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Forest Vegetation Related to Elevation in The White Mountains of New Hampshire

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ABSTRACT

Maximum tree size and species composition are related to elevation on Mount Washington (disturbed by logging) and Mount Whiteface (uncut) in the White Mountains of New Hampshire. Species migrational trends and differences between the two mountains in species elevational limits indicate that both hardwoods and softwoods will move to higher elevations in areas where cutting and heavy disturbance are eliminated.

IN THE MOUNTAINOUS areas of New England, elevation above sea level is one of the most important factors affecting the species composition and structure of forest vegetation. Because these forest characteristics relate closely to resource values and management possibilities, there is need for specific information about the influence of elevation.

Much of the past research on mountain ecology in New England has dealt with the alpine zone above timberline (*Bliss 1963 and 1966, Harries 1961, Griggs 1946*). Information about elevational relationships is available for the Adirondacks (*Holway and Scott 1969*) and the Green Mountains of Vermont (*Siccama 1968*). However, outside of the detailed vegetational work on the Hubbard Brook watersheds (*Bormann et al. 1970*), little specific information is available for the White Mountain range, which differs somewhat from other New England mountain systems in topography, geology, and past use.

AREAS AND METHODS

Our research dealt with two mountains in New Hampshire: Mount Washington, which is 1,917 meters (6,288 feet) high, and Mount Whiteface, 1,215 meters (3,985 feet) high. Mount Washington is a heavily used recreational area, whose lower slopes up to about 914 meters (3,000 feet) were irregularly logged up until the late 1800s. The study area on Mount Whiteface, in the Bowl Research Natural Area, has never been logged.

In the summer of 1971, a transect was laid out on the southeastern slope of Mount Washington, beginning at an elevation of 632 meters (2,073 feet) near the Appalachian Mountain Club's Pinkham Notch base camp and ending at 1,373 meters (4,505 feet) at the base of Nelson's Crag. At every 10-meter rise in elevation, measured with an aneroid barometer, a series of nested plots was set out.

On the main plot, which was 3 x 20 meters, laid out along the contour, the diameter above root swell was measured on all trees of at least 50 millimeters diameter. Ages of the largest and smallest stems (including those less than 50 mm) were determined by boring, sectioning, or counting terminal bud scars. On a 3 x 3-meter subplot, diameter was measured on all stems that were between 1.372 meters tall (4.5 feet) and 50 mm diameter.

Smaller vegetation was measured on a 1 m^2 circular subplot. Diameters were measured just above root swell (right at the point of curvature for the root swell on the uphill side of the tree) because this point can be identified on all sizes of trees and it is approximately the point used in making increment borings. Dbh proves useless on young trees and on stunted trees near timberline.

During the summer of 1972, a compass line was run up the northeast side of Mount Whiteface, beginning at an elevation of 610 meters (2,000 feet) at the Wonalancet River in the base of the Bowl and ending at 1,201 meters (3,940 feet) near the mountain top. At every 50-foot (15.24 m) rise in elevation, basal areas by species were accumulated with a 10-factor prism. The largest tree per species in the prism plot was measured for diameter just above the root swell and aged with an increment borer. The smallest stems per species on the prism plot or a 1 x 10-meter subplot also were measured and aged.

On both transects, elevations were double-checked at several points, and the errors were distributed. These corrected plot elevations were used in analyzing the data.

RESULTS AND DISCUSSION

Maximum Tree Diameter

Maximum tree diameters commonly ran considerably larger on Mount Whiteface than on Mount Washington except at elevations above 900 meters (table 1). This pattern probably resulted from the logging activity on Mount Washington before the turn of the century. For the typical northern hardwoods—beech, yellow birch, and sugar maple—no substantial diminution in tree size was evident on Mount Whiteface up to 900 meters. For the spruce-fir components—red spruce, balsam-fir, and paper birch—tree size remains large up to 1,100 meters on Mount Whiteface and 1,200 meters on Mount Washington.

For those who use diameter measurements at breast height, dbh in mm can be estimated from diameter above root swell by:

Hardwoods: Dbh (mm) = −11.68 + 96 (dia. mm, root swell)
$R^2 = .997$
$S_{yx} = 10.04$

Softwoods: Dbh (mm) = −17.80 + .95 (dia. mm, root swell)
$R^2 = .996$
$S_{yx} = 10.43$

Basal Area and Species Composition

On both Mount Washington and Mount Whiteface, basal areas per acre increased moderately with elevation as the proportion of softwoods increased. Then basal area seemed to decline at 1,100 meters on Mount Whiteface and at 1,300 meters on Mount Washington. Percent species composition differed somewhat between the two areas, partly because of the differences in past land use.

In general, Mount Washington has a wider range of species than the late-successional stands on Mount Whiteface (table 2). However, on both areas the typical northern hardwoods are most abundant in the 600 to 700 meter elevation classes. Red spruce appears in greatest abundance in the 800 to 1,000 meter elevation classes. Balsam-fir first becomes an important component in the 800-meter class and continues to increase in relative abundance with higher elevation. On Mount Washington, paper birch is abundant from the 700- through 1,100-meter class, while on Mount Whiteface it is evident mainly in the 1,000 to 1,100 meter classes.

Species' Elevational Ranges

Based on the occurrence of stems more than 1 year old, elevational ranges of species were

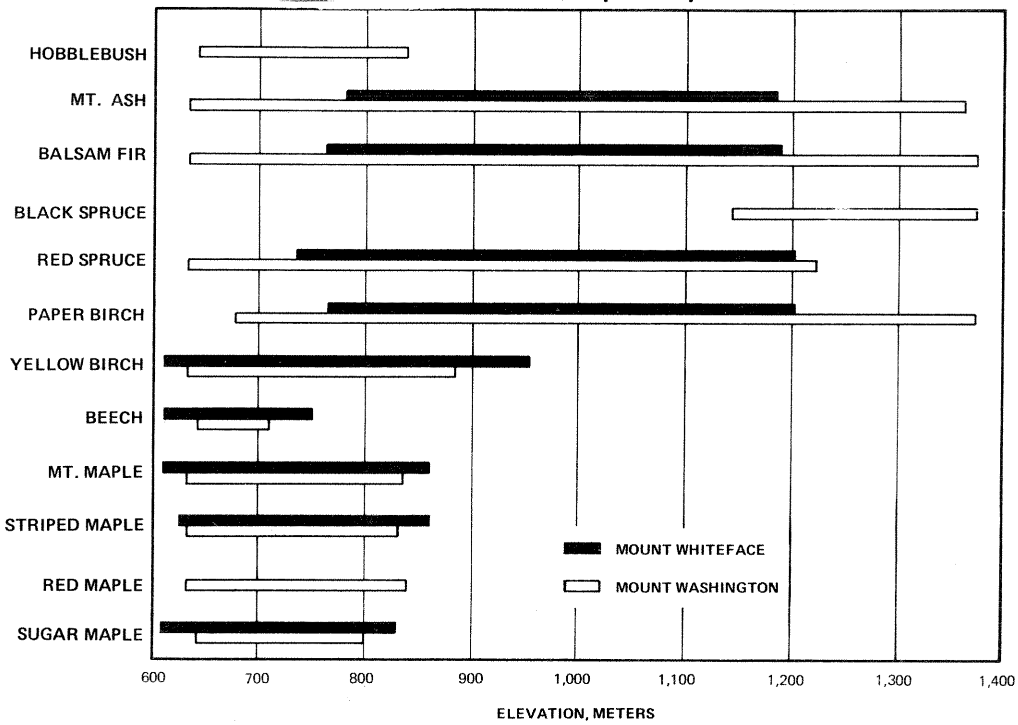
Table 1.—*Maximum tree diameters, by species and 100-meter elevation classes (600 to 699, etc.)*
[In mm, above root swell]

Elevation class (meters)	Beech	Yellow birch	Sugar maple	Red maple	Paper birch	Mt. maple	Striped maple	Mt. ash	Aspen	Red spruce	Balsam fir	Eastern hemlock	Black spruce
MOUNT WHITEFACE													
600	567	806	779	—	—	—	—	—	—	—	—	—	—
700	444	724	632	—	435	97	195	190	—	710	119	—	—
800	—	684	518	—	404	—	165	230	—	686	309	—	—
900	—	317	—	—	456	—	—	—	—	645	248	—	—
1,000	—	—	—	—	480	—	—	183	—	597	274	—	—
1,100	—	—	—	—	270	—	—	179	—	344	285	—	—
1,200	—	—	—	—	—	—	—	—	—	147	160	—	—
MOUNT WASHINGTON													
600	219	628	179	370	301	66	126	—	—	—	90	583	—
700	73	371	353	—	284	—	137	—	352	59	99	—	—
800	—	354	—	—	231	—	—	278	—	306	352	—	—
900	—	—	—	—	337	—	—	221	—	530	318	—	—
1,000	—	—	—	—	540	—	—	—	—	684	544	—	—
1,100	—	—	—	—	460	—	—	—	—	556	337	—	227
1,200	—	—	—	—	291	—	—	—	—	281	306	—	254
1,300	—	—	—	—	173	—	—	81	—	—	321	—	149

Table 2.—*Average species composition, by species and 100-meter elevation classes*
[In percent of total basal area]

Elevation class (meters)	Beech	Yellow birch	Sugar maple	Red maple	Paper birch	Mt. maple	Striped maple	Mt. ash	Aspen	Red spruce	Balsam fir	Eastern hemlock	Black spruce
MOUNT WHITEFACE													
600	29	25	46	—	—	—	—	—	—	—	—	—	—
700	28	32	15	—	6	—	2	5	—	10	2	—	—
800	—	18	4	—	8	—	4	2	—	42	22	—	—
900	—	2	—	—	4	—	—	—	—	61	33	—	—
1,000	—	—	—	—	15	—	—	2	—	37	46	—	—
1,100	—	—	—	—	38	—	—	3	—	14	45	—	—
1,200	—	—	—	—	—	—	—	—	—	24	76	—	—
MOUNT WASHINGTON													
600	2	60	4	17	4	1	1	—	—	—	1	10	—
700	—	45	12	—	32	—	1	—	7	2	1	—	—
800	—	17	—	—	12	—	—	3	—	19	49	—	—
900	—	—	—	—	14	—	—	1	—	38	47	—	—
1,000	—	—	—	—	15	—	—	—	—	37	48	—	—
1,100	—	—	—	—	13	—	—	—	—	16	68	—	3
1,200	—	—	—	—	5	—	—	—	—	3	90	—	2
1,300	—	—	—	—	3	—	—	—	—	—	89	—	8

Figure 1.—Elevational ranges of woody species on Mount Whiteface and Mount Washington, based on occurrence of stems over 1 year old. Transects began at 610 and 632 meters above sea level and ended at 1,201 and 1,373 meters, respectively.



graphed for each area (fig. 1). Occasional outliers were ignored. Northern hardwoods generally occur below 850 meters, although yellow birch is found up to 950 meters. The softwoods (and paper birch) are found throughout a much broader range although, as noted earlier, they become predominant above 800 meters.

Note that the elevational ranges of the hardwoods are consistently narrower in the disturbed Mount Washington stands than in the uncut Mount Whiteface stands. The opposite is true with softwoods: softwood (and paper birch) ranges are narrower on Mount Whiteface than on Mount Washington.

It seems likely that, when cutting is eliminated, northern hardwood ranges will expand to their upper limit—850 to 950 meters—while softwood ranges will retreat. The end result would be a general reduction in lower-altitude softwoods and a fairly strict line of demarcation between the northern hardwood and spruce-fir associations. Paper birch would remain as a permanent resident in the spruce-fir association.

The same conclusions can be made from preliminary information about the detection of species' migration. When maximum and minimum ages are plotted over elevation (or distance), it becomes possible to detect advancing, stable, or retreating species fronts. The data from Mount Washington, already published, indicated that the hardwoods generally were advancing uphill, while paper birch and spruce-fir were retreating. In contrast, the more recent data from Whiteface indicate that the northern hardwoods such as beech (fig. 2) and sugar maple have attained almost perfectly stable uphill fronts. Yellow birch (fig. 3) still seems to be advancing uphill, while the lower end of its elevational range is retreating uphill drastically (although the shape of the lower front is not well defined by the data). The softwoods and paper birch (fig. 4) seem to be retreating only sporadically and slowly uphill.

Figure 2.—Maximum and minimum age for beech over elevation, showing approximate shape of migrational fronts. Mount Whiteface.

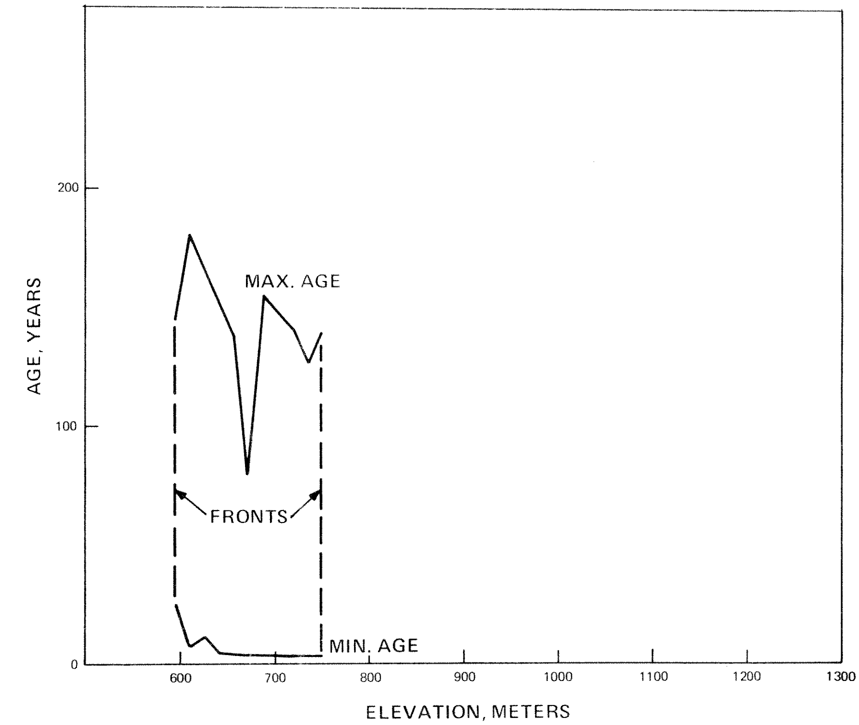


Figure 3.—Maximum and minimum age for yellow birch over elevation, showing approximate shape of migrational fronts. Mount Whiteface.

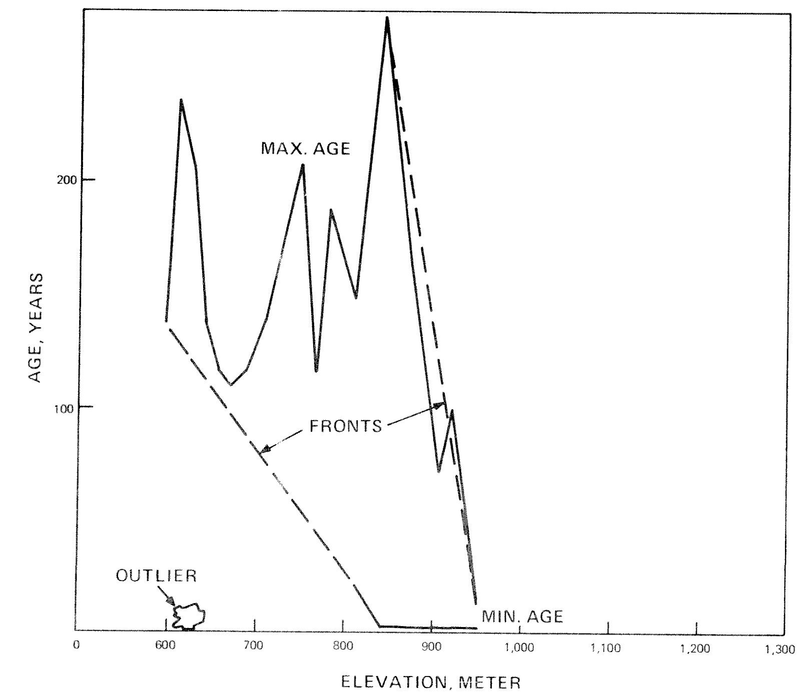
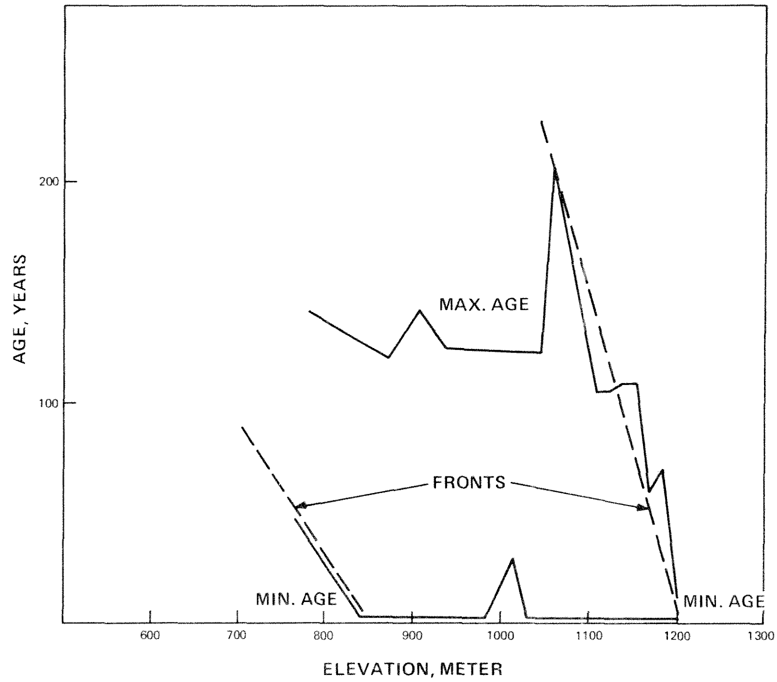


Figure 4.—Maximum and minimum age for paper birch over elevation, showing approximate shape of migrational fronts. In this case, the curves are drawn as envelope curves, ignoring some of the irregularities in plotted points. Mount Whiteface.



IN CONCLUSION

This information on species development related to elevation may be useful in forest land-use planning. The information from Mount Whiteface should be especially useful in evaluating the potential species and sizes that can develop at specific elevations. The information in this paper cannot be extended much beyond the White Mountains, although similar conditions may exist at similar latitudes in Maine, Vermont, and New York.

Preliminary evidence is given on changes in species elevational relationships in disturbed and uncut areas. Without logging, hardwoods apparently would progress, and softwoods recede, to a point of stability at higher elevations; and the line of demarcation between the two associations would tend to become more distinct.

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LIST OF SPECIES

Common Name	*Scientific Name*
American beech	*Fagus grandifolia* Ehrh.
Yellow birch	*Betula alleghaniensis* Britton
Paper birch (including mountain paper birch)	*Betula papyrifera* Marsh., including *B. cordifolia* Reg.
Sugar maple	*Acer saccharum* Marsh.
Red maple	*Acer rubrum* L.
Red Spruce	*Picea rubens* Sarg.
Balsam-fir	*Abies balsamea* (L.) Mill.
Eastern hemlock	*Tsuga canadensis* (L.) Carr.
Black spruce	*Picea mariana* (Mill.) B.S.P.
Hobblebush	*Viburnum alnifolium* Marsh.
Mountain maple	*Acer spicatum* Lam.
Striped maple	*Acer pensylvanicum* L.
Mountain-ash	*Sorbus americana* Marsh.

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