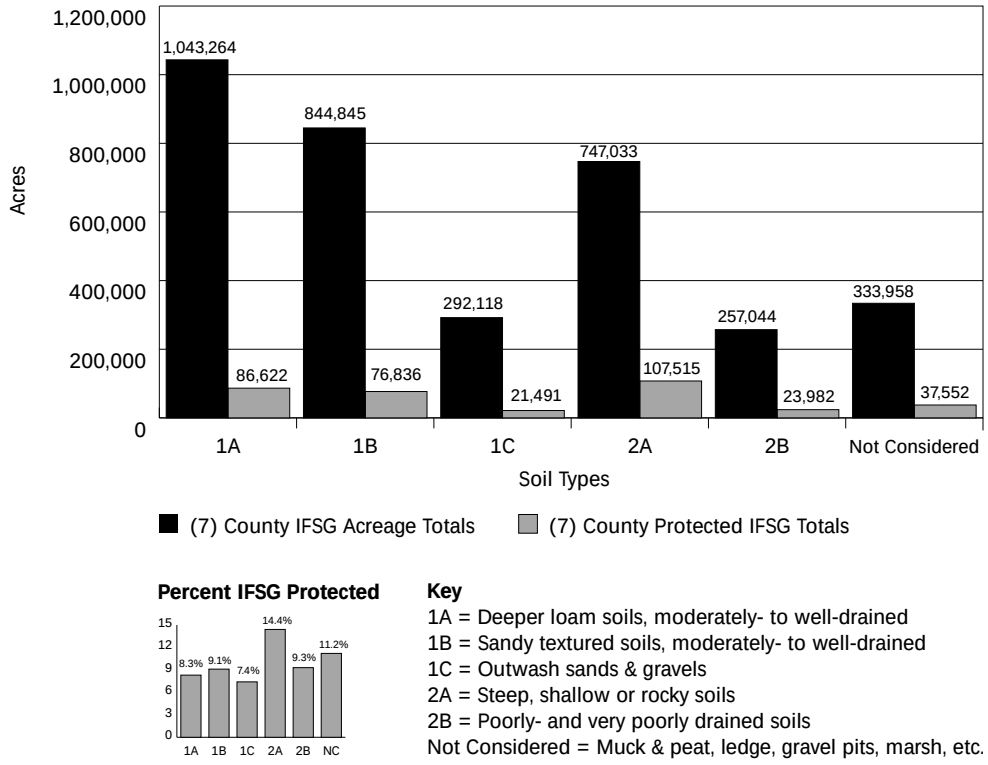
Conservation & public lands mapped at 1;24,000 by the Society for the Protection of NH Forests and the NH Office of State Planning. The data were automated by the UNH Complex Systems Research Center and last updated January 2001.

Note: Protected lands on this map are parcels of two or more acres in size that are mostly undeveloped and are set aside for conservation and/or recreation purposes. More than 94% of these parcels are permanently protected from development through conservation easements, deed restrictions, or outright ownership.

Funding for this project provided in part by the USDA Rural Development Through Forestry Program.

April 2001

FIGURE 63. SEVEN COUNTY ANALYSIS OF IMPORTANT FOREST SOILS GROUPS IN N.H. WITH PROTECTION STATUS



PROTECTION OF LARGE FOREST BLOCKS AND OWNERSHIPS

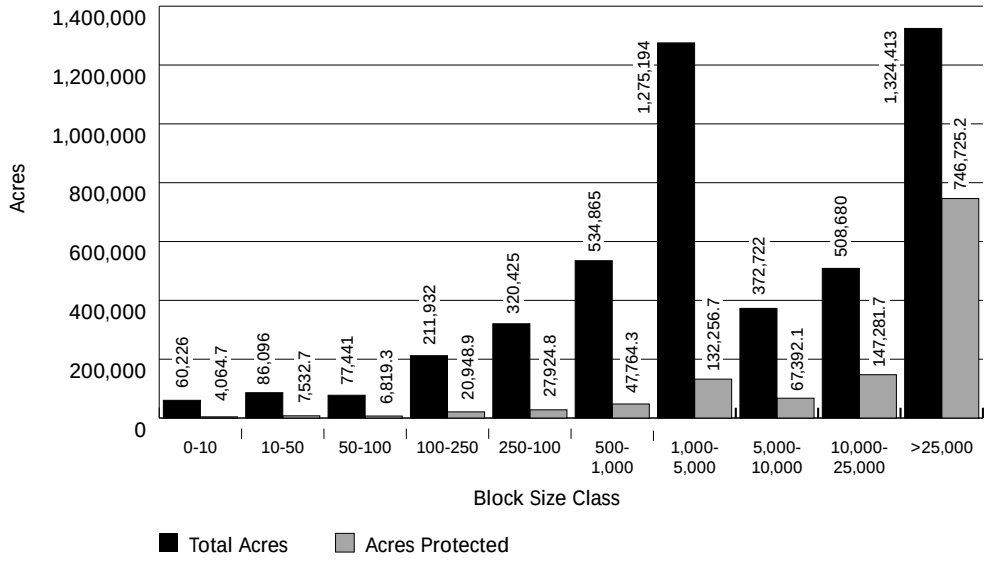
The protection status of the large blocks is depicted in Figure 64. Protection efforts have been particularly successful for the blocks over 10,000 acres. **Fifty six percent of the forest area in blocks over 25,000 acres have been protected.** In the 10,000-25,000 acre size class, 29% of the area has been protected. Forestland in the 1,000-5,000 acre class is proportionately least protected of all size classes.

Another perspective of forest block classes and their protection status is shown in Figure 65. Over sixty percent of all protected forest in the state is in blocks of over 25,000 acres. **Ninety percent of protected forestland is configured in blocks of 1000 acres or more.** This bodes well for many of the functions of the forest that rely upon large blocks, particularly the habitat and water quality values.

Another important characteristic of protected forest lands is their parcel size. Parcel size is a significant determinant for habitat quality, recreation values, ecosystem integrity and economics of management. No statewide analysis of the protection status of large parcels could be conducted, due to the lack of digital data. However, this could be done by local conservationists using paper tax maps for their communities to help identify priorities and opportunities for protection. The ten largest protected forest ownerships (including some non-forested areas) in the state are shown in Figure 66. Many of these ownerships can be seen in Figure 61.

They are important building blocks for expanded protection and linkages with other large forest blocks.

FIGURE 64. N.H. FOREST BLOCKS AND PROTECTION STATUS BY SIZE CLASS



These forests are of enormous value for a diversity of uses. Most are public ownerships including the National Forest, state parks and forests, wildlife management areas, and water supply lands. Others are owned by private conservation organizations. Still others are owned by private landowners with conservation easements that permanently restrict subdivision and development on the property.

The 1000+ acre parcels are large enough to provide remote recreational experiences, economic forest management, and habitat for many native species. A listing of all protected parcels over 1000 acres in size is in Appendix C. Together, these large parcels account for 22% of all the protected forestland. These 1000+ acre forest ownerships are far larger than the average protected

FIGURE 65. PERCENT OF FORESTED LAND AND PERCENT PROTECTED FOREST BY BLOCK SIZE CLASS

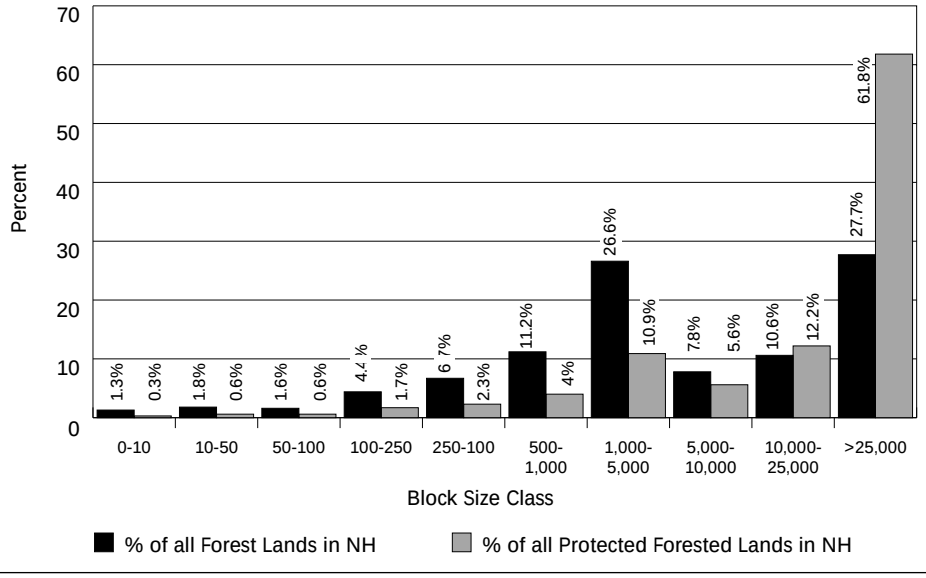


FIGURE 66. TEN LARGEST PROTECTED FOREST OWNERSHIPS IN NH (EXCLUDING WMNF)

Protected Forest Ownership	N.H. Acres*
Nash Stream State Forest	39,574
Second College Grant	26,774
Bunnell Forest	18,687
Pisgah State Park	13,249
Andorra Forest Conservation Easement	11,457
Bear Brook State Park	9472
Hopkinton-Everett Flood Control Reservoir	7813
Franconia Notch State Park	6940
Gile State Forest	6729
Cardigan Mountain State Forest	5458

*acreage from GRANIT Conservation & Public Lands datalayer, and by personal communication with TNC on Bunnell Forest

parcel of 100 acres (calculated excluding the White Mountain National Forest). However, the number, shape and spatial distribution of forest parcels may be as important as the overall acreage protected for may forest functions. Increasing parcel size and linkages between protected forests will significantly improve the functional integrity of the larger working forest landscape.

SUMMARY OF PROTECTION STATUS OF FOREST LAND BASE

New Hampshire is fortunate to have protected one in four of its forested acres. The remaining challenge is to achieve levels of protection in the south and east to match those in the north and some western towns. The remaining large forest blocks should be high priorities for permanent protection. Blocks over 500 acres in suburbanizing portions of the state should receive urgent attention. Soils and sites conducive to forestry also have been under-protected and need to be identified and conserved.

Availability of Forestland for Forest Management

What determines whether a given forest is available for forest management? The land needs to be accessible by harvesting equipment and trucks, that is, operable. Operators must be able to maneuver equipment and logs in a manner that is safe for workers and the environment. The land needs to be economically as well as physically operable, for example, large enough and close enough to market. Harvesting needs to be legally permissible according to regulations and deed restrictions. Ecologically sensitive lands should be avoided or managed according to science-based guidelines. The forest infrastructure, workers and markets need to be present. And, the most important decision-maker in the chain, the landowner, needs to be willing to harvest.

Operable Land

Terrain features and soil characteristics such as steep slopes, large boulders and wetness can restrict or prohibit the environmentally sound operation of conventional logging equipment or haul road construction in certain areas. Traditionally this has been called inoperable land. In reality, most of this land has been harvested over the years, whether by horses, tractors, or large equipment. However, operating costs are high due to long skidding distances, high road building costs, and hazardous conditions. Furthermore, operating in these areas is more likely to result in environmental damage. There is considerable debate about the definition of inoperable land. For the purposes of this analysis, lands that are not practically accessible or environmentally conducive to harvest are not considered part of the land base that is available for forestry.

Slopes greater than 35% (a rise of one foot in a run of three and a half feet) not only impose severe mechanical constraints to equipment operation, but also require added expense to avoid soil erosion resulting from skidding logs or road construction. Extensive glacial boulder fields and associated rock outcroppings can make it difficult or impossible to move machinery through a woodland. Bogs, swamps and other perennially wet areas may be accessible to machinery only when frozen, or not at all depending on the presence of water near or at the surface. Sites that may otherwise be operable may also become inaccessible due to rough intervening terrain, swamps and marshes, watercourses, or, in some situations, land under other ownership.

Topographic elevation is also a factor in determining operability, especially in the mountainous areas of the state. Above an altitude of approximately 2,500 feet, the northern hardwood forest transitions rapidly to sub-alpine spruce-fir, reflecting the climatic influences and marginal growing conditions caused by low soil fertility and cold soil temperatures. Not only is it more difficult to sustain forest productivity in this harsh environment, but steep, complex terrain and boulder fields also severely limit machinery access and mobility. A voluntary limit of 2700 feet is used in New Hampshire, but 2500 feet is used in this analysis.

Legally Restricted Land

Finally, a significant amount of land in New Hampshire is also rendered effectively unavailable from a forest management standpoint by regulation or easement and deed restrictions. As yet, there are no statewide forestry regulations that prohibit forestry on certain lands. Although there are limits on the volume that can be removed in shoreline areas, harvesting can still occur.

Designated wilderness areas in the White Mountain National Forest and certain other "natural areas" on public and private forestland are not available for timber harvest. Designated wilderness areas in the New Hampshire portion of the White Mountain National Forest encompass more than 99,200 acres of forestland. There is no tally of natural areas on private land, but it likely exceeds 20,000 acres. Recently, the Clinton administration set-aside another 45,000 acres of available forest on the White Mountain National Forest from timber harvesting. Although this decision could be reversed, it is likely that more wilderness areas will be set aside on federal and private lands in New Hampshire.

Calculation of Inoperable and Restricted Areas

Four statewide data layers were correlated in the GIS to calculate the unavailable or inoperable portions of the forest land base in New Hampshire:

- Steep slopes (gradients >35%)
- Very poorly-drained soils
- High elevations (2,500' and greater)
- Designated wilderness areas in the WMNF

The data layer for high elevation lands was generated from USGS 1:100,000 topographic contour line data converted to polygons for area measurement. Steep slopes were modeled by the GIS software from USGS digital elevation data, and then converted from the native 30-meter grid format to polygons. Very poorly-drained soils were derived from digital county soil surveys published by the Natural Resource Conservation Service for seven of ten counties in New Hampshire.[62] Official wilderness area boundary polygons for the New Hampshire portion of the White Mountain National Forest were obtained from the USDA Forest Service office in Laconia, N.H.

All data layers were overlaid on one another systematically to identify and remove overlapping polygons, thus avoiding double counting of inoperable acreage. For example, because high elevation terrain and designated wilderness areas are largely coincident, the two factors were merged into a single data layer for ease of use, and then that coverage was used to "erase" slopes greater than 35% within the combined data layer. Very poorly drained soils were similarly adjusted to remove overlapping data.

[62] Carroll, Cheshire, Grafton, Hillsborough, Rockingham, Strafford, and Sullivan Counties

The second step was to determine the actual forested land area of each factor by overlaying digital forest cover type mapping on each data layer.[63] The cover type mapping used depicts three forest cover classes: conifer-dominant, deciduous dominant, and mixed conifer and deciduous forests; however, these cover classes were combined in calculating the total forested land area within each factor affecting inoperablity.

It should also be noted that clearcuts and other large forested openings attributable to ongoing silvicultural operations were mapped as non-forest land in the original land cover type mapping by UVM. By correlating another GIS datalayer specifically made to document clearcuts statewide[64] with the non-forest cover type class, about 15,625 acres of cleared forest land was added to the acreage of forest cover in the land cover mapping to bring the total forested land area to 4,787,647 acres.

Figure 67 shows the results of this analysis of inoperable forest land, by county, with totals for the entire state. As can be seen, the total percent of unavailable forest land base is estimated to be about 18% when considering the four factors discussed above. However, it should be noted

FIGURE 67. GIS ANALYSIS OF INOPERABLE AND RESTRICTED N.H. FORESTLAND (SPNHF, 2001)

County	Forested Hydric A Soils	Forested Slopes >35%	Forested Wilderness Areas and/or Forested Elevations >2500'	Restricted and Inoperable County Totals	Total Forested Acres	Percent of County Forest Base Inoperable
Belknap	NA	12,266.1"	0	12,266.1	205,450.2	6.0%
Carroll	16,021.8	78,759.9	25,547.8	120,329.5	520,439.3	23.1%
Cheshire	13,379.1	25,593.4	621.6	39,594.1	377,539.1	10.5%
Coos	NA	98,186.1	179,686.4	277,872.5	1,050,933.6	26.4%
Grafton	9,188.8	129,958.5	153,997.3	293,144.6	965,603.6	30.4%
Hillsborough	17,438.8	12,568.7	0	30,007.5	422,469.2	7.1%
Merrimack	NA	24,413.2	627.8	25,041.0	478,263.8	5.2%
Rockingham	33,441.2	1,416.1	0	34,857.3	306,937.0	11.4%
Strafford	8,936.4	3,232.4	0	12,168.8	174,320.5	7.0%
Sullivan	4,239.2	21,790.1	219.1	26,248.4	285,691.2	9.2%
Total Acreage	102,645.3	408,184.5	360,700.0	871,529.8	4,787,647.4	18.2%

Notes:
1. Soils data are derived from (7) NH counties with digital data: Carroll, Cheshire, Grafton, Hillsborough, Rockingham, Strafford and Sullivan counties. Hydric A soils are very poorly drained soils, eg, muck and peat, with little or no potential for forest management.
2. Slope data are derived from USGS digital elevation models.
3. Wilderness areas are delineated by the USDA Forest Service. Elevation data are derived from USGS 1:100,000 hypsometry and are eliminated from mapped wilderness areas to avoid double counting.
4. Forested land is determined from land cover type mapping by the UVM Spatial Analysis Laboratory using 1992/93 Landsat Thematic Mapper satellite imagery. Accuracy assessment of forest cover exceeds 95%. Land in clearcuts has added to county forest land cover calculations.

[63] Forest cover derived from statewide land cover mapping generated by the University of Vermont Spatial Analysis Laboratory as part of the GAP Analysis Project. This land cover mapping is derived from 1992/93 Landsat TM satellite imagery and it assessed at 95% accuracy.

[64] Clearcut inventory was mapped from 1988-1990 and 1993 satellite imagery by UNH Complex Systems Research Center for NHDRED Division of Forests and Lands, 1995.

that this calculation does *not* include acreage of very poorly drained soils for three counties — Merrimack, Belknap, and Coos, for which digital soils data are unavailable.

There are also other important limiting factors that are not addressed in this analysis. Due to variability in soils mapping methods and standards, there is no practical method for determining the area of boulder fields sizeable enough to constrain equipment operation. Similar limitations on topographic and elevation data make it impossible to map complex terrain with short, steep slopes and ravines that make equipment operation difficult at site-scale.

The validity of defining inoperability using the four factors noted above was tested on a 5,000 acre SPNHF tract in Stoddard, N.H., where site conditions affecting equipment operation is well known by the managing forester. The GIS analysis for this hilly upland forest indicated about 560 acres, or 12% of the land, as inoperable, which is far below the forester's estimate of 50% inoperability. By factoring in soil map units classed as *extremely bouldery* at the surface, an additional 300 acres could be classed as inoperable, bringing the total to about 20% of the land area as being inoperable. This is still well below the forester's working knowledge of site conditions that limit operability. Complex terrain and inaccessible areas that exist on the site could not be calculated in the GIS, but would increase the area of inoperability, as would more detailed soils mapping.

Site conditions can be expected to vary widely in other locations around the state, but this tract is typical for the Monadnock region uplands. More study is required to accurately determine the extent of inoperable forestland statewide, but it is probably much greater than the 18% of land area noted above.

Ecologically Sensitive Lands

There are additional exclusions that could be made from the available forest land base to account for other ecologically sensitive areas that should not be harvested. According to Principle #6 of the Forest Stewardship Council's *Principles and Criteria*, "Forest management shall conserve biological diversity and its associated values, water resources, soils, and unique and fragile ecosystems and landscapes, and, by so doing, maintain the ecological functions and the integrity of the forest."[65] Vernal pools, rare plant populations, exemplary communities and unusual nesting or breeding areas are examples of sensitive lands. Management decisions for these areas are best made by professionals based upon a thorough knowledge of site conditions. It is impossible to establish intricate management prescriptions and exclusions at the statewide scale for GIS analysis.

There is growing support for setting aside the few remaining pockets of old growth forest. These areas act as refugia for species associated only or primarily with old growth conditions. They are also important sites for research and education. Inventories of old growth estimate that these forest communities occupy about .08% of the forest land base, primarily in inaccessible areas. Scientific recommendations for old growth retention (and creation) are sometimes in the neighborhood of 5% or more of the forest land base.[66] Because these patches of old growth are needed, in part, to serve a lifeboat function to disperse species to surrounding maturing forests, they cannot occur in just a few locations in the state, for example, White Mountain National Forest wilderness areas. The 5% of the forest land base needed for old growth probably needs to be more broadly distributed across the landscape. Much more research is needed to design an old growth forest plan for New Hampshire. For this analysis, we have assumed a 5% set-aside for old growth in addition to old growth conditions that may succeed on inoperable or legally restricted lands.

[65] Forest Stewardship Council, U.S., 1996.

[66] Whitman, Andy, Manomet Center for Conservation Sciences, personal communication, March, 2001.

To date there have been no estimates of the amount of land that would be necessary to sustain rare species habitat and exemplary natural communities. Further, for many species, it is not known what levels of timber harvesting they can tolerate or might require for survival. Far-ranging carnivores, for example, have diverse and extensive home range requirements for individuals and large land base requirements to sustain viable populations. Reliable scientific studies relevant to New Hampshire ecological conditions are unavailable for most species. Such information would be extremely valuable, but is beyond the scope of this study. It is known that three quarters of rare plant animal species and 60% of rare natural communities are not adequately protected on existing conserved lands.[67] To what extent they occur on the 18% or more of the land base that is "inoperable" is not known.

Landowners and Available Land Base

The preceding discussion of land available for forestry is based on the physical and legal characteristics of the land base. Within this context, landowners make the decision about whether or not to harvest their land.

In the 1983 New Hampshire FIA, 50% of the private, non-industrial landowners holding 70% of the "timberland" reported that they intended to harvest their land within the next 10 years. Another 27% of owners with 18% of the land base planned to harvest at an indefinite time. Forty four percent of the landowners holding 18% of the land base have never harvested but most indicated that they plan to harvest in the future. Only 3% of the private, non-industrial land base was held by non-harvesters who are opposed to harvesting.[68] Because most ownerships turn over every decade or two, it is likely that most forestland will be owned by a landowner that will make it available for harvest at some point.

In his 1993 survey of northern forestland owners, Birch found that nearly all of the owners planned to harvest in the future. The 2% who said that they never planned to harvest were not associated with any particular parcel size.[69] Unfortunately, we do not have more recent FIA data for New Hampshire. If 1983 attitudes are still held by today's landowners, almost all of the private, non-industrial land base is available for forestry, within the physical and legal limitations discussed above. Most of the corporate and industrial lands are available as well. Portions of the publicly owned land base, however, could become unavailable if anti-forestry sentiment grows or new scientific information warrants natural area designations.

In the NHFLB survey of landowners who have conducted recent harvests, 64% said that they expect that the land will be harvested within the next 25 years either by themselves or by a new owner. Eight percent said that the land will probably be developed and 25% said that their land will probably be left to grow.

For the most part, the larger the parcel, the more likely the landowner was to predict that the parcel will be harvested in the future (see Figure 68).

Another indication of the willingness of New Hampshire landowners to harvest is the amount of land enrolled in the Tree Farm Program. Excluding the White Mountain National Forest, 20% of the state's forest land base is a registered Tree Farm. See Appendix D for a list of numbers and acreage of tree farms by municipality.

[67] Sundquist, 1999.
[68] Birch, 1983.
[69] Birch, 1994

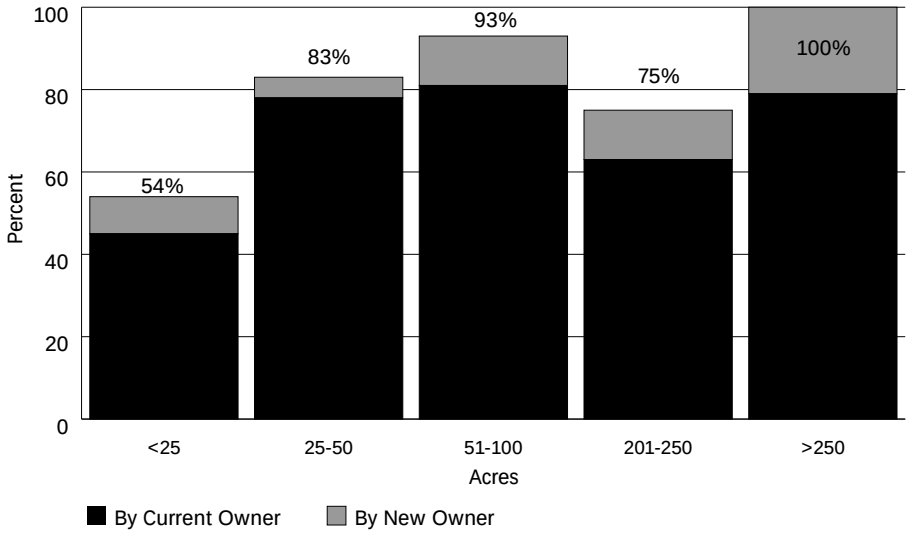
More information is needed about the willingness of landowners to harvest, particularly on parcels smaller than approximately 25 acres. Since these small parcels are less economic to harvest and these landowners profess to be more driven by aesthetics than potential timber revenue, it is not unlikely that some landowners will withdraw their smaller parcels from land base available for forestry. However, if stumpage prices are high enough and landowners are aware of options to manage their lands in an ecologically sound way, even these small parcels could be harvested.

Estimated Available Forest Land Base

It is impossible to predict with precision what the available forest land base will be in 20 years or more. However, it is unwise to ignore this question just because it is daunting. Projections are based on assumptions that can be altered and debated. They are not predictions.

Figure 69 below is an estimate of the available forest land base in 2000 and 2020. First, the inoperable lands and wilderness areas are removed from the forest land base for 2000. Then, small parcels under 10 acres are removed due to their diseconomies of scale in management, shorter tenure of landowners, lower priority placed upon harvest income, and higher frequency having their merchantable wood removed through terminal harvests and diameter limit cuts in anticipation of development. Finally, an assumption has been made that a minimum of 5% of the land base would be set aside for old growth forests and other sensitive habitats that cannot tolerate even careful management. The analysis suggests that no more than 74% of the current forest land base should be considered available for ecologically sound forest management.

Figure 68. Percent Expecting to Harvest Land Again Over Next 25 Years by Size of Harvested Area



Source: N.H. Survey of Landowners Conducting Harvests 4/98–4/99, SPNHF/UNH Survey Center, 2000

The 3.55 million acres available for management in 2000 is further reduced by 144,000 acres converted to non forest uses. By 2020, it is estimated that, at most, 3.41 million acres will be available for forestry.

Will this land base be sufficient to meet the needs of consumers, forest industry and forest workers? What will be the consequences of a smaller more fragmented forest land base? How can these needs be met without exceeding the bounds of sustainable forest management? These questions will be addressed in the next section.

FIGURE 69. AVAILABLE LAND BASE FOR FORESTRY, 2000, 2020 (SPNHF, 2001)

	Assumption	Acres	% of 2000 forest land base
N.H. forest land base, 2000	UVM satellite coverage	4,787,647	100
Minus			
Inoperable land and wilderness reas	Steep, high elevation, wet soils. (See Figure 67)	871,529	18.2
Small parcels <10 acres	FIA data	117,000	2.4
Ecologically sensitive lands	5% of forest land base, estimated	243,932	5
NH land base available for forestry in 2000		3,555,186	74
Minus			
Conversions to development and non-forest uses	See page 11 of report	144,000	3
NH forest land base available for forestry in 2020		3,411,186	NA

Sustainability

Forest sustainability is usually considered at the site scale. Is the forest being managed to sustain ecosystem functions such as hydrologic and nutrient cycling? Is soil fertility being maintained or enhanced? Is species diversity being preserved? These questions are also valid at the statewide, landscape scale.

There are many components to defining the sustainability of the complex forest/human community:

- Sustainability of the land base;
- Sustainability of the forest ecosystem and biodiversity; (not the focus of this study)
- Sustainability of forest growth;
- Sustainability of the harvest and supply to forest consumers; and
- Sustainability of the forest economy and communities.

Sustaining the Land Base

As we have seen, New Hampshire's forest land base is not being sustained. Between 9,000 and 13,000 (net) acres of forestland are converted to non-forest uses each year. At current rates, the unprotected forest lands in the southeast will be converted within 55 years. Development will consume the more productive and accessible forestland first. Fragmentation and parcelization in the towns that exceed 130 people/mi^2 may make the retention of large forest blocks infeasible. Only 25% of the forest land base is permanently conserved from development. New Hampshire's biodiversity and ecosystem functions are not sufficiently conserved by the existing system of protected lands. The protected land base falls far short of securing enough land to support the existing forest-based recreation, tourism and forest-products economy.

Sustaining Forest Growth and Volume

Although the extent of the New Hampshire forest land base has been shrinking, the age, volume and quality of the forest has been increasing overall. The 1997 FIA data reconfirms this trend. The notable exception to this improvement has been the North Country, where heavy spruce and fir removals exceed net growth. Statewide, the total volume of live trees (over 5 inches in diameter) increased by 2.1% between 1983 and 1997. The area of sawtimber stands increased and now comprises 52% of all "timberland." Growing stock volume also rose by 5.8% statewide, increasing 12.6% in the populated south and decreasing 0.7% in the north. Volume of all five top species increased, while spruce and balsam fir, primarily northern species, decreased by 18.2% and 20.4%, respectively.[70] Early successional habitat has also declined as the overall forest matures.

Sustained forest health and growth will require curbing acid deposition and other pollutants. Even if serious cuts in emissions of sulfur dioxide and nitrogen oxides are achieved in the next few years, it could be 50 years before our forest ecosystems recover to their former health and productivity.[71]

Steady increases in forest volume and maturity in recent decades are encouraging. In spite of the conversion, fragmentation and parcelization of our land base, the forest with which we enter the 21st century is a renewable resource of tremendous economic and ecological value.

Harvests

In 1997, the following products were harvested in New Hampshire:

- 107 million board feet of hardwood sawlogs,
- 345 million board feet of softwood sawlogs,
- 211,000 cords of softwood pulpwood,
- 344,000 cords of hardwood pulpwood, and
- 922,000 green tons of chips, primarily for generating electricity.[72]

This represents an increase over the statewide harvest level in 1983. Approximately 31% of the state's harvest is for fuelwood and energy, 43% is for sawlogs and 26% is for pulp and paper (Irland, 2001).

The FIA tracks growth and removals only for two regions (north and south). The only practical means of measuring harvesting activity by sub-regions or municipality is to analyze timber tax revenues. Timber taxes are charged at the time of harvest at a rate of 10% of the estimated value of the volume removed. Timber tax data was provided by the New Hampshire Department of Revenue Administration for the tax years 1996–1998. An average annual value was derived for each municipality for the period to even out annual fluctuations and unreported data. This data is available in Appendix E. The average annual timber tax per square mile for each New Hampshire municipality is shown in Figure 70.

There are limitations to this data. It is not known to what extent timber removals are underreported. Also, this does not represent volumes removed and could appear to under-emphasize

[70] Frieswyk, 2000.
[71] Driscoll, 2001.
[72] The Irland Group, 2001.

Figure 70

Average Timber Tax/ Sq. Mile by Municipality 1996, 1998 & 1999

New Hampshire's Vanishing Forests

A Project of the Society for the Protection of N.H. Forests
for the Division of Forests & Lands,
N.H. Dept. of Economic Resources & Development

White Mountain National Forest
County Boundaries
Municipal Boundaries
Water Features

DRA Timber Tax Revenue (3year average)

- $0
- $1 - 411/ Sq Mile
- $411 - 616/ Sq Mile
- $616 - 919/ Sq Mile
- $919- 1885/ Sq Mile

Data Sources:

Hydrological information and political boundaries are derived from U.S. Geological Survey digital line graphs, 1:24,000 to 1:25,000 as archived in the N.H. GRANIT database.

Timber tax averages are based on municipal timber yield tax data for 1996, 1998 & 1999 from the N.H. Dept. of Revenue Administration. Averages are normalized by square mile of land area in each municipality to better illustrate relative intensity of harvest activity.

N

0 10 Miles

Lancaster
Berlin
Littleton
North Conway
Hanover
Lebanon
Laconia
Rochester
Somersworth
Concord
Dover
Portsmouth
Keene
Manchester
Nashua

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pulpwood and biomass harvests. Despite these shortcomings, this data presents a striking picture of the geographic distribution of harvest value and activity.

This map shows significantly lower harvest values in the more developed southeastern and lakes region towns. Notable exceptions are Raymond, Sandown and Madbury, which also have high population growth rates. Unfortunately, terminally harvested wood is included in these figures, artificially inflating harvests that could be sustained in the long term. More research is needed to compare these results with post-1999 data with harvest values that exclude house-lot conversions.

Lower values are apparent for the towns along the western highlands from Dublin to Springfield, possibly reflecting lower soil productivity and less operable lands. Low values also were reported by towns located primarily within the National Forest.

Research conducted in Virginia concluded that at a population density above 150 persons per square mile, the probability of a commercial harvest falls to zero.[73] In New Hampshire, although harvesting appears to decline for municipalities with a population density above 100 persons per square mile, some harvesting still occurs. Harvesting drops to near zero only in Manchester (population density 3200), Newington (with the former air force base), and a few high-elevation, unincorporated places.

There are extremely high value removals in the Ossipee/Middleton area, probably due to easy access to Maine, where forest inventories have been drawn down. This is a cause for concern in New Hampshire as Maine mills reach farther out of state for their supplies. Other high value removals can bee seen in Northfield and Boscawen as well as Andover, Hillsborough, Windsor and Mason. More research needs to be done on these harvest values and volumes to understand the causes and long term trends.

Net Growth to Harvest Ratio

The net growth to harvest ratio is one of the most important indicators of forest sustainability. Net growth is the surplus of annual forest growth over mortality. A young forest that has not yet reached maturity has a growth rate that exceeds mortality. An old growth forest typically reaches a balance between growth and mortality. When one tract of forestland is harvested, the harvest rate almost always exceeds net growth for that year, but should not exceed net growth over the period between harvests.

At the landscape scale, it is especially important to track the net growth to harvest ratio. The Forest Service estimated this ratio for New Hampshire to be 1.3 to 1 in 1997.[74] This is reassuring information for New Hampshire. Although the ratio has been positive for many decades, however, New Hampshire should not be complacent. New Hampshire is not a forestry economy unto itself. Harvest rates are strongly influenced by demand from mills in surrounding states, Canada and even Europe. As was noted above, a negative growth to harvest ratio in Maine is already influencing the intensity of harvests in New Hampshire.

Harvest to Consumption Ratio

Forest products, water, MacIntosh apples and fluid milk are perhaps the only major renewable natural resources in which New Hampshire is "net" self sufficient. In other words, New Hampshire can produce at least its own share of global supply and sustain its own demand. New Hampshire's

[73] Wear et als, 1999.
[74] Frieswyk, 2000.

current harvest of forest products exceeds net in-state consumption. This can be called the harvest to consumption ratio. The current ratio is 1.5 to 1.

For a state with a forestland per capita ratio (4 acres per person) that is more than double the global average (1.5 acres per person), it would be hard to justify a harvest to consumption ratio that would be less than one. New Hampshire would be consuming more than it produces at the expense of foreign and out-of state forests, where management quality and social equity cannot be assured for the foreseeable future.

Sustaining the Forestry Infrastructure and Economy

The impact of forestland conversion, parcelization and fragmentation on the forestry infrastructure is of vital importance to the future of forestry. This research did not investigate this topic, but it should be on the agenda for future research in the state.

Elements of the forestry infrastructure include:

- quality forestry workers,
- educational system for foresters at the University of New Hampshire,
- Cooperative Extension and other forestry education for landowners,
- continuing education and training programs for foresters and loggers,
- forestry equipment dealers and repair services,
- insurance and financial services,
- informed public officials,
- markets.

If forestry becomes less visible in a region or the state as a whole, fewer people may choose forestry as a profession. Educational opportunities may be difficult to provide when the number of students falls below a critical mass needed to fill classes. Equipment dealers may close or cease carrying forestry related items if there is not enough business in a region. Lenders and insurance providers will be less informed about forestry issues and may charge more for their services. Public officials may pay greater heed to complaints about noise, logging truck traffic, and Current Use Assessment and be less sympathetic to landowners attempting to manage their forests and keep them undeveloped.

Finally, as has been discussed in this report, mills may become less competitive as trucking costs increase, a higher percentage of wood comes from smaller lots, and the land base is reduced. Currently, New Hampshire manufacturers produce more forest products than New Hampshire residents consume.[75]

[75] "The Economic Importance of New Hampshire's Forests" 2001.

An Exercise in Sustainability

In the publication, "The Economic Importance of New Hampshire's Forests," State Forester Phil Bryce estimates that New Hampshire consumers used 711 million board feet or 1.4 million cords of wood products per year. This is equivalent to approximately 1.15 cords of wood per person per year.

In 1997, approximately 2,126,000 cords of wood were harvested from New Hampshire's forests.[76] This is about 50% more than what residents currently consume. The harvest to consumption ratio is 1.5 to 1. But for how long will New Hampshire be able to sustain this ratio? Plug in your own assumptions in the example given below to calculate your answer.

By 2020, the population is predicted to rise to 1.6 million (Office of State Planning). The forest land base is expected to decline by 3% due to development (Sundquist, 1999). As discussed above, the land base available for economic and ecologically sound forestry is expected to decline even further due to parcelization, fragmentation, natural areas designation and ecosystem based management. If the forest land base were to shrink by 5% while the population grows, what will this do to the harvest to consumption ratio for 2020? If we presume that the harvest is evenly spread across all acres and the current harvest rate remains constant, the overall harvest would decline by 5% to 2,019,700 cords. In 2020, if wood use per capita remains constant, the harvest would exceed consumption by only 26%. The "surplus" harvest that existed in 1997 would be cut in half. It is likely that before 2050, New Hampshire would cease to be (net) self-sufficient in forest products. Citizens would consume more than their forests grow.

[76] Irland, 2001.

Recommendations and Conclusions

Much remains to be done to conserve the forest land base and sustain the forest economy in New Hampshire. Actions can be implemented by the landowner, municipalities, the forestry community, and state and federal government. Recommendations that would enable New Hampshire citizens to sustain their forestlands follow.

1. Improve research and monitoring.

- The status of the forest land base, its owners and management needs to be monitored in greater detail and with greater frequency—at least every five years.
- Regular updates of accurate satellite imagery and support of land cover analysis, as is currently underway, is vital.
- Monitoring of forest block and parcel sizes should be done at the statewide and regional levels.
- More sophisticated inventories of growth and harvests and growth/harvest ratios need to be conducted. These inventories should be statewide, for smaller regions (smaller than the current north/south split by the FIA), and for species of concern.
- Population viability analyses and habitat protection needs for rare species and exemplary communities need be researched for New Hampshire ecosystems.
- Studies of the relationship of forest cover to water and stream quality need to be applied to New Hampshire.
- Research needs to be conducted on the status and trends in forestry infrastructure as they are affected by forest conversion, fragmentation and parcelization.
- Further research on the minimum economic parcel size for forestry is needed.

2. Set 10-year state forestland protection goals.

New Hampshire needs more specific forestland protection goals than are in the current forest plan. Goals should address productive lands, large un-fragmented blocks, regional inequities in protected land, and expansion and connections between existing state holdings. These protection goals for working forestland should be integrated with the Ecological Reserve System (see below). The New Hampshire Department of Resources & Economic Development could facilitate the development of these goals for the next ten years as part of the next forest plan. An emphasis upon voluntary action by willing sellers should help prevent misconceptions about takings.

3. Refine the role for managed forestland within the Ecological Reserve System.

Identify boundaries of exemplary communities and rare element habitats needing complete protection from development and forest management within the System. Identify matrix lands that support these populations where forest management is acceptable. Conduct population viability analyses, particularly for species with larger home ranges. Determine what the habitat needs are to support viable populations in the state and for various regions in the state. Determine what types of forest management are compatible with these needs.

4. Direct public acquisition programs to protect productive land for forestry.

Public acquisition programs should be encouraged to give greater emphasis to forestland protection. Forests are not a scarce resource in most areas, and forests for forestry receive little attention with the exception of the Forest Legacy Program. These programs should consider block size, parcel size, productivity, stocking, management history and operability of the property, as well as other natural resource values.

5. Create marketing and management strategies to improve economics for small parcels.

As this report demonstrates, small parcels cannot take advantage of the economies of scale necessary for profitable forest management. Landowner management or marketing cooperatives or other strategies may help small parcel owners and managers become more efficient and competitive. Landowner forestry assistance provided by Cooperative Extension and others is vital to help small landowners overcome their diseconomies of scale.

6. Master plan for forestry.

Towns should develop visions for their forests and forestry and express these goals in their master plans. The economic and social value of forestry should be considered in the economic sections of master plans. Forest resources should be included in natural resource inventories. Towns can adopt open space and forest conservation plans that set priorities, for example to conserve the remaining large blocks of forestland and linkages between them.

7. Designate forest conservation zoning districts.

Towns become what they zone. For most New Hampshire municipalities, this means that they will become 2-5 acre lot suburbs, punctuated by villages and cities. With only a couple of exceptions, New Hampshire municipalities have zoned forestry out of their futures. The Town of Lyme is one of those exceptions. In 1989, Lyme voters created a Mountain and Forest Conservation District in a sparsely settled section of town that still had large blocks of un-fragmented forest. In this zone, which is set back 1000 feet from publicly maintained roads, the minimum lot size is 50 acres, "to encourage continuation of large contiguous tracts of forestland in private ownership to provide forest resources and outdoor recreation." The ordinance is founded in the town's master plan, which provides for greater population densities near existing infrastructure and in the villages. The ordinance was upheld by the Supreme Court in 1995, which found that the 50 acre minimum lot size was "rationally related" to Lyme's legitimate objective of promoting forestry.[77]

8. Enable planning boards to require clustering to conserve strategic forestland.

Whether or not a town can create a Forest Conservation District, it can conserve significant tracts of forest by implementing cluster zoning, more recently referred to as open space subdivisions. In the case of developments where certain special resources would be eliminated by conventional (e.g. 2-acre lot) zoning, planning boards can require the developer to submit an open space subdivision plan. Such a plan would concentrate the development on smaller lots in exchange for permanently protecting approximately 50% of the land as open space.[78] Over time, a town can implement its open space plan parcel by parcel, through connected open space subdivisions, as well as donations or acquisitions.

9. Engage forestry community in expanding concept of sustainable forestry to include conserving the land base.

Landowners, foresters, loggers and mills all need to be engaged in conserving the land base necessary to sustain forestry in New Hampshire. Landowners can take voluntary action by donating or selling conservation easements or land. The livelihood of foresters, loggers and mills literally depends on this land base. They can play a much greater role in educating landowners, municipalities and state legislators about forestland conservation.

Conclusions

What does it mean if New Hampshire depletes its most significant natural endowment? What does this mean for the identity of New Hampshire's people and communities? What does this mean for our connection to nature and our rural history? What does it mean for local control and sustainability of our economy? What does it mean for our water, our wildlife, our health?

[77] Van Ryn, Tammara, "Patterns and Plans," Forest Notes, Spring, 1996.
[78] Zoning Ordinance, Town of Gilmanton, N.H. 2001.

The effects of forestland conversion and parcelization are complex and will take years to play out. It is difficult to predict the impacts of these trends on factors such as the quality of management, mill investments, forest workers' livelihoods, and landowners' decisions to harvest. Other influences such as global demand and supply, formal and informal wilderness designation, acid deposition, and climate change may play far greater roles than parcelization and forest conversion in determining the sustainability and profitability of the state's rural forest economy. However, as this study demonstrates, it is highly likely that whatever the future holds, as an increasing proportion of the wood supply comes from small parcels and as the local forested land base shrinks, profitability for landowners, foresters, loggers and ultimately the entire forestry community will be reduced.

As the profitability of forest management on smaller parcels declines, it can be anticipated that some landowners may be induced to further subdivide or develop their land, particularly if they cannot pay the property taxes. The opportunity to practice economically and ecologically sound forest management is a vital force in retaining the forest land base—for forestry and so many other purposes. The economics of forest management matters in this era of conversion, fragmentation and parcelization. It matters for wildlife, clean water, and our livelihoods and quality of life in our rural communities.

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Appendices

A. New Hampshire Forest Land Base Surveys

B. Locus Map of Municipalities, Unincorporated Places and Counties in New Hampshire

C. Protected Parcels Over 1000 Acres in Size in New Hampshire

D. Analysis of Average Timber Tax by Municipality in New Hampshire for 1996, 1998 and 1999

E. Percent of Municipal Land Area Enrolled in Tree Farm Program

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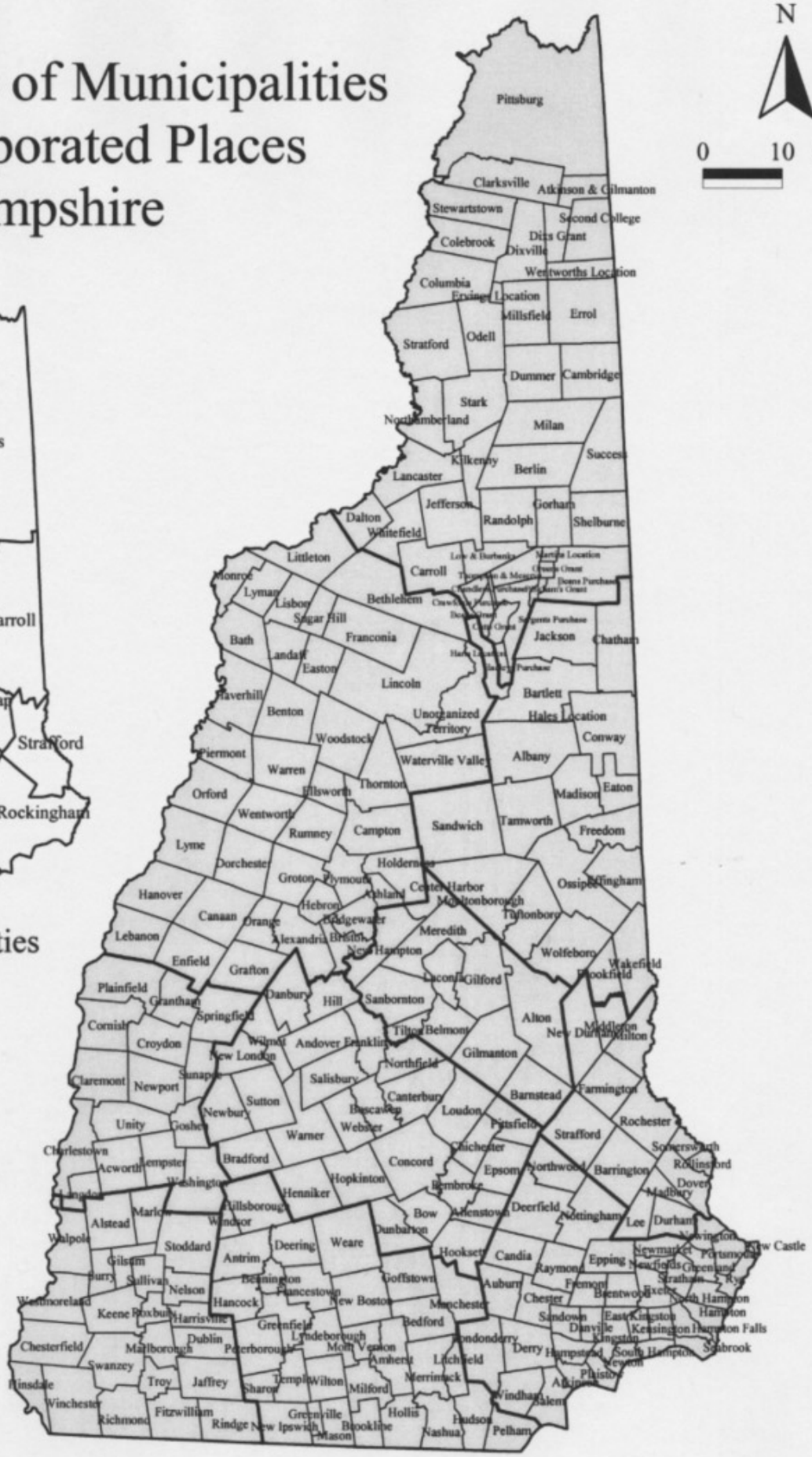
Appendix B

Locus Map of Municipalities & Unincorporated Places in New Hampshire

N.H. Counties



Appendix C. Protected Forest Land Parcels >1000 Acres in Size

Tract Name	Acres	Protection Type
Nash Stream Forest	39,573.8	FO
Second College Grant	26,773.9	FO
Bunnell Tract	18,687.5	FO
Pisgah State Park	13,248.6	FO
Andorra Forest	11,456.6	CE
Bear Brook State Park	9,472.1	FO
Hopkinton-Everett Flood Control Reservoir	7,813.4	FO
Franconia Notch State Park	6,939.6	FO
Gile State Forest	6,728.7	FO
Cardigan Mountain State Forest	5,458.0	FO
Crawford Notch State Park	5,453.8	FO
Pawtuckaway State Park	5,409.9	FO
Green Hills Preserve	4,971.1	FO
Mt. Moosilauke	4,412.7	FO
Retsof/Chocorua Forestlands	4,387.6	DR
Pillsbury State Park	4,252.5	FO
Mount Kearsarge State Forest	3,878.4	FO
Icegulch Town Forest - Town of Gorham	3,761.4	FO
Blackwater Flood Control Reservoir	3,653.8	FO
Peirce Wildlife + Forest Reservation	3,479.5	FO
Pine River State Forest	3,130.0	FO
Hidden Valley, B.S.A.	3,024.9	CE
Monadnock Reservation	2,977.3	FO
Satellite Tracking Facility	2,910.4	FO
Enfield WMA	2,896.4	FO
Keene Watershed	2,716.1	FO
Sunapee State Park	2,328.9	FO
Mascoma River WMA	2,172.8	CE
Umbagog State Park	1,993.6	CE
Briggs	1,987.5	CE
Appalachian Trail Tract 161-01	1,943.7	FO
Cape Horn State Forest	1,919.2	FO
Connecticut Lakes State Forest	1,812.9	FO
Low State Forest	1,792.8	FO
Manchester Water Works Land	1,754.8	FO
Belknap County Recreation Area	1,707.1	FO
Wapack National Wildlife Refuge	1,698.6	FO
Hemenway State Forest	1,694.8	FO

APPENDIX C. PROTECTED FOREST LAND PARCELS >1000 ACRES IN SIZE — CONT.

Tract Name	Acres	Protection Type
Murphy Dam/Lake Francis	1,658.4	FO
Meadowsend Timberlands, Ltd	1,639.5	CE
Surry Mountain Lake	1,636.1	FO
Annett State Forest	1,521.7	FO
Pillsbury State Park	1,516.2	CE
Fox State Forest	1,471.0	FO
Coleman State Park	1,434.9	FO
Franklin Falls Reservoir	1,433.2	FO
Hanover Water Works Co. Land	1,379.7	FO
Franklin Falls Reservoir	1,371.3	FO
Belknap Mountain State Forest	1,344.2	FO
Chandler Reservation	1,330.2	FO
Marceau	1,314.1	CE
Cardigan	1,198.4	FO
Rhododendron State Park	1,171.2	CE
Shepherd River Tracts	1,169.7	FO
Edward MacDowell Lake	1,099.0	FO
Amey, J.	1,095.6	CE
Murphy Dam/Lake Francis	1,091.8	FO
Green Acres Woodlands	1,071.3	CE
Gap Mountain Reservation	1,069.8	FO
Manchester Water Works Land	1,069.5	FO
Jones Brook WMA	1,069.0	FO
Great Bay National Wildlife Refuge	1,057.0	FO
Enfield WMA	1,048.4	FO
Kearsarge WMA	1,035.8	FO
High Watch Preserve	1,033.0	FO
Manchester Water Works Land	1,008.6	FO
Pontook — Lease Area	1,003.2	FO
	266,616.4	acres

Source: GRANIT Conservation and Public Lands datalayer issued 2/2001.

FO = Fee Ownership
CE = Conservation Easement
DR = Deed Restriction

APPENDIX D. ANALYSIS OF AVERAGE TIMBER TAX BY MUNICIPALITY IN NEW HAMPSHIRE FOR 1996, 1998 AND 1999

Municipality	1996 Timber Tax	1998 Timber Tax	1999 Timber Tax	Average Timber Tax 1996/98/99
Alton	$26,003	$28,359	$41,920	$32,094
Acworth	$14,642	$29,454	n/a	$22,048
Albany	$11,474	$34,828	$34,984	$27,095
Alexandria	$11,772	$22,386	$31,781	$21,980
Allenstown	$0	$16,569	$3,588	$6,719
Alstead	$19,531	$24,423	$23,638	$22,531
Amherst	$12,974	$7,858	$8,834	$9,889
Andover	$11,646	$28,472	$94,259	$44,792
Antrim	$18,920	$22,862	$24,608	$22,130
Ashland	$1,451	$365	$1,626	$1,147
Atkinson	$818	$0	$0	$273
Atkinson & Gilmanton	$7,238	$31,329	$7,357	$15,308
Auburn	$2,668	$2,771	$7,446	$4,295
Barnstead	$9,119	$11,302	$0	$10,211
Barrington	$20,237	$33,171	$26,081	$26,496
Bartlett	$0	$14,147	$20,806	$11,651
Bath	$24,373	$16,606	$33,647	$24,875
Beans Grant	$0	$0	$0	$0
Beans Purchase	$462	$3,502	$0	$1,321
Bedford	$4,702	$2,996	$21,703	$9,800
Belmont	$3,895	$19,557	$9,421	$10,958
Bennington	$12,628	$7,708	$0	$6,779
Benton	$10,843	$11,857	$13,337	$12,012
Berlin	$16,852	$16,739	$20,308	$17,966
Bethlehem	$48,891	$42,263	$15,926	$35,693
Boscawen	$13,171	$25,309	$33,516	$23,999
Bow	$12,702	$31,497	$5,984	$16,728
Bradford	$17,050	$18,285	$43,841	$26,392
Brentwood	$5,040	$9,688	$4,942	$6,557
Bridgewater	$9,812	$4,811	$20,653	$11,759
Bristol	$7,580	$11,223	$5,220	$8,008
Brookfield	$30,015	$22,153	$19,340	$23,836
Brookline	$6,164	$12,315	$12,906	$10,462
Cambridge	$35,510	$36,874	$73,361	$48,582
Campton	$18,429	$98,785	$21,262	$46,159
Canaan	$16,577	$41,404	$33,686	$30,556
Candia	$9,960	$6,979	$7,885	$8,275
Canterbury	$17,479	$20,782	$46,633	$28,298

APPENDIX D. ANALYSIS OF AVERAGE TIMBER TAX BY MUNICIPALITY IN NEW HAMPSHIRE FOR 1996, 1998 AND 1999 — CONT.

Municipality	1996 Timber Tax	1998 Timber Tax	1999 Timber Tax	Average Timber Tax 1996/98/99
Carroll	$82,993	$24,342	$13,576	$40,304
Center Harbor	$5,799	$3,545	$5,810	$5,051
Chandlers Purchase	$0	$0	$0	$0
Charlestown	$8,528	$20,832	$19,001	$16,120
Chatham	$17,039	$6,421	$20,355	$14,605
Chester	$6,468	$17,499	$15,031	$12,999
Chesterfield	$13,641	$19,798	$24,255	$19,231
Chichester	$12,011	$12,105	$20,964	$15,027
Claremont	$22,486	n/a	$12,037	$17,262
Clarksville	$18,478	$18,620	$21,499	$19,532
Colebrook	$32,642	$35,601	$34,122	
Columbia	$23,187	$50,533	$31,121	$34,947
Concord	$42,715	$83,979	$52,668	$59,787
Conway	$32,875	$26,838	$80,411	$46,708
Cornish	$4,832	$40,016	$12,178	$19,009
Crawfords Purchase	$5,835	$0	$0	$1,945
Croydon	$20,079	$11,476	$33,156	$21,570
Cutts Grant	$0	n/a	n/a	$0
Dalton	$13,395	$15,306	$19,256	$15,986
Danbury	$7,919	n/a	$13,587	$10,753
Danville	$3,031	$1,783	$2,375	$2,396
Deerfield	$21,002	$30,191	$19,514	$23,569
Deering	$21,432	$15,664	$13,460	$16,852
Derry	$4,355	$8,204	$5,481	$6,013
Dixs Grant	$31,288	$14,341	$443	$15,357
Dixville	$65,501	$44,163	$6,899	$38,854
Dorchester	$25,701	$9,677	n/a	$17,689
Dover	$6,325	$9,341	$19,047	$11,571
Dublin	$9,112	$7,767	$4,146	$7,008
Dummer	$18,241	$18,219	n/a	$18,230
Dunbarton	$14,814	$18,184	$11,225	$14,741
Durham	$777	$2,300	$1,498	$1,525
East Kingston	$479	$220	$6,509	$2,403
Easton	$2,370	$18,731	$9,737	$10,279
Eaton	n/a	$20,544	$22,786	$21,665
Effingham	$34,015	$42,934	n/a	$38,475

APPENDIX D. ANALYSIS OF AVERAGE TIMBER TAX BY MUNICIPALITY IN NEW HAMPSHIRE FOR 1996, 1998 AND 1999 — CONT.

Municipality	1996 Timber Tax	1998 Timber Tax	1999 Timber Tax	Average Timber Tax 1996/98/99
Ellsworth	$18	$127	n/a	$73
Enfield	$8,673	$25,903	n/a	$17,288
Epping	$14,124	$4,436	$8,866	$9,142
Epsom	$9,184	$12,355	$7,575	$9,705
Errol	$46,676	$56,938	n/a	$51,807
Ervings Location	$0	$0	$0	$0
Exeter	$9,890	$2,392	$3,027	$5,103
Farmington	$7,199	$20,485	$23,974	$17,219
Fitzwilliam	$5,788	$29,622	n/a	$17,705
Francestown	$14,363	$27,256	$20,763	$20,794
Franconia	$10,187	$7,826	$9,099	$9,037
Franklin	$18,240	$14,259	$26,058	$19,519
Freedom	$18,208	$22,831	$25,447	$22,162
Fremont	$2,397	$7,268	$12,140	$7,268
Gilford	$22,763	$6,686	$15,265	$14,905
Gilmanton	$18,215	$24,966	$22,012	$21,731
Gilsum	$5,999	$8,268	$7,752	$7,340
Goffstown	$7,809	$3,732	$13,593	$8,378
Gorham	$15,286	$15,938	$16,730	$15,985
Goshen	$2,199	$12,625	$7,050	$7,291
Grafton	$27,478	$22,740	$3,354	$17,857
Grantham	$7,039	$13,970	$15,013	$12,007
Greenfield	$11,949	$21,924	$0	$11,291
Greenland	$250	$0	$13,968	$4,739
Greens Grant	$0	$0	$4,263	$1,421
Greenville	$9,524	$0	$1,408	$3,644
Groton	$15,437	n/a	$51,194	$33,316
Hadleys Purchase	$0	n/a	n/a	$0
Hales Location	$0	$4,309	$1,674	$1,994
Hampstead	$1,837	$2,764	$1,202	$1,934
Hampton	$590	$174	$598	$454
Hampton Falls	$629	$4,338	$21	$1,663
Hancock	$12,169	$14,549	$8,018	$11,579
Hanover	$15,423	$18,067	$22,858	$18,783
Harrisville	$4,231	$12,045	$11,877	$9,384
Harts Location	$0	$1,358	$105	$488

APPENDIX D. ANALYSIS OF AVERAGE TIMBER TAX BY MUNICIPALITY IN NEW HAMPSHIRE FOR 1996, 1998 AND 1999 — CONT.

Municipality	1996 Timber Tax	1998 Timber Tax	1999 Timber Tax	Average Timber Tax 1996/98/99
Haverhill	$15,868	$32,113	$29,607	$25,863
Hebron	$5,809	n/a	n/a	$5,809
Henniker	$40,578	$16,414	$17,077	$24,690
Hill	$13,412	$16,430	$15,232	$15,025
Hillsborough	$13,077	$64,037	$55,879	$44,331
Hinsdale	$1,189	$11,625	$9,960	$7,591
Holderness	$13,930	$2,967	$15,414	$10,770
Hollis	$0	$18,658	$26,808	$15,155
Hooksett	$2,051	$6,848	$4,814	$4,571
Hopkinton	$20,078	$30,650	$22,576	$24,435
Hudson	$3,268	$7,306	$1,027	$3,867
Jackson	$4,764	$1,745	$7,729	$4,746
Jaffrey	$18,706	$39,990	$20,911	$26,536
Jefferson	$19,400	$29,914	$15,001	$21,438
Keene	$9,896	$8,720	$30,353	$16,323
Kensington	$363	$7,702	$4,002	$4,022
Kilkenny	$0	$0	$0	$0
Kingston	$9,232	$6,829	$10,391	$8,817
Laconia	$7,790	$5,811	$9,335	$7,645
Lancaster	$22,617	$28,736	$25,229	$25,527
Landaff	$18,985	$45,939	$21,221	$28,715
Langdon	$4,671	$8,683	n/a	$6,677
Lebanon	$1,983	$8,019	$11,797	$7,266
Lee	$618	$5,470	$920	$2,336
Lempster	$19,669	$19,163	$28,059	$22,297
Lincoln	$2,930	$1,197	$0	$1,376
Lisbon	$32,329	$10,691	$16,232	$19,751
Litchfield	$200	$6,584	$10,442	$5,742
Littleton	$38,282	$38,577	$46,999	$41,286
Londonderry	$2,265	$9,366	$29,357	$13,663
Loudon	$11,904	$19,008	$25,849	$18,920
Low & Burbanks	$0	$6,871	n/a	$3,436
Lyman	$24,789	$20,024	$10,770	$18,528
Lyme	$21,865	$12,291	$11,453	$15,203
Lyndeborough	$15,128	$20,175	$34,984	$23,429
Madbury	$22,611	$2,019	$2,019	$8,883

APPENDIX D. ANALYSIS OF AVERAGE TIMBER TAX BY MUNICIPALITY IN NEW HAMPSHIRE FOR 1996, 1998 AND 1999 — CONT.

Municipality	1996 Timber Tax	1998 Timber Tax	1999 Timber Tax	Average Timber Tax 1996/98/99
Madison	$15,519	$29,169	$37,110	$27,266
Manchester	$0	$0	$0	$0
Marlborough	$7,609	$6,189	$12,292	$8,697
Marlow	$6,037	$9,538	$13,616	$9,730
Martins Location	$0	$0	$0	$0
Mason	$41,570	$47,901	$27,323	$38,931
Meredith	$17,268	$11,792	$16,744	$15,268
Merrimack	$13,354	$7,633	$10,495	$10,494
Middleton	$32,409	$19,714	$5,846	$19,323
Milan	$27,287	$29,133	$34,067	$30,162
Milford	$16,644	$14,393	$14,918	$15,318
Millsfield	$34,526	$40,158	$51,140	$41,941
Milton	$10,172	$6,531	$36,786	$17,830
Monroe	$37,296	$5,229	$11,737	$18,087
Mont Vernon	$4,700	$17,737	$16,816	$13,084
Moultonborough	$9,021	$8,087	$7,732	$8,280
Nashua	$3,696	$6,748	$3,254	$4,566
Nelson	$9,841	$5,636	$5,771	$7,083
New Boston	$17,599	$39,028	$20,624	$25,750
New Castle	$0	$0	$0	$0
New Durham	$3,251	$41,078	$47,062	$30,464
New Hampton	$22,892	$21,114	$31,033	$25,013
New Ipswich	$5,277	$19,848	$24,749	$16,625
New London	$3,218	$8,790	$7,138	$6,382
Newbury	$11,955	$27,563	$11,243	$16,920
Newfields	$1,029	$4,632	$85	$1,915
Newington	$0	$0	$0	$0
Newmarket	$0	$1,856	$1,484	$1,113
Newport	$30,987	$40,666	$27,732	$33,128
Newton	$2,928	$1,916	$1,401	$2,082
North Hampton	$23	$2,233	$1,163	$1,140
Northfield	$22,792	$36,378	$23,302	$27,491
Northumberland	$13,117	n/a	$10,518	$11,818
Northwood	$5,594	$11,366	$12,766	$9,909
Nottingham	$16,568	$21,591	$14,569	$17,576
Odell	$15,978	$24,972	$17,330	$19,427

APPENDIX D. ANALYSIS OF AVERAGE TIMBER TAX BY MUNICIPALITY IN NEW HAMPSHIRE FOR 1996, 1998 AND 1999 — CONT.

Municipality	1996 Timber Tax	1998 Timber Tax	1999 Timber Tax	Average Timber Tax 1996/98/99
Orange	$10,257	$1,332	n/a	$5,795
Orford	$14,917	$16,282	$20,420	$17,206
Ossipee	$91,916	$33,891	$78,138	$67,982
Pelham	$7,533	$23,358	$2,221	$11,037
Pembroke	$9,431	$7,532	$11,906	$9,623
Peterborough	$15,163	$45,289	$25,464	$28,639
Piermont	$15,936	$32,505	$36,787	$28,409
Pinkham's Grant	$0	$0	$0	$0
Pittsburg	$64,293	$63,276	$80,973	$69,514
Pittsfield	$11,808	$3,744	$9,529	$8,360
Plainfield	$16,326	$30,655	$40,257	$29,079
Plaistow	$0	$5,389	$1,071	$2,153
Plymouth	$24,176	$10,618	$0	$11,598
Portsmouth	$161	$268	$243	$224
Randolph	$14,477	$15,191	$32,328	$20,665
Raymond	$15,677	$37,855	$21,376	$24,969
Richmond	$20,794	n/a	n/a	$20,794
Rindge	$16,340	$55,274	$21,282	$30,965
Rochester	$11,064	$0	$41,611	$17,558
Rollinsford	$326	$0	$0	$109
Roxbury	$8,068	n/a	$3,137	$5,603
Rumney	$13,244	$22,760	$16,481	$17,495
Rye	$981	$0	$1,518	$833
Salem	$4,008	$3,616	$1,733	$3,119
Salisbury	$24,712	$32,566	$17,101	$24,793
Sanbornton	$27,359	$41,520	$17,652	$28,844
Sandown	$4,340	$2,945	$19,910	$9,065
Sandwich	$36,687	$75,968	$54,618	$55,758
Sargents Purchase	$0	$0	$0	$0
Seabrook	$0	$913	$658	$524
Second College	$16,550	$24,854	$18,440	$19,948
Sharon	$6,931	$12,219	$4,617	$7,922
Shelburne	$23,175	$22,519	$10,180	$18,625
Somersworth	$1,320	$2,348	$4,728	$2,799
South Hampton	$532	$160	$300	$331
Springfield	$14,522	$11,983	$16,238	$14,248

APPENDIX D. ANALYSIS OF AVERAGE TIMBER TAX BY MUNICIPALITY IN NEW HAMPSHIRE FOR 1996, 1998 AND 1999 — CONT.

Municipality	1996 Timber Tax	1998 Timber Tax	1999 Timber Tax	Average Timber Tax 1996/98/99
Stark	$10,146	$6,316	$15,089	$10,517
Stewartstown	$24,833	$20,359	$37,898	$27,697
Stoddard	$13,025	$15,171	$17,104	$15,100
Strafford	$9,845	$35,505	$14,587	$19,979
Stratford	$59,247	$92,734	$18,852	$56,944
Stratham	$44	$56	$7,461	$2,520
Success	$0	$28,745	$86,851	$38,532
Sugar Hill	$9,355	$6,645	$5,742	$7,247
Sullivan	$5,006	$10,896	$9,757	$8,553
Sunapee	$2,816	$6,283	$3,781	$4,293
Surry	$11,722	n/a	n/a	$11,722
Sutton	$29,466	$16,855	$50,736	$32,352
Swanzey	$7,188	$39,621	$42,911	$29,907
Tamworth	$49,838	$44,110	$59,185	$51,044
Temple	$15,660	$17,132	$9,134	$13,975
Thompson & Meserve	$0	$3,574	$0	$1,191
Thornton	$15,332	$29,654	$29,245	$24,744
Tilton	n/a	$1,789	$4,200	$2,995
Troy	$8,496	$11,540	$22,184	$14,073
Tuftonboro	$13,872	$24,921	$36,002	$24,932
Unity	$18,909	$34,756	$32,303	$28,656
Unorganized Territory	$2,139	$8,676	$911	$3,909
Wakefield	$27,916	$27,958	$27,599	$27,824
Walpole	$8,723	$8,948	$14,930	$10,867
Warner	$28,486	$31,883	$31,651	$30,673
Warren	$5,870	$24,796	$14,422	$15,029
Washington	$4,901	$25,096	$17,711	$15,903
Waterville Valley	$0	$2,143	$7,127	$3,090
Weare	$25,321	$35,461	$35,548	$32,110
Webster	$14,146	$22,377	$18,448	$18,324
Wentworth	$13,878	$22,447	$42,411	$26,245
Wentworths Location	$13,067	$4,453	$8,715	$8,745
Westmoreland	$2,025	$10,323	$12,325	$8,224
Whitefield	$32,530	$13,859	$11,242	$19,210
Wilmot	$8,497	$13,495	$38,237	$20,076
Wilton	$4,127	$22,198	$30,535	$18,953

APPENDIX D. ANALYSIS OF AVERAGE TIMBER TAX BY MUNICIPALITY IN NEW HAMPSHIRE FOR 1996, 1998 AND 1999 — CONT.

Municipality	1996 Timber Tax	1998 Timber Tax	1999 Timber Tax	Average Timber Tax 1996/98/99
Winchester	$24,440	$30,142	$29,742	$28,108
Windham	$3,555	$56	$5,525	$3,045
Windsor	$25,321	$4,846	n/a	$15,084
Wolfeboro	$24,927	$15,418	$12,285	$17,543
Woodstock	$2,164	$10,537	$11,440	$8,047
Totals	$3,451,396	$4,393,790	$4,293,065	$4,192,316

Data provided by the N.H. Dept. of Revenue Administration.
"n/a" indicates data not available for that year.

Appendix E. Percent of Municipal Land Area Enrolled in Tree Farm Program

Name	Number of Tree Farms	Acres in Tree Farms	Percent of Land Area in Tree Farms
Alton	19	4,081	10.0%
Barnstead	5	371	1.4%
Belmont	5	650	3.4%
Center Harbor	5	812	9.6%
Gilford	9	2,304	9.3%
Gilmanton	11	3,349	9.1%
Laconia	3	281	2.2%
Meredith	6	1,843	7.2%
New Hampton	7	2,548	10.7%
Sanbornton	12	3,234	10.6%
Tilton	1	25	0.3%
Albany	2	385	0.8%
Bartlett	4	539	1.1%
Brookfield	6	1,138	7.8%
Chatham	3	407	1.1%
Conway	11	2,022	4.5%
Eaton	18	3,881	25.0%
Effingham	10	1,863	7.5%
Freedom	7	810	3.7%
Hales Location	0	0	0.0%
Harts Location	0	0	0.0%
Jackson	1	475	1.1%
Madison	9	2,221	9.0%
Moultonborough	6	5,103	13.3%
Ossipee	16	6,970	15.4%
Sandwich	41	7,477	12.8%
Tamworth	16	7,657	20.0%
Tuftonboro	16	4,468	17.2%
Wakefield	14	3,732	14.8%
Wolfeboro	22	2,399	7.8%
Alstead	10	4,375	17.6%
Chesterfield	5	1,187	4.1%
Dublin	4	2,374	13.2%
Fitzwilliam	8	896	4.0%
Gilsum	3	2,773	26.0%
Harrisville	7	1,482	12.2%
Hinsdale	1	409	3.1%
Jaffrey	6	4,609	18.7%

Appendix E. Percent of Municipal Land Area Enrolled in Tree Farm Program — Cont.

Name	Number of Tree Farms	Acres in Tree Farms	Percent of Land Area in Tree Farms
Keene	12	1,682	7.1%
Marlborough	7	1,068	8.2%
Marlow	7	2,575	15.5%
Nelson	3	689	4.9%
Richmond	14	3,716	15.5%
Rindge	7	1,785	7.5%
Roxbury	1	1,033	13.4%
Stoddard	3	15,795	48.6%
Sullivan	7	2,336	19.7%
Surry	3	977	9.8%
Swanzey	16	4,514	15.7%
Troy	7	1,384	12.4%
Walpole	7	2,021	8.9%
Westmoreland	3	611	2.7%
Winchester	13	1,974	5.6%
Atkinson & Gilmanton	0	0	0.0%
Beans Grant	0	0	0.0%
Beans Purchase	0	0	0.0%
Berlin	2	109	0.3%
Cambridge	1	18,701	57.4%
Carroll	1	3,794	11.8%
Chandlers Purchase	0	0	0.0%
Clarksville	0	24,994	64.6%
Colebrook	10	2,027	7.8%
Columbia	6	2,459	6.3%
Crawfords Purchase	0	0	0.0%
Cutts Grant	0	0	0.0%
Dalton	13	1,975	11.2%
Dixs Grant	1	13,182	102.7%
Dixville	2	34,319	109.4%
Dummer	2	18,213	59.6%
Errol	3	17,394	45.3%
Ervings Location	1	1,237	51.5%
Gorham	4	4,203	20.5%
Greens Grant	0	0	0.0%
Hadleys Purchase	0	0	0.0%
Jefferson	5	7,932	24.7%
Kilkenny	0	0	0.0%

Appendix E. Percent of Municipal Land Area Enrolled in Tree Farm Program — Cont.

Name	Number of Tree Farms	Acres in Tree Farms	Percent of Land Area in Tree Farms
Lancaster	14	1,821	5.7%
Low & Burbanks	0	0	0.0%
Martins Location	0	0	0.0%
Milan	4	1,009	2.5%
Millsfield	2	23,739	82.8%
Northumberland	6	1,097	4.8%
Odell	1	16,086	56.4%
Pinkham's Grant	0	0	0.0%
Pittsburg	4	150,423	83.3%
Randolph	4	11,686	38.8%
Sargents Purchase	0	0	0.0%
Second College	1	27,000	101.0%
Shelburne	1	9,460	30.6%
Stark	3	1,875	5.0%
Stewartstown	7	6,613	22.3%
Stratford	1	2,712	5.3%
Success	1	4,248	11.7%
Thompson & Meserve	0	0	0.0%
Wentworths Location	0	10,530	89.8%
Whitefield	11	3,249	14.8%
Alexandria	3	995	3.6%
Ashland	2	186	2.6%
Bath	7	848	3.5%
Benton	0	0	0.0%
Bethlehem	12	6,392	11.0%
Bridgewater	3	485	3.5%
Bristol	1	410	3.7%
Campton	4	1,308	3.9%
Canaan	10	6,262	18.3%
Dorchester	4	6,074	21.3%
Easton	3	281	1.4%
Ellsworth	1	115	0.8%
Enfield	3	299	1.2%
Franconia	4	470	1.1%
Grafton	7	2,369	8.9%
Groton	5	5,764	22.1%
Hanover	18	3,663	11.6%
Haverhill	8	2,944	9.0%

Appendix E. Percent of Municipal Land Area Enrolled in Tree Farm Program — Cont.

Name	Number of Tree Farms	Acres in Tree Farms	Percent of Land Area in Tree Farms
Hebron	1	1,704	15.8%
Holderness	6	3,063	15.7%
Landaff	3	530	2.9%
Lebanon	6	948	3.7%
Lincoln	1	12	0.0%
Lisbon	3	650	3.8%
Littleton	7	2,804	8.8%
Lyman	2	735	4.0%
Lyme	24	4,286	12.4%
Monroe	5	1,036	7.2%
Orange	1	223	1.5%
Orford	15	10,183	34.2%
Piermont	6	3,082	12.4%
Plymouth	7	2,541	14.0%
Rumney	13	1,401	5.2%
Sugar Hill	3	349	3.2%
Thornton	1	563	1.7%
Warren	2	770	2.5%
Waterville Valley	0	0	0.0%
Wentworth	5	794	3.0%
Woodstock	2	460	1.2%
Unorganized Territory	0	12,119	29.7%
Amherst	3	265	1.2%
Antrim	4	2,644	11.6%
Bedford	3	89	0.4%
Bennington	0	1,050	14.4%
Brookline	8	989	7.8%
Deering	5	1,488	7.6%
Francestown	12	2,269	11.9%
Goffstown	7	1,747	7.3%
Greenfield	7	1,169	6.9%
Greenville	1	75	1.7%
Hancock	8	6,587	34.4%
Hillsborough	6	1,020	3.7%
Hollis	6	2,724	13.4%
Hudson	2	195	1.1%
Litchfield	0	0	0.0%
Lyndeborough	8	1,603	8.3%

Appendix E. Percent of Municipal Land Area Enrolled in Tree Farm Program — Cont.

Name	Number of Tree Farms	Acres in Tree Farms	Percent of Land Area in Tree Farms
Manchester	2	7,773	36.5%
Mason	9	1,793	11.7%
Merrimack	4	1,533	7.3%
Milford	3	4,084	25.1%
Mont Vernon	4	157	1.5%
Nashua	1	1,400	7.1%
New Boston	12	3,203	11.7%
New Ipswich	6	1,239	5.9%
Pelham	3	848	5.1%
Peterborough	13	3,470	14.3%
Sharon	9	5,298	52.9%
Temple	7	1,359	9.5%
Weare	10	2,100	5.6%
Wilton	7	1,345	8.2%
Windsor	1	213	4.0%
Allenstown	0	0	0.0%
Andover	11	5,100	19.8%
Boscawen	3	1,219	7.6%
Bow	4	1,692	9.4%
Bradford	6	1,405	6.2%
Canterbury	17	3,368	11.9%
Chichester	2	97	0.7%
Concord	19	5,441	13.2%
Danbury	5	1,284	5.3%
Dunbarton	4	278	1.4%
Epsom	5	936	4.3%
Franklin	2	261	1.5%
Henniker	11	1,793	6.3%
Hill	6	2,881	16.9%
Hooksett	1	85	0.4%
Hopkinton	12	1,269	4.5%
Loudon	3	127	0.4%
Newbury	12	2,817	12.3%
New London	6	1,773	12.5%
Northfield	6	1,338	7.3%
Pembroke	3	538	3.7%
Pittsfield	2	142	0.9%
Salisbury	6	3,209	12.7%

Appendix E. Percent of Municipal Land Area Enrolled in Tree Farm Program — Cont.

Name	Number of Tree Farms	Acres in Tree Farms	Percent of Land Area in Tree Farms
Sutton	10	1,160	4.3%
Warner	13	5,038	14.3%
Webster	7	886	4.9%
Wilmot	5	2,197	11.7%
Atkinson	1	280	3.9%
Auburn	6	587	3.6%
Brentwood	10	482	4.5%
Candia	4	353	1.8%
Chester	4	109	0.7%
Danville	8	252	3.4%
Deerfield	23	2,202	6.8%
Derry	4	1,197	5.3%
East Kingston	6	244	3.8%
Epping	13	1,353	8.2%
Exeter	5	1,260	9.9%
Fremont	8	842	7.6%
Greenland	2	160	2.3%
Hampstead	5	723	8.4%
Hampton Falls	6	520	6.6%
Hampton	2	32	0.4%
Kensington	7	371	4.9%
Kingston	5	1,146	9.1%
Londonderry	4	1,315	4.9%
New Castle	0	0	0.0%
Newfields	3	215	4.7%
Newington	0	0	0.0%
Newmarket	7	454	5.6%
Newton	2	126	2.0%
North Hampton	3	139	1.6%
Northwood	17	1,480	8.2%
Nottingham	8	847	2.8%
Plaistow	6	159	2.3%
Portsmouth	0	0	0.0%
Raymond	5	587	3.2%
Rye	8	351	4.3%
Salem	1	96	0.6%
Sandown	5	418	4.7%
Seabrook	0	0	0.0%

APPENDIX E. PERCENT OF MUNICIPAL LAND AREA ENROLLED IN TREE FARM PROGRAM — CONT.

Name	Number of Tree Farms	Acres in Tree Farms	Percent of Land Area in Tree Farms
South Hampton	1	22	0.4%
Stratham	0	0	0.0%
Windham	2	88	0.5%
Barrington	26	2,183	7.3%
Dover	14	648	3.7%
Durham	10	3,531	24.5%
Farmington	35	3,852	16.5%
Lee	11	1,001	7.8%
Madbury	11	642	8.6%
Middleton	8	2,188	18.9%
Milton	19	1,985	9.4%
New Durham	29	3,452	13.1%
Rochester	16	814	2.8%
Rollinsford	3	103	2.2%
Somersworth	0	0	0.0%
Strafford	45	6,994	22.4%
Acworth	7	2,622	10.6%
Charlestown	4	847	3.7%
Claremont	11	1,668	6.0%
Cornish	19	7,282	27.1%
Croydon	2	9,983	42.4%
Goshen	2	724	5.1%
Grantham	1	2,593	14.9%
Langdon	4	1,375	13.2%
Lempster	5	1,897	9.2%
Newport	7	2,070	7.4%
Plainfield	10	6,782	20.3%
Springfield	9	1,936	6.9%
Sunapee	1	538	4.0%
Unity	4	1,721	7.3%
Washington	6	3,067	10.5%
		837,486	14.6%

Based on N.H. Tree Farm program database issued 8/2000.