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Dynamics of White Pine in New England

William B. Leak
J.B. Cullen
Thomas S. Frieswyk

Abstract

The growth, regeneration, and quality of white pine between the 1970's and 1980's were analyzed for the six-state New England region. Growth was comparable among all states except for Rhode Island where the growth (1.71%) was low in comparison with other states and with the growth of red maple (4.29%) within the state. For all states, the proportion of acreage in white pine seedling/sapling stands was too small (8%) to maintain the current volume and acreage of the species. However, stems in the 2- to 10-inch diameter class were adequately J-shaped over all states to sustain the species. Because many of these small stems must be in small openings or under partial canopies, efforts to regenerate and release white pine seem warranted. The percentage of volume in grades 1 and 2 more than doubled between the 1970's and 1980's in all states except Massachusetts and Connecticut where the percentage remained about constant.

The Authors

WILLIAM B. LEAK is a research silviculturist with the Northeastern Forest Experiment Station, Durham, New Hampshire.

J.B. CULLEN is a forester in charge of the Forest Information and Planning Bureau within the New Hampshire Division of Forests and Lands in Concord, New Hampshire.

THOMAS S. FRIESWYK is a forester with the Forest Inventory and Analysis Unit of the Northeastern Forest Experiment Station at Radnor, Pennsylvania.

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USDA FOREST SERVICE
5 RADNOR CORP CTR STE 200
PO BOX 6775
RADNOR PA 19087-8775

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Introduction

White pine has been the dominant tree species in the economic and social history of New England. No other species has played a more important role in the settlement, industrial growth, and international relationships of the region. Because of its rapid growth and utility, no species offers greater opportunities for management. Numerous papers have been written about the characteristics, culture, and status of white pine such as Frothingham's (1914) early summary and proceedings from a symposium on eastern white pine in 1985 (Funk 1986) at the University of New Hampshire.

A very optimistic picture was presented at the University of New Hampshire symposium. It was reported that volumes and quality of white pine continued to increase in New England. Acreage in white pine stands declined only slightly in the last decade over the region as a whole. Markets and prices continued to be relatively strong; however, despite the salability of white pine, growth was reported as twice the amount cut for the region, and equal to or exceeding the cut in each state. Traditional difficulties with quality, regeneration, white pine weevil, and blister rust disease were reported as manageable rather than insurmountable.

However, in recent years, new environmental hazards have been recognized—primarily from atmospheric pollutants and the possible side effects. Because of the importance of white pine, its occurrence near industrial centers, and its known susceptibility to pollutants, a closer examination of the dynamics of white pine in the six New England states is worthwhile to determine whether this important resource is adequately growing and regenerating. Unless otherwise noted, this analysis is based primarily on the USDA Forest Service inventory and analysis data from the early 1970's (1971-73) through the early to mid-1980's (1982-85) (Dickson and McAfee 1988a,b,c; Frieswyk and Malley 1985a,b; Powell and Dickson 1984).

Status of White Pine

White pine is a common species in the white pine and white pine/hemlock cover types—defined as stands where these species make up at least half the stocking. These two cover types, plus the hemlock and red pine types, comprise the white pine/red pine type group—a group of four cover types that contains about three-fourths of the white pine in the six-state area. (In Massachusetts, the oak/pine type group also is important because white pine comprises about 30 percent of the cubic-foot volume.) The white pine and white pine/hemlock types account for 12 percent (3,907,000 acres) of the timberland in the region, ranging from 5 percent (17,000 acres in Rhode Island and 95,000 acres in Connecticut) to 24 percent (1,162,000 acres in New Hampshire). The white pine/red pine type group accounts for 16 percent (5,141,000 acres) of the region's timberland, ranging among states from 5 to 28 percent (Table 1).

White pine comprises 43 percent of the region's cubic volume in the white pine/red pine type group. The stands in Maine, Vermont, and Connecticut contain 26 to 37 percent white pine; the stands in the other states are more pure, containing 51 to 76 percent white pine. On all timberland (all cover types) in the region, white pine accounts for 11 percent of the volume. Overall, the species is fairly abundant in New Hampshire and Massachusetts where it accounts for 19 and 24 percent of the volume, compared to 6 to 11 percent in the other states (Table 2).

In the six-state area, about 76 percent of the white pine/red pine acreage is in sawtimber stands—defined as stands where half or more of the basal area (the cross-sectional area of all trees on an acre) is in trees larger than 9.0 inches in diameter, and many trees are much larger. Only 6 percent of the acreage is in seedling/sapling stands. The average basal area is 121 square feet per acre (Table 3). The general situation is that most white pine/red pine stands are characterized by large trees, high stocking, and few areas of young stems of regeneration. Keep in mind that the figures for individual states such as Rhode Island are tentative due to the small sample.

Growth

Choice of an appropriate measure of growth performance is critical. We defined growth as the average annual change in cubic-foot volume of the growing stock trees (live trees excluding rough and rotten as classified in the 1970's) by species from one measurement period (1970's) to another (1980's) PLUS the removal volume (harvested, culturally removed, etc.) and MINUS the ingrowth (trees that became 5.0 inches diameter or larger during the measurement period). Technically, this growth measure is defined as gross growth minus mortality and minus ingrowth. Ingrowth is related to long-term reproductive success, rather than growing conditions per se, so we wanted to keep it separate (Table 4) along with mortality and removals. We did not include cull increment (the volume of growing stock in the 1970's that became rough or rotten by the 1980's) in the calculations because this measure is somewhat subjective. Because the available data do not permit the calculation of growth per acre, we have expressed growth, mortality, ingrowth, and removals of white pine as an annual percentage of the 1970's volume—comparable to the simple interest rate on a bank account. For comparison, we have calculated the same statistics for red maple, a species known to be very aggressive in New England forests. Remember, these growth figures by species include all cover types and type groups combined.

Over all states (Table 4), growth of white pine (3.25%) is negligibly less than red maple (3.42%). And, mortality of pine (0.49%) is only moderately higher than red maple's (0.39%). However, pine growth in Rhode Island is low (1.71%), and it is notably less than red maple's (4.29%).

Table 1.—Number of acres (thousands) in timberland, the white pine/red pine type group,[a] and white pine types,[b] by state in the 1980's

State	Timberland	White/red pine group	White pine types
	Thousands of acres		
Maine (1982)	17,060	2,195 (13%)	1,537 (9%)
New Hampshire (1983)	4,812	1,356 (28%)	1,162 (24%)
Vermont (1983)	4,422	631 (14%)	432 (10%)
Rhode Island (1985)	372	17 (5%)	17 (5%)
Massachusetts (1985)	2,929	776 (26%)	664 (23%)
Connecticut (1985)	1,777	166 (9%)	95 (5%)
All	31,372	5,141 (16%)	3,907 (12%)

[a]Consists of the white pine, white pine/hemlock, hemlock, and red/scotch pine cover types.
[b]White pine and white pine/hemlock cover types.

Table 2.—Cubic feet of growing stock of white pine and all species together, by state and type group in the 1980's

State	Timberland		White/red pine group	
	All species	White pine	All species	White pine
	Millions of cubic feet			
Maine	22,796	1,736 (8%)	3,350	1,263 (37%)
New Hampshire	8,019	1,529 (19%)	2,470	1,250 (51%)
Vermont	6,275	449 (7%)	976	316 (32%)
Rhode Island	404	44 (11%)	33	25 (76%)
Massachusetts	4,652	1,107 (24%)	1,611	861 (53%)
Connecticut	2,778	155 (6%)	414	106 (26%)
All	44,954	5,020 (11%)	8,884	3,821 (43%)

Table 3.—Acreage in the white pine/red pine type group, by stand size class and state; and average basal area per acre (square feet) in the 1980's

State	Sawtimber	Poletimber	Seedling/sapling	All	Basal area
	Thousands of acres				(Ft^2)
Maine	1,537 (70%)	557	101	2,195	120
New Hampshire	1,067 (79%)	185	103	1,356	124
Vermont	522 (83%)	65	44	631	113
Rhode Island	12 (71%)	5	0	17	123
Massachusetts	640 (84%)	93	42	776	126
Connecticut	148 (89%)	18	0	166	133
All	3,926 (76%)	923	290	5,141	121

Table 4.—Growth,[a] mortality, ingrowth, and removals, in percent, of the 1970's cubic volume for pine[b] and red maple, by states

State	Growth		Mortality		Ingrowth		Removals	
	Pine	Red maple	Pine	Red maple	Pine	Red maple	Pine	Red maple
	Percent							
Maine	3.76	—[c]	0.61	—	1.00	—	2.56	—
New Hampshire	2.49	2.38	0.52	0.32	0.57	1.20	2.54	0.79
Vermont	3.32	3.83	0.29	0.45	0.69	1.61	1.89	0.76
Rhode Island	1.71	4.29	0.38	0.33	0.38	0.93	1.89	1.13
Massachusetts	3.80	4.09	0.39	0.32	0.52	2.75	2.03	1.00
Connecticut	2.99	4.27	0.10	0.56	1.09	1.27	0.05	0.99
All	3.25	3.42	0.49	0.39	0.72	1.63	2.33	0.87

[a]Growth percent is annual gross growth minus mortality minus ingrowth expressed as a percent of the 1970's cubic volume.
[b]Pine is mostly white pine, but includes small amounts of red pine in Maine, New Hampshire, and Vermont.
[c]Not reported as a separate species.

New Hampshire has the second lowest pine growth rate (2.49%), but it exceeds that of red maple (2.38%). There is no obvious reason why Rhode Island exhibits low pine growth rates: mortality is low (0.38%); the removal rate is fairly high (1.89%) but no higher than in other states except for Connecticut. The only unusual characteristic is that stands in the white pine/red pine group average higher in the percentage of pine (76%) in Rhode Island than in any other state, a condition that might cause intense within-species competition and increased risk from insects/disease. In addition, pine ingrowth in Rhode Island is low (0.38%), which raises questions about seed production/viability, site, and understory conditions—points discussed later.

Sampling Error

Any discussion of species' growth would be incomplete without some mention of sampling errors. The sampling errors for the 1970's cubic volumes—the denominators for the Table 4 percentages—are 30 to 31 percent for white pine in Rhode Island and Connectcut, and less in the other states (Table 5). This means that unless a 1-out-of-3 chance has occurred, the true cubic volume lies within 30 to 31 percent (or less) of the volumes used in the Table 4 calculations. In addition, there is sampling error in the growth/mortality/ingrowth/removal volumes as well. But even with these sampling errors, the white pine growth percent in Rhode Island seems low.

Table 5.—Sampling errors (one standard deviation), in percent, for the 1970's cubic volume of growing stock

State	White pine	Red maple
	Percent	
Maine	7	5
New Hampshire	7	6
Vermont	12	8
Rhode Island	30	24
Massachusetts	10	8
Connecticut	31	14

Radial Growth

As part of the 1980's survey, increment cores were taken from up to four dominant or codominant trees per plot for an estimation of site index—a measure of site quality based on average dominant-tree height at 50 years of age. These cores were used to determine annual ring widths, by year, for several species (Hornbeck et al. 1988). The data for white pine from this study are shown by state (Fig. 1).

Most states show a slightly parabolic trend over time—rising then falling— though the trend generally declines for Rhode Island and Connecticut combined. The consistencies among states in certain peaks and troughs presumably are due to weather conditions. Massachusetts shows one of the more precipitous declines over the last 5 to 10 years as well as the lowest end point, while Vermont shows little decline and the highest end point. But these growth rates do not correspond to the growth rates in Table 4: Massachusetts has a higher growth rate than Vermont from the 1970's to the 1980's. An independent study of ring widths in New Hampshire white pine stands (Cooke 1989) showed a steady decline over time for all trees averaged together (Fig. 2); a similar trend occurred for dominant/codominant or intermediate crown classes examined separately. This steady decline was attributed to increasing stand density over time, as well as the influence of tree age or size on ring width. The differences in trends between figures 1 and 2 illustrate the sensitivity of white pine to stand dynamics, and the difficulty of using radial growth to detect abnormal growth decline.

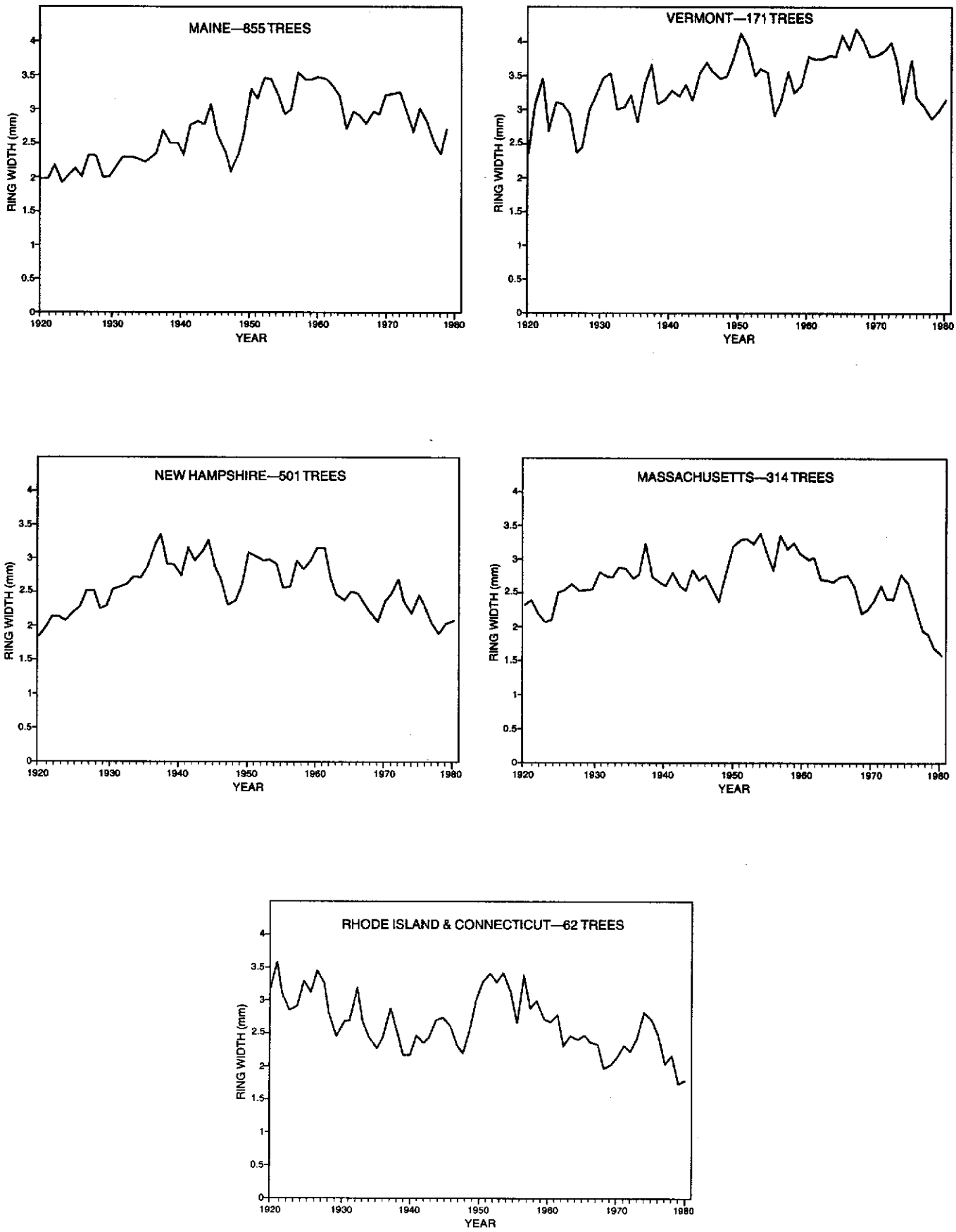

Figure 1.—Average annual ring width (mm) of dominant site index trees of white pine, by state, from 1920 to 1980 (Hornbeck et al. 1988).

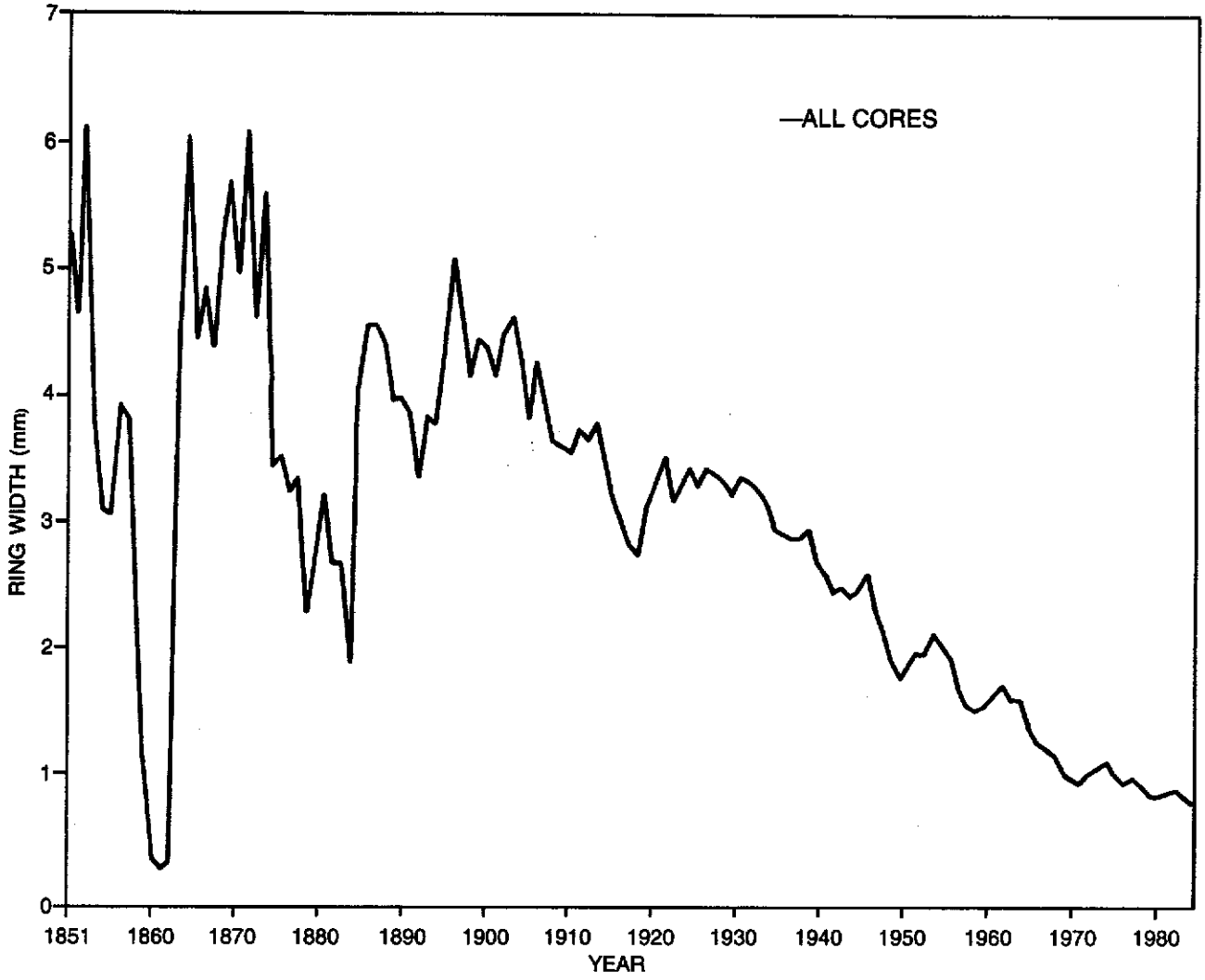

Figure 2.—Average annual ring width (mm) of white pine on New Hampshire growth plots for all crown classes combined, 1851 to 1980 (Cooke 1989).

Regeneration

Three approaches were used to examine the regeneration dynamics of white pine: ingrowth percentages, percentages of seedling/sapling stands, and diameter distributions.

The ingrowth percentages in Table 4 show the annual cubic-foot volume of growing stock trees that became 5.0 inches diameter or larger during the measurement period expressed as a percentage of the 1970's volume. Ingrowth is a measure of the rate at which small trees enter the poletimber class, and thus it is related to the abundance and growth rate of stems in the seedling/sapling size classes. Ingrowth rates of white pine varied appreciably among states. Maine and Connecticut had rates of about 1 percent; New Hampshire, Vermont, and Massachusetts had intermediate rates of 0.52 to 0.69 percent; and Rhode Island had the lowest rate of 0.38 percent. White pine ingrowth rates were about half those of red maple, except in Connecticut where rates for the two species were quite similar.

Percentages of the white pine type in seedling/sapling stands were examined for each state during the 1970 and 1980 remeasurement periods. In a fully regulated, even-aged forest, about 20 to 25 percent of the acreage should be in seedling/sapling stands to maintain continued production (Cullen and Leak 1988). This figure is based on a rotation of 80 to 100 years, coupled with yield-table data showing that 20 to 25 years are required for a stand to grow beyond the seedling/sapling stage.

Between the 1970's and 1980's, the seedling/sapling acreage in the white pine type dropped from about 25 to 8 percent for all states combined (Table 6), and a comparable change took place in the red maple/hardwood types. During this period, total acreage in the white pine and red maple/hardwood types dropped slightly.

Apparently, all states are short of acreage in young white pine, and the trend has been sharply downward over the last decade. However, since white pine can endure partial shade, it is possible that the species is regenerating to

some extent under partial overstories or in very small openings that would not be included in the seedling/sapling acreage. To examine this possibility, we looked at the diameter distributions of white pine stems. To provide replacement trees for those that grow larger, die, or are removed, the numbers of trees plotted over diameter class must follow an inverse J-shaped form. Number of live trees in the 2- to 10-inch diameter class for white pine and red maple in all cover types combined follows this shape for the six-state region (Fig. 3A). Number of small pine is only about one-fourth the number of red maple, which reflects the general abundance of the two species. Multiplying the white pine numbers by three places the two curves at a similar position in Fig. 3A; this shows that the red maple curve is the steeper of the two—which is characteristic of an aggressive, rapidly increasing species. This result aligns with Table 4, which showed that red maple has twice the ingrowth rate of white pine over the six-state region.

Diameter distributions for the separate states are variable in shape (Fig. 3B). Massachusetts and Maine have well-formed J-shaped curves with no evidence of regeneration deficits, though the overall abundance in Maine is much lower. New Hampshire and Connecticut show marked deficits in the 4-inch class, probably for either of two reasons. First, it is possible that regeneration conditions (seed supply, weather, insects/disease) were poor for a period of years and have since improved. Second, it is likely that many of the 2-inch white pine are in an understory position, and move very slowly into the 4-inch class. This latter explanation is logical in view of the minimal acreage in seedling/sapling stands (Table 6), implying that much of the small white pine is in the understory. Vermont shows a deficit in the 4-inch class coupled with a rather low number of 2-inch trees, whereas Rhode Island has equal numbers of 2- and 4-inch stems. These latter two curve forms denote inadequate numbers of small stems for recruitment into the larger sizes, leading to eventual losses in volume and acreage of white pine.

To summarize the status of white pine regeneration: for all states combined, the diameter distribution of white pine is fairly regular and J-shaped, implying that white pine regeneration and development are adequate to maintain the species. However, the curve for white pine is less steep than that for red maple, and the ingrowth rate much less, which indicates that the latter species is more aggressive.

Maine and Massachusetts have regular J-shaped distrubutions and moderate to high ingrowth rates, indicating that white pine regeneration and development are adequate; however, much of the white pine is in small openings or the understory. New Hampshire and Connecticut have reasonable numbers of 2-inch stems and deficiencies in the 4-inch class; this could suggest that regeneration of small stems is adequate, but movement into the 4-inch class is slow due to overtopping and the need for release. Vermont and Rhode Island have low numbers of 2-inch stems, possibly due to poor regeneration conditions or the gradual displacement of white pine from good old-field sites better suited to hardwood species.

Quality

For all states combined, the proportion of board-foot volume in log grades 1 and 2 nearly doubled (Fig. 4) between the 1970's and 1980's, and more than doubled in Maine, Vermont, and Rhode Island. This general improvement is due to the increasing size of the trees over time as well as stand improvement practices. Grade 1 logs are large (14 inches or more in diameter inside the bark on the log's small end) with about half the exterior free of knots or branches. Grade 2 logs may be smaller (6 inches diameter) with small red or black knots from living or dead branches, respectively. Grade 1 accounts for one-third or less as much volume per state as grade 2. The lack of quality increase in Massachusetts and Connecticut is notable. However, both states had higher-than-average percentages of grade 1 and 2 in the 70's. Both states have slightly higher proportions of acreage in sawtimber stands than the other states (Table 3), indicating, perhaps, that the stands are slightly larger and older—a condition that would raise the grade potential.

Table 6.—Percentage of acreage in seedling/sapling stands in the white pine and red maple/hardwood (northern and central) types during the 1970's and 1980's, by state

State	White pine type		Red maple/hardwood types	
	1970's	1980's	1970's	1980's
	Percent			
Maine	36.5	5.9	35.7	14.1
New Hampshire	21.8	9.2	10.6	4.6
Vermont	22.5	13.6	4.1	4.7
Rhode Island	0.0	0.0	9.3	0.0
Massachusetts	12.1	7.3	26.1	0.0
Connecticut	22.6	0.0	21.1	4.9
All	24.9	7.8	23.9	8.1

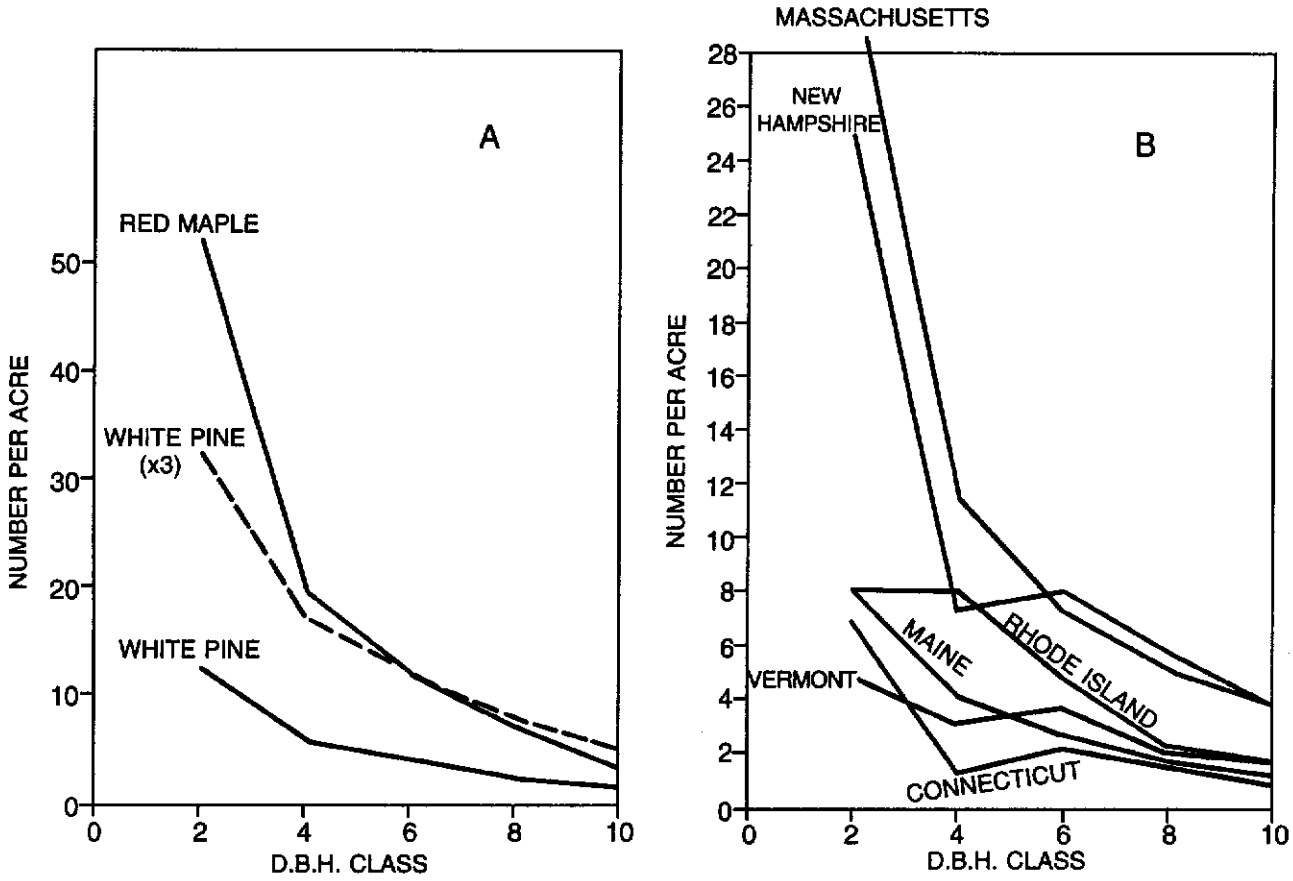

Figure 3.—Number of live white pine trees per acre by 2-inch d.b.h. classes for (A) all states combined compared with number of red maple; and (B) separate states.

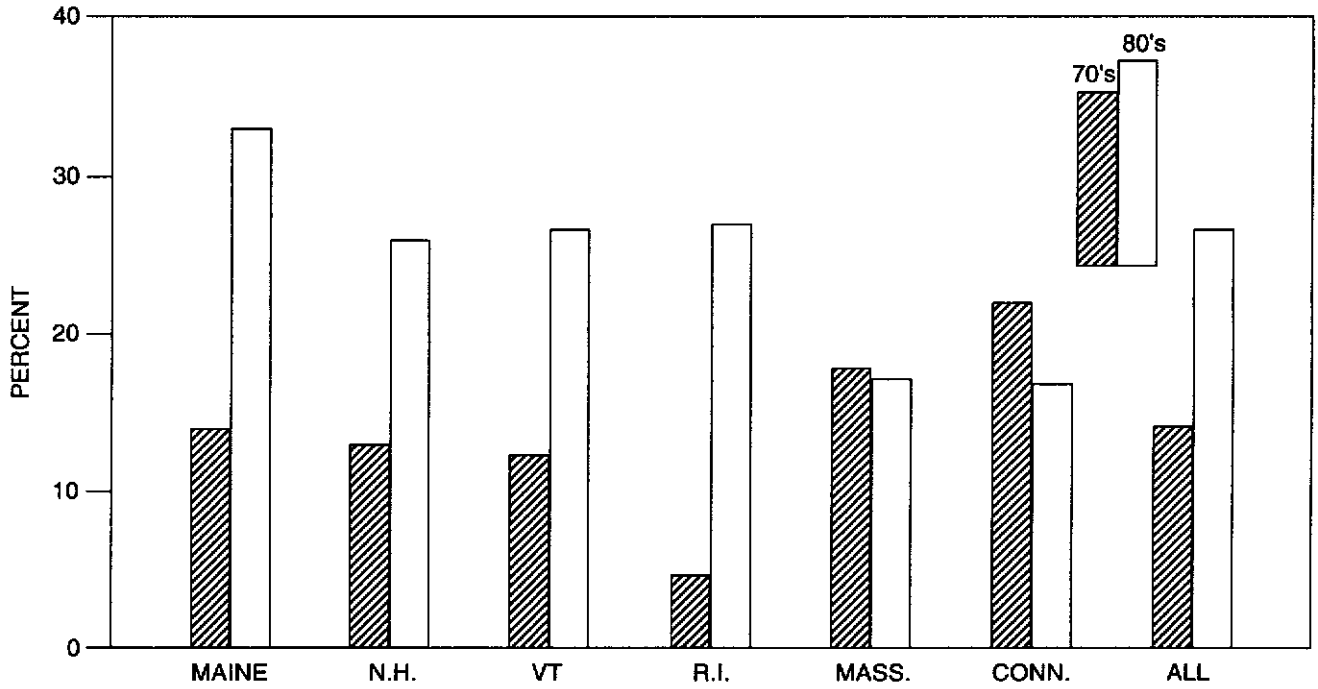

Figure 4.—Percentage of board-foot volume of white pine in grades 1 and 2, by states, in the 1970's and 1980's.

Discussion

Several features of this analysis of white pine dynamics in New England deserve to be highlighted.

1. Growth rates seem fairly comparable in all states except Rhode Island, where the percentage of growth based on cubic volume seems low (1.71%) in comparison with other states and in comparison with red maple (4.29%). No explanation can be given except for the possibility of localized poor site conditions, insect/disease problems, or atmospheric/environmental impact. Because radial growth trends seem to be influenced by stand dynamics, abnormal growth trends cannot easily be detected.

2. In all states combined, the proportion of acreage in seedling/sapling stands is too small (8%) to sustain the current volume and acreage of white pine. However, the diameter distribution in white pine stems between 2 and 10 inches seems adequately J-shaped in all states combined as well as in Massachusetts and Maine to sustain the white pine resource; many of the stems must be growing in very small openings or under partial canopies. Diameter distributions in other states show deficiencies in the 2-inch class (Vermont and Rhode Island) or the 4-inch class (New Hampshire and Connecticut). The former may indicate the need for intensive efforts to regenerate pine; the latter, a need to release overtopped pine.

3. Increases in quality have been substantial. The percentage of volume in grade 1 and 2 has more than doubled from the 1970's to the 1980's in all states except Massachusetts and Connecticut, where the percentage has remained about constant.

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Analysis of growth, regeneration, and quality changes for white pine between the 1970's and 1980's in the six-state New England region. Growth rates seemed comparable among all states except Rhode Island, where the percentage of growth (1.71%) seemed low. Over all states, the proportion of acreage in seedling/sapling white pine stands averaged too low (8%) to maintain the current volume and acreage of white pine. The diameter distribution of stems between 2 and 10 inches was J-shaped for all states combined, but deficiencies were noted in all states except Massachusetts and Maine. Many of the small stems must occur in small openings or under partial canopies. The percentage of volume in grades 1 and 2 more than doubled between the 1970's and 1980's in all states except Massachusetts and Connecticut, where the percentage remained about constant.

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