

**A Reconstruction of the Presettlement Forest in
the White Mountains of New Hampshire**

by

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Abstract

The current species composition of forest stands in northern New England are the result of human impact and natural processes. To fully understand the interactions between the two, we must reconstruct the composition and condition of the presettlement forests. This study aims to reconstruct presettlement forests in the White Mountains of central New Hampshire in order to establish a quantitative record of population changes over time. If the changes can be correlated with the environmental stresses driving the system, then the future of New England forests can be predicted to a greater degree.

This study utilizes archival land surveys and witness tree accounts, which are subject to some irregularities. However, fraud, settlement influence prior to the survey, misidentification of trees, sampling bias, and surveyor bias do not invalidate the effectiveness of the reconstruction of the presettlement forest. A total of 993 trees from 14 towns were superimposed on topographical maps, resulting in a data set of species, elevation, and aspect. The results were similar across towns, establishing beech, red spruce, and birch as the three dominant species. Hemlock, maple, and balsam fir were also important to various degrees. The species composition and abundance indicates that the forest was mature with little fire disturbance. This reconstruction is similar in composition to other presettlement reconstructions of northern New England forests and to the first U.S. Forest Service Survey conducted in 1903. The pollen record indicates a similar species composition of presettlement forests.

The forest was dominated by beech and hemlock below 400 meters, and by spruce, fir, and some birch above 600 meters. It is marked by a transition in the zone between 400 and 600 meters. An analysis of aspect indicates that beech, fir, and spruce were more abundant on the northern slope while maple and hemlock appeared more frequently on the southern slope. Birch was equally abundant on both slopes. Aspect analysis was correlated with elevation, showing an increase in the number of spruce and fir on the southern face at higher elevations. Fir was not recorded below 500 meters while hemlock and maple were not recorded above 500 and 700 meters, respectively.

The reconstructed presettlement forest varied from the current forest composition at comparable elevations in areas such as the Hubbard Brook Valley, Area I of the Bowl Natural Area, and old-growth stands in the Bartlett Experimental Forest. The general trend appears to be a decrease in spruce and an increase in hardwoods like birch, maple, and beech. Aspect data for current forest compositions was not available.

Introduction

The forest ecosystem of New England is a product of natural processes from the past and present intertwined with human activities (Whitney, 1994). Human influence has caused major environmental changes, and the ecological consequences of these past deeds cannot be ignored (White, 1985; Worster, 1988). In order to understand the impact of human activities on New England forest ecosystems, we must first reconstruct the composition and condition of presettlement forests. The forest prior to European settlement has been described in romantic, literary, utilitarian, and ecological terms by Whitney (1994), and this paper attempts to describe it in a quantitative manner. Whitney (1994) has also used methodology similar to this paper to reconstruct presettlement forests in other areas.

Old-growth forest stands have commonly been accepted as a baseline from which to evaluate the long-term effects of resource utilization, the impact of disturbance, innate species characteristics, and successional trends (Filip, *et. al.*, 1960; Leak, 1973; Martin, 1977). Today, few old-growth stands remain in the Northeast, and second growth and scattered old growth do not accurately represent the original vegetation (Bourdo, 1956). Disturbed tracts are substantially altered, typically composed of even-aged, primary, and intermediate successional species (Bourdo, 1956; Leak, 1961; Leak and Wilson, 1958). Presettlement stand reconstruction provides a more complete survey of the forest prior to disturbance, and creates a vehicle for observing the forest over several generations (Hamburg and Cogbill, 1988). Establishment of a long-term perspective allows longer, natural cycles to be analyzed separately from short-term processes (Hamburg and Cogbill, 1988; Clawson, 1979). Viewing environmental and anthropogenic trends and

changes in composition and spatial distribution over time allows the assessment of successional trends and the creation of sound management policies (Kent, 1952; Clawson, 1979).

This study aims to reconstruct presettlement forests in the White Mountains of central New Hampshire in order to establish a quantitative record of population changes for the evaluation of forest composition over time. A sound understanding of the changes that have occurred will allow the determination of the environmental stresses driving the system. If we can link those stresses to particular changes in species composition and forest structure, we can predict the future of northern New England forests with greater confidence.

The White Mountains cover about 328,000 ha, including northern Grafton county, Carroll, and southern Coos county (figure 1; Chittenden, 1903). Three mountain ranges, the Presidential, the Carter-Moriah, and the Franconia, run from the northeast towards the southwest with a peak elevation of 2,011 meters (U.S. Forest Service, 1949). The mountains receive consistent precipitation throughout the year (101.6 centimeters per year), and the humidity is relatively high at 75% (Chittenden, 1903). Four rivers drain the White Mountains: the Connecticut, the Merrimack, the Androscoggin, and the Saco (Chittenden, 1903; U.S. Forest Service, 1949).

This study includes data from the following towns in the White Mountains: Benton, Bethlehem, Campton, Crawford's Purchase, Elkin's Grant, Franconia, Hart's Location, Lincoln, Low and Burbank's Grant, Martin's Location, Nash and Sawyer's Grant, Shelburne, and Woodstock (figure 1). These towns provide an ideal study area due to the preservation of historical records and the minimal impact of Indians prior to

European settlement (Swanton, 1962, as cited in Hamburg, 1984). In southern New England, Day (1953) has documented extensive fires which significantly altered the composition of the coastal forests. Some aboriginal activity may have occurred in the river valleys of the White Mountains, where the land was more fertile and less rocky, but the mountainous region covered by this study is an unlikely area for extensive burning or land clearing by Indians (Russell, 1980; Hamburg, 1984). The first permanent European settlements were established in the broad valleys of the Connecticut, Saco, and Androscoggin Rivers between 1760 and 1765 (U.S. Forest Service, 1949). By 1800, most of Carroll, Grafton, and southwest Coos counties were settled (U.S. Forest Service, 1949). The remote areas of Carroll and Grafton counties were slower to settle, and still have relatively sparse populations today. In the mid to late 1700s, the settled land was cleared quickly to support agriculture, the primary industry. Later, logging became the mainstay of the economy and nearly all the remaining old growth stands in the White Mountains were cut over.

Two methods exist for assessing presettlement forest stand structure: direct measurement of old-growth undisturbed by European settlers and historical records (Hamburg, 1984). Old-growth forests are few and have typically been influenced in some way by European settlement, so this paper uses only historical evidence. This information falls into three categories (Hamburg, 1984; Whitney, 1994):

1. Documentary evidence: traveler's and settler's accounts, local histories, and legal documents
2. Manuscript materials: land surveys and witness tree accounts, town clerk and proprietor's records, maps and photographs
3. Field evidence: pollen analysis and old-growth forest (accounting for disturbance history)

Of the three methods, the land surveys and witness tree accounts in the manuscript materials were used most extensively in this study. To enable colonization, lots were surveyed in the towns and sold to settlers. The town borders or lots were identified by bearing trees, which marked the direction of the line, or witness trees, which was the closest tree to a corner (Bourdo, 1956; Siccama, 1971). The species of each witness tree was recorded and preserved in the proprietor's or town clerk's records (Hamburg, 1984). By superimposing lots and witness trees on a topographical map, we can determine geographic relationships of trees in the presettlement forest. Hamburg (1984) maintains that survey error due to the extensive amount of land covered by a surveyor in one day (8 km or 27 lots in Campton) does not significantly alter the spatial distribution of the trees. Elevation of the trees can still be approximated, and the large witness tree population diminishes the impact of inconsistencies.

The witness tree data are subject to several shortcomings and irregularities. Whitney (1994) mentions fraud, settlement influence prior to the survey, misidentification of trees, sampling bias, and surveyor bias as the most important considerations. Stewart (1935) and Bourdo (1983; 1955, as cited in Hamburg, 1984) have documented the more extensive cases of fraud. For example, some proprietors created false witness tree accounts and sold to settlers land that did not exist. Most sources appear to be reliable, however, and all survey lines have been checked against topographic features of modern maps to ensure consistency (Hutchinson, 1988, as cited in Hamburg, 1984). Settlement influence prior to the survey is rare, but exotic tree species provide good indicators. Surveyors were not trained as botanists, so some tree species may have been identified improperly due to unfamiliarity and most trees have

only been identified to the genus level. Such general information is still useful because of the limited number of species in the study area.

Because witness tree data covers only a percentage of the White Mountain region, sampling bias may cause the over or under representation of some vegetation types. The large number of trees over a variety of topographic features helps to minimize this effect and provide a useful view of the average composition of the forest over all elevations. Surveyor bias in tree selection, based on size or species, is also a factor. Bourdo (1956) discusses the possible biases and determines that while witness tree selection may not be purely random, it does constitute a valid sample of the vegetation. Bourdo (1956) also maintains that smooth-barked trees are not selected over rough-barked trees, and that the nearest tree is chosen instead. In the Midwest, saplings and old trees were not selected as witness trees and trees under 15 centimeters in diameter were probably not selected (Bourdo, 1956). Similar tendencies most likely occurred in the White Mountains (Hamburg, 1984). Species selection was not biased. Siccama (1971) tested for preference in a presettlement forest in Vermont by analyzing the distance from the stake to the nearest tree. A preferred species would exhibit a significantly greater average distance to the stake than for all the species. None of the stake-to-tree differences were statistically significant for any species, indicating no systematic bias. Although these results cannot be assumed to apply to the White Mountain region data, stand composition is consistent throughout the towns surveyed and similar to other northern New England presettlement forest communities (Hamburg, 1984; Torbert, 1935; Siccama, 1971; Satterson, 1977, as cited in Hamburg, 1984). More than one surveyor recorded witness

tree data in most towns, so surveyor biases that affect the sampling should be random and unsystematic.

This paper seeks to answer three questions:

1. What was the structure and composition of the White Mountain forests prior to European settlement?
2. How does this reconstruction compare with other presettlement forests of New England?
3. How does this reconstruction compare with old growth stands and the current composition of the White Mountains?

The comparisons to other presettlement forests, old growth stands, and current forest composition will be made in the Discussion section.

Methods

The archival data utilized in this study was collected from four main repositories: the New Hampshire State Library, the New Hampshire Division of Records Management and Archives, the New Hampshire State Historical Society, and the Dartmouth College Library (Richardson-Gile Collection¹). The State Library contains microfilm sets of early town records and proprietor's books for the majority of towns in New Hampshire, some of which list witness trees and lotting information. The State Archives, State Historical Society, and Dartmouth College mostly contain traveler's accounts and historical maps with trees plotted on boundaries or lots.

Data from each town was compiled and plotted on a lotting map of each town. The lots were then superimposed on a 7.5 minute United States Geographic Survey (USGS) topographic map by using a zoom transfer scope, and the trees were plotted in their appropriate corners. The elevation and aspect was then determined from the

¹ The Richardson-Gile Collection is located in the Baker Library Special Collection. See the following maps: 184, 292, 294, 298, 299, 300, 323, 570, 1346, 1362, 1372, 1529, 1540, 1892, 1895, 2257, 2800.

topographic map for each tree. The aspect analysis includes only those trees on north or south facing slopes, and does not include east, west, northeast/west, or southeast/west.

The witness trees for the town of Campton were not included in the aspect analysis.

Some towns no longer exist as separate entities, so Elkin's Grant was redrawn as part of Lincoln while Nash and Sawyer's Grant was part of Carroll (Figure 1).

Results

A total of 993 witness trees were collected from 14 towns², with full lotting accounts from Benton, Campton, and Woodstock (table 1). The dates range from as early as 1770 to as late as 1900. Dates later than 1850 generally cannot be relied upon as presettlement information, but the data in the later maps appear to be copied from earlier maps whose original dates are unknown.

The percent composition of presettlement forests in the White Mountains of New Hampshire are listed in table 2. Campton, which represents the lowest average elevation of witness tree samples at 320 meters, was dominated by beech³ (32.8%). Hemlock (21.7%), red spruce (16.2%), and maple (10.7%) were the other main components of the stand. Woodstock represents the intermediate elevations with an average of 530 meters. This town was clearly dominated by spruce at 40.3%, while beech (25.1%) and birch (13.7%) were also important species. The town of Benton was about 100 meters higher in elevation than Woodstock, and the most important species were beech (29.7%), birch (25.8%), and spruce (22.7%). Data from the ten other towns were combined, and spruce (38.6%) and birch (30.5%) were the dominant trees. An analysis of the combined data

² A complete list of the raw data by town is listed in Appendix A. The data set includes the point number, elevation, species, and aspect.

³ A list of tree species and scientific names is included in Appendix B.

for the White Mountains, based on 100-meter elevation bands, clearly shows the compositional trends due to changing elevations (table 3, figure 2). Below 400 meters, the forest is dominated by beech, hemlock, and some spruce. Between 400 and 600 meters the forest is transitional to a composition typical of higher elevations. Spruce tends to dominate the upper slopes, with some birch. Balsam fir becomes a major component of the forest at elevations higher than 800 meters. The species composition above 1000 meters in elevation was combined due to the low number of trees. At these high elevations, fir (42.3%) was the dominant species although spruce (30.8%) was also an important component.

An analysis of composition based on aspect reveals that beech, fir, and spruce were more abundant on the north-facing slopes, which are usually cooler and moister than south-facing slopes (figure 3). Maple and hemlock were more common on the south-facing slopes, while birch was equally abundant on the northern and southern slopes. If species composition is broken down by elevation bands, the influence of aspect and elevation can be seen (figure 4). Some bands were combined, due to the low number of individuals. Because of the small sample number, the trends resulting from the analysis may not be entirely accurate. Spruce exhibits the clearest trend, growing more abundantly on the northern side at low elevations and changing towards the southern side. At elevations greater than 700 meters, spruce appears equally on northern and southern slopes. Fir shows a similar pattern, but is not documented at elevations lower than 500 meters. At 900 meters, fir becomes more abundant on southern slopes than on northern slopes. Hemlock, in contrast, appears more often on the south-face and is not recorded at elevations higher than 500 feet. Beech, birch, and maple exhibit more erratic

and less predictable patterns, showing no clear trends. Maple does not appear above 700 meters in elevation.

Discussion

According to composition averages across the White Mountains, this presettlement forest qualifies as hemlock-spruce-northern hardwoods (Braun, 1950). The forest below 400 meters can be classified as hemlock-hardwood, changing into a spruce-hardwood forest above 600 meters (figure 2; Braun, 1950). Of particular note is the decrease in abundance of beech, hemlock, and maple, and the increase in spruce and birch in the transition zone. Above 800 meters, spruce began to decrease in abundance as its main competitor, balsam fir, increased. Hemlock and maple reached the upper end of their tolerance at 700 and 900 meters, respectively. The abundance of beech, spruce, fir, sugar maple, hemlock, and yellow birch all indicate that the presettlement forest was a mature stand with little fire disturbance (Fowells, 1965). Some primary succession species, such as paper birch and red maple, may have been present but they were not a major component of the majority of the forest. Paper birch may have been important at high elevations. Because differentiation is rare in witness tree data between species of maple and birch, however, the amount of each type cannot be determined.

According to Fowells (1965), all six of the major genus prefer the cool, moist northern aspect. However, only beech, fir, maple, and spruce exhibited this behavior (figure 3). Hemlock and birch perhaps were more abundant on the south-facing slope due to the effects of higher elevation in the mountains, which typically causes the climate to be cooler and less hospitable.

When compared with other presettlement data from the New England area, the results from the White Mountains represent a similar sample of forest composition (table 4). The most noticeable differences in species composition can be attributed to different latitudes and average elevations. The Williamstown, Massachusetts forest contains more hardwoods and oaks, and is located further south in a more temperate climate. The White Mountains and Vermont, composed more of beech and spruce, is cooler and further to the north. To account for differences in elevation, the White Mountain data from 580 to 700 meters were compared to the 1903 data by the U.S. Forestry Bureau in the same elevation range (table 5; Chittenden, 1903). The survey was located in Waterville, ranging in elevation from 580 to 1000 meters, and Low and Burbank's Grant (Chittenden, 1903). Species composition in the White Mountains was relatively similar to the Forest Bureau data, showing spruce, beech, and birch as the most important species.

An alternate method of reconstructing the presettlement forest lies in pollen analysis. According to Davis and Webb (1975), the White Mountains were classified as conifer/hardwood forest and consisted of white pine, arboreal birch, and hemlock with beech, maple, and oak further south. The data were assembled from 478 pollen counts from surface samples at 406 locations in eastern North America and represents the late Quaternary period. An analysis of the pollen counts show similarities between the witness tree data and the percent pollen from trees. Davis and Webb (1975) indicate that the pollen from the presettlement forest of the White Mountain area consisted of 30-45% birch, 15-30% spruce, and 5-10% of fir, maple, beech, and hemlock. The percent composition of pollen of spruce, fir, maple, and hemlock are consistent with the witness

tree data, while birch abundance is much higher and beech abundance is much lower. Due to inconsistencies in pollen preservation, some species may be over or under represented.

The presettlement forest differs from the current composition of several areas in the White Mountains, including Hubbard Brook Valley, Area I of the Bowl Natural Area, and old-growth stands in the Bartlett Experimental Forest. WS-6 of the Hubbard Brook Experimental Forest is composed of 38% sugar maple, 34% beech, 26% yellow birch, and 2% other for trees with a diameter at breast height greater than 15 cm (Bormann, et. al., 1970; Hamburg, 1984). Compared to the presettlement forests, the importance of spruce has decreased while the importance of sugar maple and yellow birch has increased. The virgin stands in Area I of the Bowl also show a decrease in spruce abundance, and an increase in beech and maple. These spruce-fir and northern hardwood forests consist of 50% beech, 13% yellow birch, 32% maple, and 4% spruce (Leak, 1973). The old-growth northern hardwood stands of the Bartlett Experimental Forest are slightly different from Hubbard Brook and the Bowl. Last cut in the late 1800's, this forest is composed of 36% beech, 23% maple, 19% hemlock, 9% yellow birch, 3% paper birch, and 2% spruce (Leak, 1973). Compared to the presettlement forests, Bartlett shows an increase in birch, maple, and hemlock, and a decrease in spruce. If Hubbard Brook, Area I of the Bowl, and Bartlett Experimental Forest are representative of the current composition of the White Mountains, then the general trend has been a decrease in the importance of spruce and an increase in the importance of hardwoods like birch, maple, and beech.

In general, the reconstructed presettlement forest presented in this paper is consistent with other presettlement forests in New England and with the pollen data. The presettlement forests were characterized by beech, hemlock, and some spruce below 400 meters, and by spruce, fir, and some birch above 600 meters. The transition zone between 400 and 600 meters was marked by a decrease in beech and hemlock and an increase in spruce and birch. In comparison to contemporary forests, the presettlement forests had a greater abundance of spruce, and hardwoods like birch, maple, and beech were less important species. The possible causes and implications of the reduced spruce population are explored in other papers (Hamburg and Cogbill, 1988).

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TABLES

Table 1. Summary of Witness Tree Data Sources from Towns in the White Mountains, New Hampshire.

Town Names	Date of Data	Known Surveyors	Number of Trees
Benton	1786, 1798, 1799	Willard, Gerrish, McDuffie	128
Bethlehem	1884 ⁴		68
Campton	1770-1797	5 different surveyors	457
Crawford's Purchase	1869, 1882, 1900 ⁴	Wilkins ⁵ , Macy	31
Elkin's Grant	1880 ⁴	Wilkins ⁵	6
Franconia	1884 ⁴ , 1898 ⁴		33
Gorham	≈1770, 1803		5
Hart's Location	unknown		6
Lincoln	1898 ⁴		28
Low and Burbank Grant	≈1772		4
Martins Location	≈1773		7
Nash and Sawyer's Grant	1868 ⁴ , 1874 ⁴	Wilkins ⁵	8
Shelburne	≈1769		1
Woodstock	1794		211

⁴ These dates are not necessarily the original dates of witness tree surveys. The data appears to have been copied onto these maps by subsequent surveyors at a later date.

⁵ P.C. Wilkins was a surveyor from Littleton, New Hampshire, cited in many of the Richardson-Gile maps as the original source of data.

Table 2. Percent Species Composition of Presettlement Forests in Towns in the White Mountains of New Hampshire.

Species	Benton, New Hampshire		Campton ⁶ , New Hampshire		Woodstock, New Hampshire		Other ⁷ , New Hampshire	
	n	%	n	%	n	%	n	%
Beech	38	29.7	150	32.8	53	25.1	22	11.1
Hemlock	7	5.5	99	21.7	17	8.0	4	2.0
Spruce	29	22.7	74	16.2	85	40.3	76	38.6
Maple	10	7.8	49	10.7	12	5.7	10	5.1
Pine	0	0.0	23	5.0	0	0.0	2	1.0
Birch	33	25.8	21	4.6	29	13.7	60	30.5
Ash	1	.08	13	2.8	0	0.0	0	0.0
Oak	1	0.8	11	2.4	0	0.0	0	0.0
Basswood	0	0.0	6	1.3	0	0.0	0	0.0
Fir	3	2.3	2	0.4	15	7.1	21	10.7
Other	6	4.7	9	2.0	0	0.0	2	1.0
Total	128		457		211		197	
Average Elevation (meters)	628		320		530		687	
Density of Sample (trees/km ²)	5.2		3.3		3.6			

⁶ From Hamburg, 1984.

⁷ Includes the towns and grants of Bethlehem, Crawford's Purchase, Elkin's Grant, Franconia, Gorham, Hart's Location, Lincoln, Low and Burbank's Grant, Nash and Sawyer's Grant, and Shelburne.

Table 3. Percent Species Composition of the Witness Tree Population of the White Mountains of New Hampshire by 100-Meter Intervals.

Elevation (meters)	100-200		200-300		300-400		400-500		500-600		600-700		700-800		800-900		900-1000		1000+	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Ash	3	3	6	4	1	1	3	2	0	0	0	0	1	2	0	0	0	0	0	0
Basswood	6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beech	31	25	60	38	56	37	39	29	33	23	21	17	12	18	7	17	1	5	3	12
Birch ⁸	6	5	9	6	9	6	18	13	31	22	39	31	13	20	10	24	4	18	4	15
Elm	0	0	0	0	1	1	3	2	3	2	1	1	0	0	0	0	0	0	0	0
Fir	0	0	0	0	0	0	2	1	9	6	7	6	5	8	2	5	5	23	11	42
Hemlock	26	21	35	22	34	23	20	15	10	7	2	2	0	0	0	0	0	0	0	0
Maple ⁹	19	16	12	8	17	11	14	10	9	6	7	6	2	3	1	2	0	0	0	0
Oak	2	2	7	4	1	1	0	0	1	1	0	0	1	2	0	0	0	0	0	0
Pine	20	16	2	1	0	0	0	0	0	0	1	1	0	0	0	0	2	9	0	0
Spruce	4	3	27	17	29	19	37	27	47	33	48	38	32	48	22	52	10	45	8	31
Other	5	4	2	1	2	1	0	0	0	0	0	0	0	0	0		0	0	0	0
Total	122		160		150		136		143		126		66		42		22		26	

⁸ Includes yellow, white, silver, and red birch species and races.

⁹ Includes sugar and red maple species.

Table 4. Percent Species Composition of New England Presettlement Forests.

Species	White Mountains, New Hampshire		Lebanon ¹⁰ , Vermont		Northern Vermont ¹¹		Chittenden County ³ , Vermont		Williamstown ¹² , Massachusetts	
	n	%	n	%	n	%	n	%	n	%
Beech	263	26.5	154	29.0	556	30.4	816	40.4	217	41.1
Hemlock	127	12.8	131	24.7	195	10.8	149	7.3	20	3.8
Spruce	264	26.6	2	0.4	296	16.4	115	5.6	2	0.4
Maple	81	8.2	59	11.1	278	15.4	321	15.8	92	17.4
Pine	25	2.5	72	13.6	21	1.2	129	6.3	9	1.7
Birch	143	14.4	30	5.6	198	11.0	104	5.1	34	6.4
Ash	14	1.4	19	3.6	35	1.9	67	3.3	14	2.7
Oak	12	1.2	22	4.1	10	0.6	57	2.8	65	12.3
Basswood	6	0.6	19	3.6	29	1.6	58	2.8	19	3.6
Fir	41	4.1	0	0.0	83	4.6	5	0.2	0	0.0
Other	17	1.7	23	4.3	102	5.6	217	11.6	56	10.0
Total	993		531		1803		2038		528	
Average Elevation (meters)	541						190		360	
Density of Sample (trees/km ²)							1.4-2.7		4.3	

¹⁰ From Torbert, 1935.¹¹ From Siccama, 1971¹² From Satterson, 1977, as cited in Hamburg, 1984.

Table 5. A Comparison of Presettlement Forests in the White Mountains with U.S. Forest Survey Data by Chittenden in 1903.

Location	Witness Trees					Direct Measurement	
	Benton	Campton	Woodstock	Other	Total (not including Campton)	Waterville	Low and Burbank
Date of Measurement	1786, 1798, 1799	1770-1797	1794	1770-1900 ¹³		1903	1903
Logging	none	none	none	none		limited, if any	limited, if any
Elevation range (m)	580-700	580-700	580-700	580-700	580-700	580-700	unknown
Number of trees	41	29	29	55	125	5,420	506
Species	Forest Composition (%)						
Spruce	37	45	41	29	34	29	42
Beech	20	21	20	5	15	35	24
Birch	24	10	17	47	34	24	20
Maple	10	3	0	11	8	8	6
Hemlock	5	7	2	0	2	3	5
Fir	0	7	2	7	4	<1	0
Other	5	6	0	0	2	<1	3

¹³ These dates are not necessarily the original dates of witness tree surveys. The data appears to have been copied onto these maps by subsequent surveyors at a later date.

FIGURES

Figure 2. Elevation gradients in species composition of the presettlement forest in the White Mountains of New Hampshire.

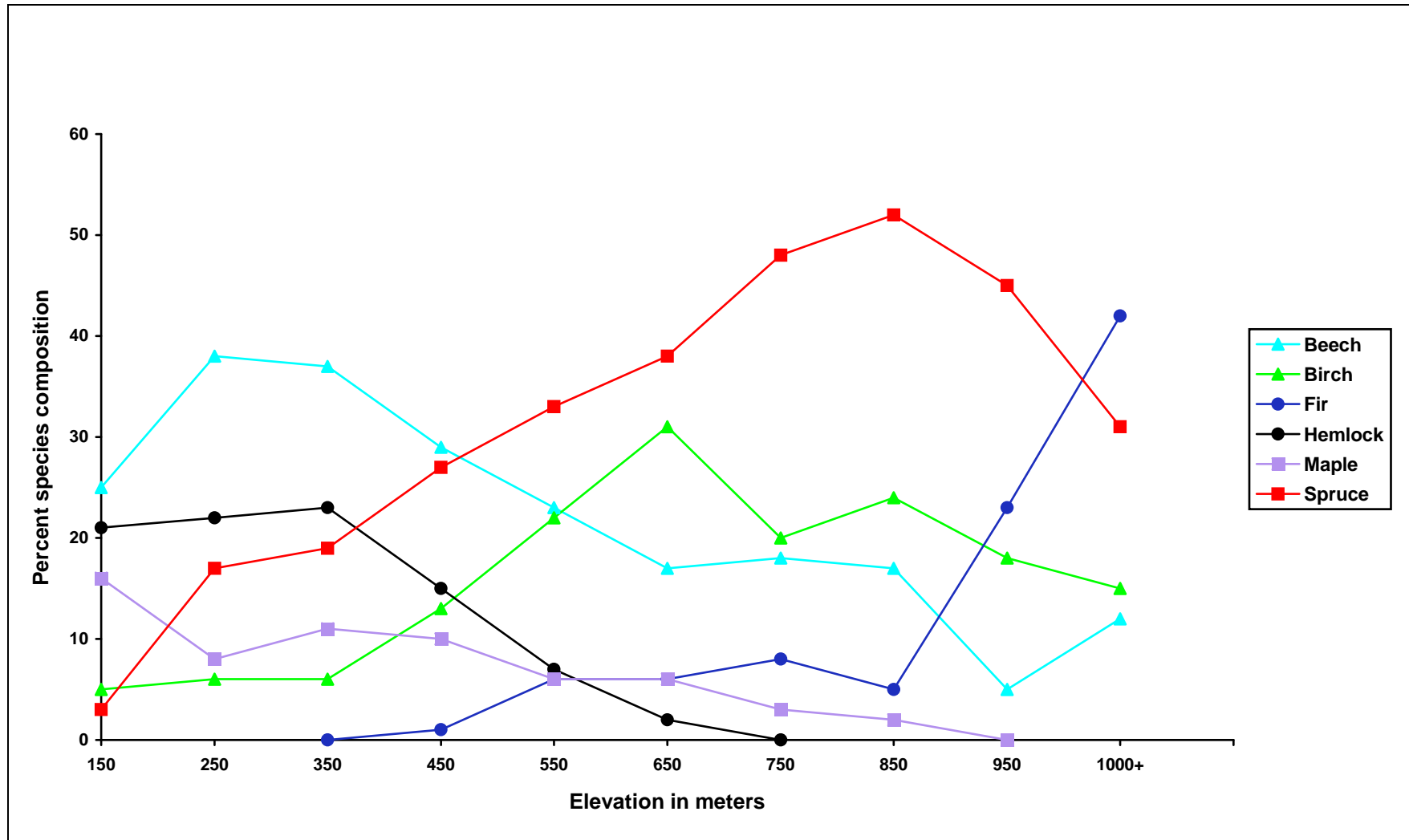


Figure 3. Slope aspect preference in species composition in the White Mountains of New Hampshire. North: n = 122. South: n = 71.

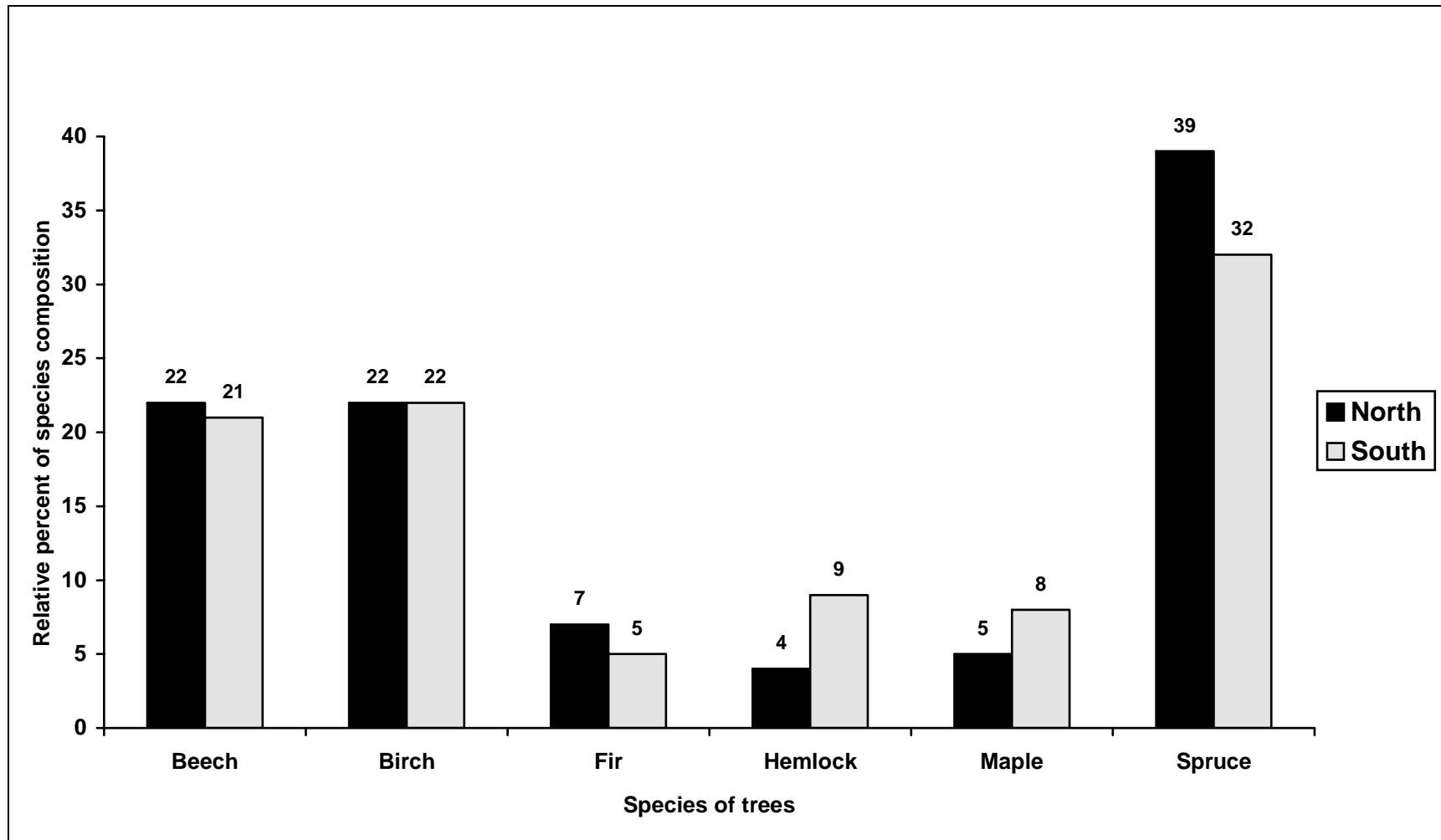


Figure 4. Percent species composition by aspect and elevation in the White Mountains of New Hampshire. Some elevation bands were combined due to the low number of individuals on each slope. North and South represents only those slopes facing purely north or south, and does not include northeast/west or southeast/west. The witness trees from the town of Campton are not included.

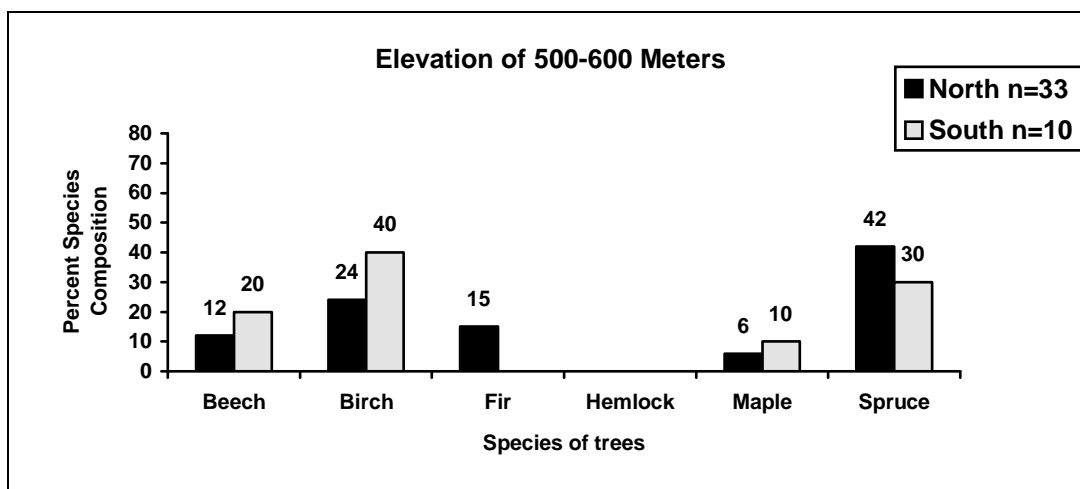
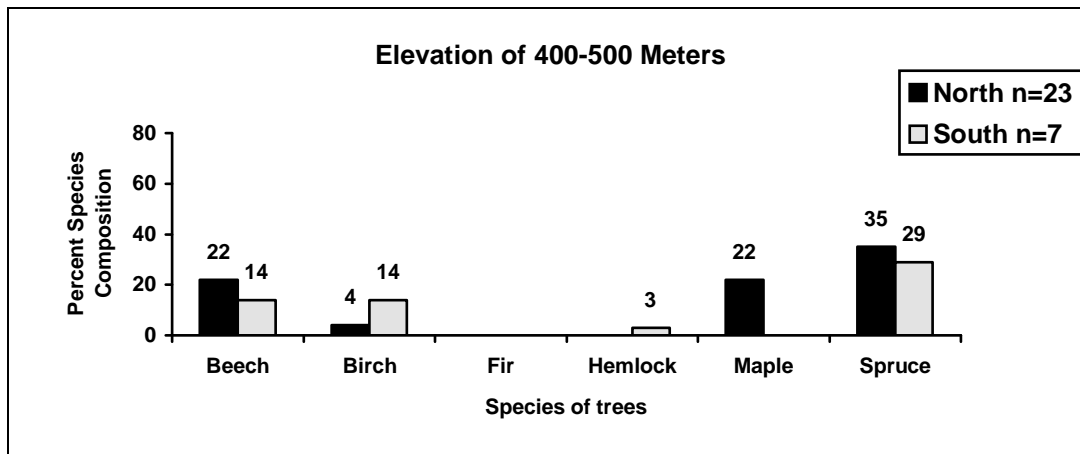
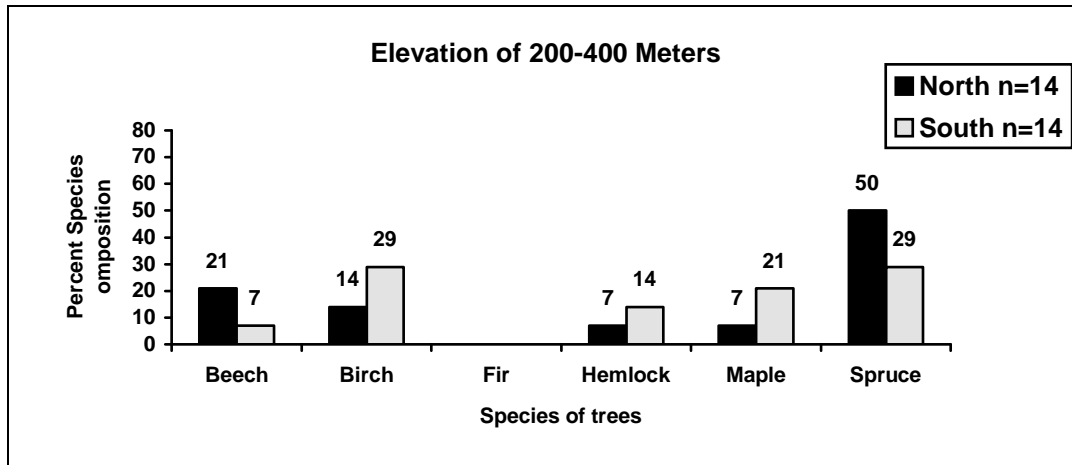
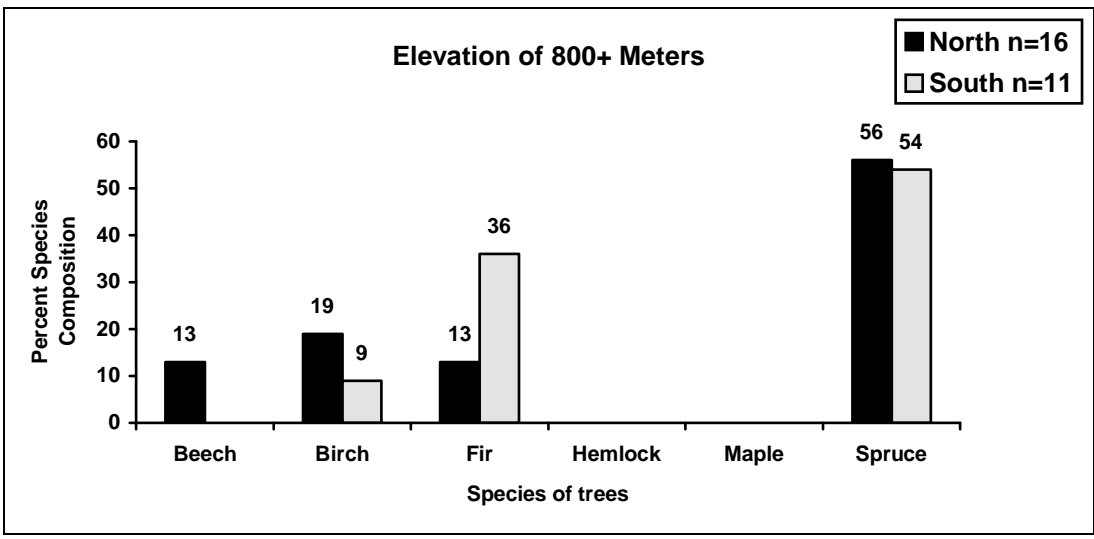
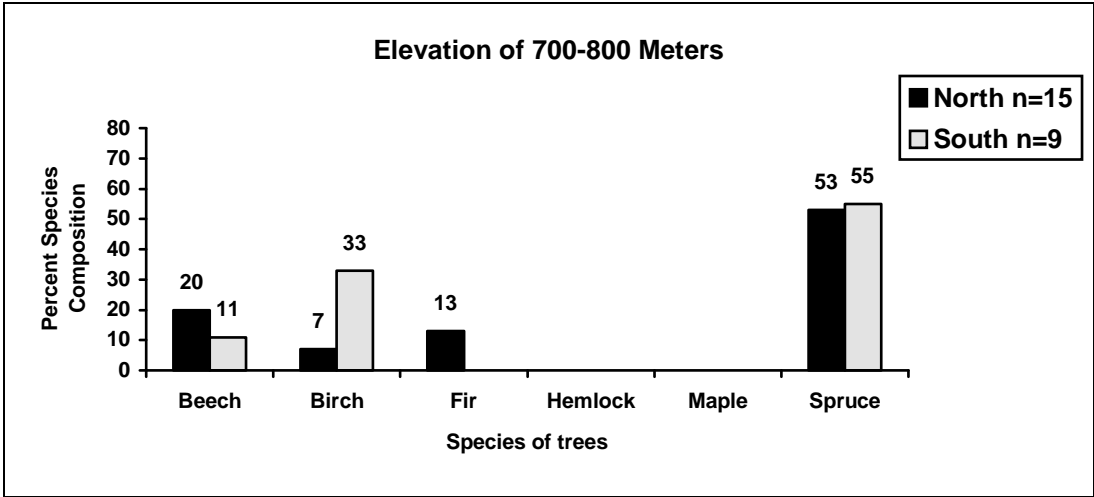
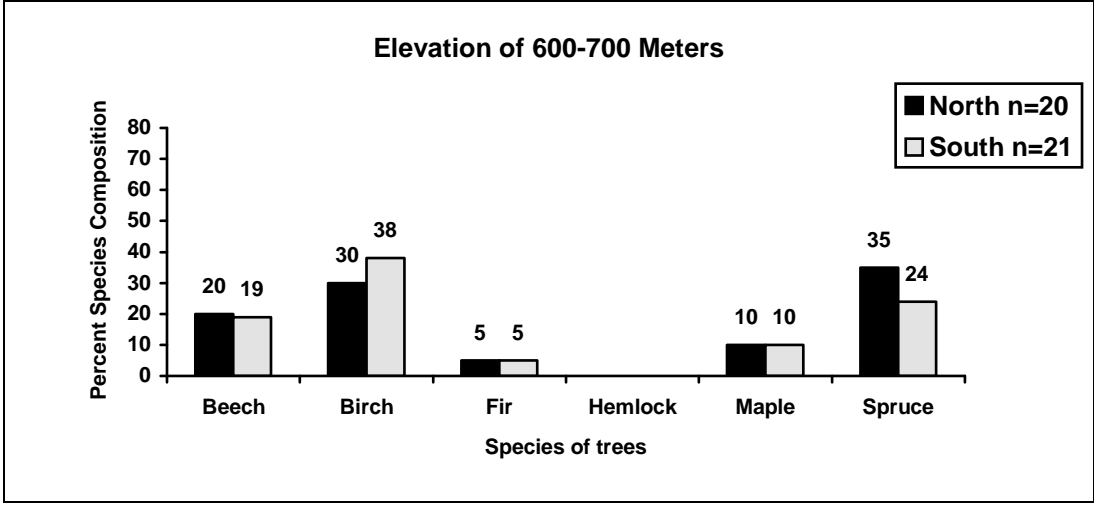


Figure 4 Continued.



APPENDIX A

WITNESS TREE DATA BY TOWN¹⁴**Benton, New Hampshire**

<u>Point #¹⁵</u>	<u>Species</u>	<u>Elevation (ft)</u>	<u>Elevation (m)</u>	<u>Aspect¹⁶</u>
2	Beech	1100	335	N
3	Beech	1100	335	NE
4	Spruce	1300	396	NW
5	Spruce	1405	428	N
7	Birch	1500	457	N
9	Beech	1340	408	N
16	Beech	1280	390	N
17	Beech	1240	378	NE
18	Maple	1500	457	N
19	Maple	1520	463	N
20	Hemlock	1460	445	N
21	Beech	1880	573	N
22	Spruce	1490	454	NE
23	Beech	1460	445	N
31	Beech	1420	433	NW
32	Beech	1520	463	N
33	Spruce	1500	457	N
36	Birch	1780	543	SW
37	Beech	1850	564	SW
38	Beech	1760	536	SE
40	Birch	1680	512	NW
41	Hemlock	1900	579	NW
42	Beech	2000	610	SE
44	Hemlock	1580	482	SE
45	Beech	1640	500	NW
47	Beech	1320	402	NW
48	Beech	1570	479	NW
49	Beech	1680	512	NE
50	Maple	1550	472	N
51	Spruce	1920	585	S
53	Birch	2120	646	NW
63	Beech	1560	475	NW
64	Birch	1740	530	N

¹⁴ A list of tree species and scientific names is included in Appendix B.

¹⁵ All maps with the original points are located at Brown University, Providence, Rhode Island in the Center for Environmental Studies (CES).

¹⁶ The symbol "X" signifies that an aspect could not be determined for that point.

65	Birch	1800	549	N
66	Birch	1850	564	N
67	Birch	1800	549	NW
69	Beech	2360	719	N
70	Hemlock	1800	549	SE
71	Hemlock	1610	491	NW
75	Birch	1660	506	W
76	Spruce	2200	671	NW
77	Birch	1980	603	NE
78	Maple	1930	588	NE
79	Hemlock	1930	588	NW
81	Beech	2120	646	NE
82	Birch	1880	573	NE
83	Beech	1880	573	NW
84	Hemlock	1940	591	NE
86	Beech	1800	549	NW
87	Spruce	2360	719	NW
88	Spruce	2190	667	NE
89	Spruce	2090	637	N
92	Birch	2520	768	SE
93	Birch	1840	561	E
94	Spruce	1900	579	NW
95	Beech	2000	610	W
96	Spruce	2580	786	SE
97	Beech	2290	698	S
98	Spruce	2280	695	N
99	Birch	2100	640	S
101	Beech	2500	762	SE
102	Spruce	1960	597	NE
103	Birch	1990	607	NW
104	Spruce	2200	671	W
105	Ash	2320	707	SE
106	Birch	2120	646	S
107	Birch	2160	658	X
108	Spruce	2190	667	X
112	Spruce	2080	634	NW
114	Beech	2120	646	S
115	Beech	1980	603	SW
116	Beech	2200	671	NE
117	Spruce	2300	701	S
118	Spruce	2190	667	X
120	Birch	2620	799	NE
121	Spruce	2190	667	NE
123	Birch	2800	853	SW

124	Spruce	1480	451	S
125	Spruce	1270	387	W
126	Spruce	2460	750	N
127	Beech	2290	698	N
128	Spruce	2190	667	W
130	Birch	3050	930	NE
132a	Birch	2240	683	NW
133	Beech	3240	988	NW
134	Spruce	1460	445	NW
135	Sugarleaf Oak	2600	792	N
136	Beech	2580	786	N
137	Beech	2420	738	NE
138	Spruce	2190	667	N
140	Spruce	3240	988	NE
141a	Fir	3680	1122	NW
145	Beech	1540	469	SW
148	Maple	1980	603	SW
150	Beech	2680	817	N
151	Birch	2280	695	NE
153	Spruce	3280	1000	NE
159	Elm	2140	652	SW
160	Birch	2650	808	W
161	Birch	2860	872	NW
163	Birch	2600	792	S
166	Elm	1780	543	SW
167	Maple	2200	671	SW
168	Beech	2440	744	SW
169	Birch	3540	1079	NW
174	Elm	1640	500	W
176	Fir	2700	823	SE
178	Beech	2600	792	SE
180	Maple	2400	731	W
183	Elm	1060	323	X
185	Spruce	2020	616	SW
186	Maple	1460	445	W
188	Elm	1640	500	W
189	Elm	1940	591	W
191	Birch	2650	808	S
192	Birch	1940	591	SW
194	Maple	2040	622	S
196	Birch	2040	622	SE
197	Fir	2440	744	SW
200	Maple	2850	869	SW

202	Birch	3680	1122	SW
203	Birch	1800	549	S
208	Beech	2800	853	NW
210	Birch	1760	536	S
219	Beech	2740	835	SW
220	Beech	2920	890	SW
226	Birch	1660	506	S
234	Spruce	2140	652	SW

Bethlehem¹⁷, New Hampshire

<u>Point #</u>	<u>Species¹⁸</u>	<u>Elevation (ft)</u>	<u>Elevation (m)</u>	<u>Aspect</u>
1	Fir		546	N
2	Birch		678	N
3	Fir		552	N
4	Spruce		554	N
5	Spruce		716	NW
6	Fir		552	E
7	Spruce	2760	841.2	E
10	Spruce	3040	926.5	E
11	Beech		504	NW
12	Spruce	2860	871.7	N
13	Spruce	3220	981.4	E
14	Birch		474	NW
14a	Spruce	2640	804.6	N
15	Spruce	3120	950.9	W
16	Spruce	3650	1112.5	N
17	Fir	3400	1036.3	E
18	Beech		462	NW
19	W. Birch	3240	987.5	E
20	Spruce	3840	1170.4	N
21	Hemlock		474	NW
22	Spruce	2880	877.8	N
23	Fir	3540	1078.9	W
24a	Spruce		470	N
25	Spruce	3120	950.9	NE
26	S. Maple	2200	670.5	N
27	Spruce	2780	847.3	N
28	S. Maple	2220	676.6	N
29	Spruce	2760	841.2	N
30	Spruce	2800	853.4	W
31	Spruce	3640	1109.4	W

¹⁷ In the data analysis, Bethlehem is grouped with the towns listed as “Other”.

¹⁸ The following abbreviations are used in the data listings: S. Maple is sugar maple; Y. Birch is yellow birch; W. Birch is white birch; S. Birch is silver birch.

32	Beech		462	E
33	Y. Birch		480	W
34	S. Maple	1920	585.2	N
35	W. Birch	2000	609.6	NW
36	Beech	2680	816.8	NW
37	Fir	3080	938.7	NW
38	Beech		504	N
39	Fir	1600	487.7	N
40	Spruce	1940	591.3	N
41	Spruce	2020	615.7	S
42	Beech	2320	707.1	W
43	Spruce	2800	853.4	W
44	Maple	1840	560.8	W
45	Y. Birch	1920	585.2	W
46	Spruce	1920	585.2	W
47	Fir	2040	621.8	W
48	Birch		432	W
49a	Y. Birch	1690	515.1	W
49	Y. Birch	1400	426.7	X
50	Y. Birch	1920	585.2	N
51	Spruce	2160	658.3	N
52	Y. Birch	1840	560.8	N
53	Spruce	2000	609.6	N
54	Spruce	1680	512.0	NW
55	Beech	1530	466.3	X
56	Spruce	1510	460.2	N
57	Spruce	1640	499.8	N
58	Spruce	1720	524.2	N
59	S. Birch	1310	399.3	N
60	Spruce	1470	448.0	N
61	Spruce	1680	512.0	N
62	Y. Birch	1540	469.4	W
63	Beech	1800	548.6	NE
64	Spruce	1280	390.1	NW
65	S. Birch	1680	512.0	NW
66	Spruce	1260	384.0	S
67	Y. Birch	1280	390.1	N
68	Spruce	1590	484.6	NW

Crawford's Purchase¹⁹, New Hampshire

Point # Species²⁰ Elevation Elevation (m) Aspect

¹⁹ In the data analysis, Crawford's Purchase was grouped with the towns listed as "Other".

²⁰ The following abbreviations are used in the data listings: Y. Birch is yellow birch; W. Birch is white birch.

1	Maple		546	S
2	W. Birch		510	S
3	Birch		492	X
4	Birch	1640	500	NW
5	Birch	1720	524	NW
6	Spruce	1840	561	NW
7	Y. Birch	1920	585	W
8	Birch	2180	664	NW
9	Birch	2120	646	NW
10	Spruce	2120	646	NW
11	Spruce	2180	664	NW
12	Spruce	2240	683	NW
13	Birch	2160	658	NW
14	Fir		666	W
15	Birch		666	W
16	Spruce		720	SW
16a	Birch		720	SW
17	Spruce		744	S
18	Birch		780	S
19	Spruce		840	S
20	Birch		879	S
21	Spruce		804	W
22	Fir		726	W
23	Spruce		705	S
24	Birch		660	S
25	Birch		645	S
26	Birch		684	SE
27	Spruce		684	S
28	Birch		636	S
29	Fir		627	S
30	Fir		549	X

Woodstock, New Hampshire

<u>Point #</u>	<u>Species</u>	<u>Elevation (ft)</u>	<u>Conversion (m)</u>	<u>Aspect</u>
3	Spruce	1790	546	NW
4	Spruce	2040	622	NW
6	Hemlock	1480	451	S
7	Hemlock	1190	363	NW
9	Spruce	1650	503	X
11	Hemlock	710	216	S
12	Beech	840	256	W
13	Maple	620	189	X
17	Beech	680	207	S
19	Beech	790	241	SE

20	Beech	1160	354	SE
21	Birch	870	265	NW
23	Hemlock	800	244	SE
24	Beech	920	280	SE
26	Beech	640	195	NW
28	Beech	630	192	X
30	Beech	840	256	W
31	Spruce	900	274	NW
32	Hemlock	800	244	NW
34	Beech	1550	472	SE
35	Beech	1600	488	NW
36	Beech	1640	500	S
37	Spruce	2200	671	S
38	Spruce	2290	698	NW
39	Birch	1440	439	NW
40	Beech	1480	451	NW
42	Beech	960	293	SW
43	Beech	780	238	X
45	Beech	660	201	X
47	Spruce	800	244	N
49	Hemlock	1040	317	SE
51	Hemlock	990	302	SE
52	Beech	1020	311	N
53	Spruce	1140	347	X
54	Birch	1120	341	S
55	Spruce	1040	317	SE
56	Spruce	920	280	N
57	Maple	1360	415	N
60	Spruce	1190	363	NW
61	Spruce	1110	338	N
62	Hemlock	1360	415	S
63	Spruce	2080	634	SE
64	Beech	1840	561	NE
66	Spruce	1760	536	NE
68	Hemlock	1120	341	SE
69	Spruce	1150	351	SE
70	Spruce	1480	451	S
71	Hemlock	1100	335	E
72	Hemlock	980	299	S
74	Spruce	720	219	NE
75	Beech	700	213	X
76	Spruce	700	213	X
77	Spruce	710	216	SW
78	Beech	780	238	SW

80	Spruce	900	274	N
82	Birch	940	286	S
83	Spruce	1100	335	N
84	Spruce	1400	427	N
85	Spruce	1400	427	SE
86	Spruce	1520	463	N
87	Maple	1820	555	NE
88	Hemlock	1680	512	SE
89	Hemlock	1560	475	S
91	Birch	1680	512	N
92	Beech	2180	664	N
93	Birch	2280	695	SE
94	Spruce	1880	573	S
95	Birch	1600	488	W
96	Beech	1520	463	NE
97	Beech	1680	512	SE
100	Birch	1930	588	SE
101	Beech	2010	613	SE
102	Beech	2240	683	SE
103	Beech	2320	707	N
105	Spruce	1820	555	N
106	Maple	1550	472	N
108	Spruce	1860	567	S
109	Beech	2120	646	N
110	Spruce	1870	570	N
111	Beech	1760	536	N
112	Beech	1960	597	NW
114	Hemlock	1160	354	NE
115	Spruce	1060	323	NE
116	Spruce	910	277	NE
117	Hemlock	760	232	N
118	Beech	760	232	X
119	Maple	890	271	SE
119a	Spruce	830	253	SE
120	Beech	890	271	SE
121	Birch	720	219	NW
122	Beech	1040	317	NW
123	Spruce	1360	415	N
124	Beech	1530	466	NW
125	Spruce	1560	475	NW
126	Spruce	1660	506	N
128	Birch	1840	561	NW
129	Birch	1840	561	NW
131	Birch	1414	431	X

132	Fir	1680	512	N
133	Birch	2020	616	N
134	Spruce	2300	701	N
135	Spruce	2620	799	N
136	Spruce	2380	725	S
137	Beech	2130	649	S
140	Spruce	2240	683	S
142	Beech	2720	829	N
143	Spruce	1950	594	N
144	Beech	1760	536	N
145	Beech	1480	451	NE
146	Birch	1430	436	X
147	Maple	1430	436	X
148	Hemlock	1640	500	SW
150	Maple	1720	524	N
151	Beech	1540	469	N
152	Spruce	1180	360	N
153	Spruce	1080	329	N
154	Maple	980	299	N
155	Birch	960	293	NW
156	Spruce	980	299	S
157	Beech	1140	347	NW
158	Maple	1160	354	NW
158a	Spruce	1100	335	NE
159	Beech	1690	515	NE
160	Birch	1600	488	SE
162	Beech	1140	347	SE
166	Spruce	1340	408	NE
167	Maple	1340	408	SE
169	Spruce	1460	445	SE
170	Spruce	1450	442	SE
171	Spruce	1460	445	NE
172	Fir	1550	472	N
173	Fir	1860	567	N
174	Spruce	2040	622	N
175	Fir	2280	695	N
176	Spruce	2600	792	N
177	Spruce	2640	805	SE
180	Spruce	2800	853	S
181	Spruce	2980	908	NE
182	Birch	2600	792	NE
183	Beech	2180	664	NE
184	Birch	2050	625	NE
185	Beech	1860	567	NE

186	Spruce	1820	555	SE
187	Birch	2000	610	SE
188	Beech	1900	579	NE
189	Spruce	1680	512	N
190	Beech	1460	445	N
191	Birch	1440	439	E
192	Birch	1280	390	NE
193	Spruce	1190	363	NE
194	Birch	1450	442	S
195	Spruce	1510	460	NE
196	Maple	1400	427	SE
197	Spruce	1900	579	SW
198	Birch	1880	573	N
200	Spruce	2440	744	SE
201	Birch	2120	646	NW
202	Spruce	1720	524	SW
203	Beech	1220	372	NE
204	Birch	1540	469	NE
206	Spruce	1820	555	SE
209	Spruce	2120	646	NE
210	Birch	2300	701	S
211	Hemlock	2090	637	SE
212	Spruce	2160	658	NE
214	Spruce	2440	744	NE
215	Fir	2560	780	N
216	Beech	2840	866	NW
217	Spruce	2640	805	SW
221	Spruce	2060	628	SW
222	Spruce	2160	658	SW
223	Beech	2370	722	SW
224	Spruce	2720	829	NE
225	Maple	2600	792	SE
226	Spruce	2560	780	E
227	Beech	2570	783	SE
228	Spruce	2560	780	E
231	Fir	2800	853	SE
232	Spruce	2560	780	NE
233	I	2090	637	
234	Spruce	1480	451	NE
235	Beech	1600	488	S
236	Spruce	2000	610	SW
238	Spruce	2600	792	N
239	Spruce	2410	735	NW
240	Fir	2600	792	N

241	Spruce	2800	853	S
242	Spruce	2640	805	S
243	Spruce	2480	756	SE
245	Fir	1880	573	N
246	Spruce	2560	780	N
247	Fir	3040	927	N
248	Fir	3360	1024	S
249	Fir	3080	939	NE
250	Fir	3420	1042	NE
251	Spruce	3560	1085	SE
254	Fir	3260	994	S
255	Spruce	2800	853	S
256	Beech	2280	695	S
257	Birch	2000	610	S
258	Beech	1820	555	S
266	Fir	3760	1146	E
267	Fir	3740	1140	NE
268	Birch	3340	1018	N
269	Spruce	2600	792	N
270	Spruce	1850	564	N
271	Spruce	2530	771	S
272	Spruce	2640	805	NE
273	Spruce	2440	744	NW
274	Beech	2400	731	SW
275	Birch	2520	768	SW

Other Towns in New Hampshire:

Low and Burbank

<u>Point #</u>	<u>Species</u> ²¹	<u>Elevation (ft)</u>	<u>Elevation (m)</u>	<u>Aspect</u>
31	Rock Maple		636	S
32	Spruce		472	NW
33	Spruce		502	W
34	Spruce		892	NW

Shelburne

<u>Point #</u>	<u>Species</u>	<u>Elevation (ft)</u>	<u>Elevation (m)</u>	<u>Aspect</u>
1	Maple	1240	377.9	S

Gorham

<u>Point #</u>	<u>Species</u> ²²	<u>Elevation (ft)</u>	<u>Elevation (m)</u>	<u>Aspect</u>
1	Spruce	1640	499.8	N

²¹ The following abbreviations are used in the data listings: Rock Maple is sugar maple.

²² The following abbreviations are used in the data listings: R. Birch is red birch.

2	Spruce	1680	512.0	NW
3	Elm	1700	518.1	NW
4	Y. Birch	2250	685.8	SW
5	R. Birch	2060	627.9	SW

Martin's Location

<u>Point #</u>	<u>Species</u> ²³	<u>Elevation (ft)</u>	<u>Elevation (m)</u>	<u>Aspect</u>
1	Beech	2660	810.7	E
2	Hemlock	1660	505.9	E
3	R. birch	2030	618.7	S
4	R. birch	2600	792.4	NW
5	Elm	1380	420.6	N
6	R. birch	1790	545.6	W
7	Spruce	1400	426.7	W

Nash and Sawyer

<u>Point #</u>	<u>Species</u>	<u>Elevation (ft)</u>	<u>Elevation (m)</u>	<u>Aspect</u>
1	Birch		660	N
2	Birch		624	N
3	Birch		654	N
4	Fir	1720	524.2	NE
5	Beech	1840	560.8	NE
6	Beech	1860	566.9	NE
7	Birch	1940	591.3	NE
8	Spruce	2040	621.8	NE

Hart's Location

<u>Point #</u>	<u>Species</u>	<u>Elevation (ft)</u>	<u>Elevation (m)</u>	<u>Aspect</u>
1	Birch	2720	829.0	SE
2	Beech	2520	768.1	S
3	Maple	2120	646.1	SW
4	Pine	2960	902.2	S
5	Fir	3600	1097.2	N
6	Beech	3720	1133.8	W

Elkin's Grant

<u>Point #</u>	<u>Species</u>	<u>Elevation (ft)</u>	<u>Elevation (m)</u>	<u>Aspect</u>
	Hemlock	1360	414.5	
	Spruce	1260	384.0	
1	Fir	3020	920.5	S
1	Birch	1650	502.9	NE
2	Beech	2200	670.5	SW

²³ The following abbreviations are used in the data listings: R. Birch is red birch.

3	Spruce	1960	597.4	N
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APPENDIX B

LIST OF COMMON AND SCIENTIFIC NAMES OF WITNESS TREES FROM THE WHITE MOUNTAINS, NEW HAMPSHIRE

<u>Common Name</u>	<u>Equivalent Scientific Name</u> ²⁴
Ash	<i>Fraxinus</i> spp.
Beech	<i>Fagus grandifolia</i> Ehrh.
Birch	<i>Betula</i> spp.
Red Birch	<i>Betula papyrifera</i> Marsh.
Silver Birch	<i>Betula alleghaniensis</i> Britton
White Birch	<i>Betula papyrifera</i> Marsh.
Yellow Birch	<i>Betula alleghaniensis</i> Britton
Basswood	<i>Tilia americana</i> L.
Elm	<i>Ulmus</i> spp.
Balsam Fir	<i>Abies balsamea</i> (L.) Mill.
Hemlock	<i>Tsuga canadensis</i> (L.) Carr.
Maple	<i>Acer</i> spp.
Red Maple	<i>Acer rubrum</i> L.
Rock Maple	<i>Acer saccharum</i> Marsh.
Sugar Maple	<i>Acer saccharum</i> Marsh.
White Pine	<i>Pinus strobus</i> L.
Sugarleaf Oak	<i>Quercus rubra</i> (?)
Spruce	<i>Picea rubens</i> Sarg.

²⁴ From Fowells, 1965.