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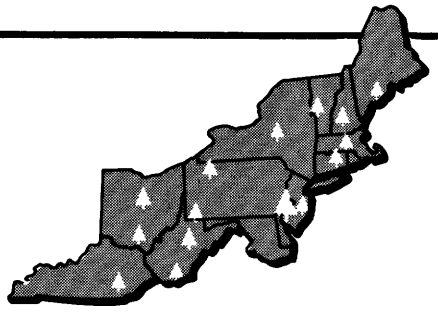

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DISTRIBUTION OF TREE SPECIES IN AN UNDISTURBED NORTHERN HARDWOOD-SPRUCE-FIR FOREST, THE BOWL, N. H.

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ABSTRACT.—Knowledge acquired from forests that have never been logged can provide clues to the long-term effects of resource utilization. In 1974, a survey was made of the vegetation of the Bowl Research Natural Area in central New Hampshire, known to be undisturbed by humans; and an adjacent watershed known to have been logged in the late 1880's. There were no significant differences in the mean basal areas and aboveground biomass of trees between the two watersheds, indicating that 90 years after logging this forest has nearly recovered. The major species in the Bowl are yellow birch, beech, sugar maple, red spruce, and balsam fir. The forest has a mean basal area of 28 m^2/ha and contains about 260 metric tons of aboveground dry biomass. A nearby 60-year-old second growth forest contains about 23 m^2/ha basal area and only about 140 t/ha.

Knowledge acquired from forests that have never been logged can provide clues to the long-term effects of resource utilization. Very few virgin forests remain in the northeastern United States. The Bowl Research Natural Area (Area I, fig. 2) near Wonalancet, N. H., administered by the White Mountain National Forest, is one of the few left.

In 1973, a study of the flux of chemical elements through this undisturbed watershed was begun (Martin 1975). Several nutrients essential to plant growth were measured in precipitation. These same nutrients were also measured as they left the forest dissolved in streamwater. An analysis of the vegetation on the watersheds was necessary to evaluate the differences between these inputs and outputs. The results of the vegetation survey are presented here.

The objectives of the study were: (1) to describe generally the forest vegetation of the valley as a whole; (2) to determine the relationship between tree distribution and elevation; (3) to determine the logging and wind damage history; (4) to compare the vegetation between the reserved natural area of the Bowl and the rest of the valley; (5) to compare the forest vegetation of the Bowl with other forests nearby.

The Study Area

The study area is a 607-hectare (ha) valley on the southern flank of the White Mountains near Wonalancet, N.H. (Fig. 1). The valley is bordered on the north by Mt. Passaconaway 1,238 m), on the east by Mt. Wonalancet (854 m), and on the west by Mt. Whiteface (1,215 m). It is bisected by a central ridge running from north to south that rises to an elevation of about 1,000 m (Fig. 2), and divides the valley into two major watersheds, East and West.

The 206-ha area west of the West Branch Stream (Area I, Fig. 2) up to the ridge top from Mt. Whiteface nearly to Mt. Passaconaway has been reserved for research by the U. S. Forest Service (Lyon and Bormann 1962). Several surveys of the vegetation in the reserved area (Leak 1974, 1973; Oosting and Billings 1951) indicated that this part of the forest developed naturally; there was no evidence of past logging. No data were available for Area II.

Some of the East Branch watershed has been logged. A temporary portable steam-powered lumber mill operated there in 1888 (Harkness 1958). There is no record of the duration of the operation, the amount of lumber sawed, or the amount of firewood cut.

Methods

In 1974, the Bowl was divided into four areas conforming to the four major slopes (Fig. 2). A systematic sample of circular 100-square-meter plots (Cain and Castro 1971) on a 100-meter grid was selected for areas I, II, and III. A 100- x200-meter grid was used in area IV. The survey was confined to elevations below 915 meters. Spruce-fir dominates the forest above this elevation, and it has been windthrown to the point of masking even recent human disturbances. To avoid duplications of effort, some data on basal areas per hectare by species that had been collected by D. G. Mott of the Forest Service were used to supplement my data in Area I.

Analysis of variance was used to test the hypothesis that there were no significant

Figure 1.—A view of the Bowl, looking due North into the West and East watersheds.

Figure 2.—Map of the Bowl near Wonalancet, N. H.

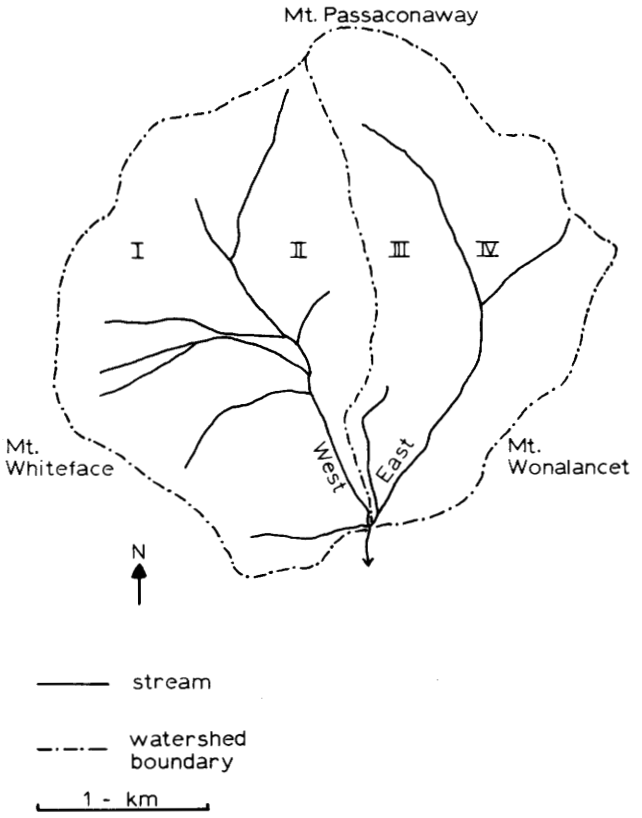

Table 1.—*Summary of statistical analysis of vegetation survey data*

Statistic	Area I	II	III	IV
Number of plots	28	56	83	51
Mean basal area (m^2/ha)	29.1	29.9	27.2	27.0
Standard deviation	15.7	10.1	10.6	13.2

Analysis of variance showed no significant differences among areas.

differences between the mean basal areas of the trees in the four areas (Table 1).

Above ground dry-weight biomass of trees and shrubs was calculated from diameter measurements alone, using the following equations selected from Whittaker, et al. (1974):

Log_{10} y *(Acer saccharum)* = 2.2151 + 2.4209 $\log_{10}$ x

Log_{10} y *(Betula alleghaniensis)* = 2.2264 + 2.4150 $\log_{10}$ x

Log_{10} y *(Fagus grandifolia)* = 2.2916 + 2.3916 $\log_{10}$ x

Log_{10} y *(Acer spicatum)* = 2.3096 + 2.2524 $\log_{10}$ x

Log_{10} y *(Picea rubens)* = 2.3151 + 2.1830 $\log_{10}$ x

y = aboveground dry weight in grams.
x = dbh in cm.
Abies balsamea was combined with *P. rubens.*
Betula papyrifera was combined with *B. alleghaniensis.*

Results

Yellow birch (*Betula alleghaniensis* Britt.) was the dominant tree in the 607-ha valley, with 27 percent of the basal area. Beech. (*Fagus grandifolia* Ehrh.), red spruce (*Picea rubens* Sarg.), sugar maple (*Acer saccharum* Marsh.), balsam fir (*Abies balsamea* L. Mill.), paper birch (*Betula papyrifera* Marsh.), and striped maple (*Acer pensylvanicum* L.) followed in importance (Table 2).

The smallest diameter class (0-12 cm) accounted for 16 percent of the basal area; red spruce and balsam fir made up nearly half of it. The major hardwoods accounted for 55 percent of the next size class (12-28 cm), with yellow birch predominant. Beech accounted for a high proportion of the 28-40 cm class, while sugar maple made up 40 percent of the largest size class (Table 2).

Yellow birch accounted for more than 23 percent of the total basal area at each elevation (Table 3). At the lower elevations (575-650 m) the northern hardwoods (birch-beech-maple) accounted for 88 percent. In the middle slopes (650-850 m) these species still accounted for more than 50 percent, but red spruce began to make a considerable contribution, with 17 to 20 percent of the basal area. At the higher elevations (850-915 m) beech and sugar maple dropped out, balsam fir and yellow birch accounted for 50 percent of the basal area, with paper birch and mountain maple ("other" in Table 3) adding 24 percent, and red spruce alone contributing 18 percent of the population.

Yellow birch may be found in all stages of succession, but it regenerates and survives

Table 2.—*Estimated basal area of trees in the Bowl by species and diameter class*

Dbh	Beech	Yellow birch	Sugar maple	Red spruce	Balsam fir	Paper birch	Striped maple	Others [a]	Total	Percent
cm				m^2/ha						
0-12	0.6	0.7	0.3	1.0	0.9	0.2	0.5	0.3	4.5	16
12-28	1.5	3.3	0.8	1.9	0.9	1.3	0.2	0.3	10.2	36
28-40	2.8	2.1	1.1	.9	0	0.3	0	0.1	7.3	26
40+	1.0	1.6	2.5	1.0	0	0	0	0.1	6.2	22
Total	5.9	7.7	4.7	4.8	1.8	1.8	0.7	0.8	28.2	
Percent	21	27	17	17	6	6	3	3		

[a] Other species included pin cherry (*Prunus pensylvanica* L.), mountain maple (*Acer spicatum* Lam.), mountain ash (*Sorbus americana* Marsh.), red maple (*Acer rubrum* L.), and hemlock (*Tsuga canadensis* L. Carr.). Hobblebush (*Viburnum alnifolium* Marsh.) was prolific, but was not inventoried.

Table 3.—*Stand composition in percent of basal area by species and elevation*

Elevation (m)	Beech	Yellow birch	Sugar maple	Red spruce	Balsam fir	Paper birch	Striped maple	Others
575-650	30	42	16	7	1	1	1	2
650-750	28	29	18	17	2	3	2	1
750-850	18	24	13	20	7	10	4	4
850-915	0	23	2	18	27	13	5	12

Of the 190 plots inventoried:
Pin cherry occurred on 22 plots; 16 of these plots were in windthrow in Area III.
Mountain maple occurred on 25 plots at all elevations.
Mountain ash occurred on 7 plots, all above 850m.
Red maple occurred on 5 plots, all below 750m.
Hemlock occurred on 4 plots, all below 750m.
One Canadian yew (*Taxus canadensis* Marsh.) and one white ash (*Fraxinus americana* L.) were noted.

readily only after some type of disturbance (Leak 1974). This might be the death of a single tree providing an opening. But the apparent dominance of yellow birch in the Bowl indicates a major disturbance some time in the past (Forcier 1975). Paper birch was almost exclusively associated with the spruce-fir type at the higher elevations. Pin cherry was included in this analysis as an indicator of recent disturbance. It was found at the site of windthrow disturbances, usually limited to a very few hectares widely scattered throughout the forest. In Area III approximately 24 ha have been disturbed twice rather recently. The current vegetation contains a high percentage of pin cherry in decadence. Borings indicated that the stand ranges in age from 35 to 55 years. Therefore, it may or may not have been the result of the 1938 hurricane. Observations of fallen stems indicated that the previous stand was predominately red spruce and paper birch with an average dbh of 30cm. Many old paper birch logs remain with all of the wood rotten but the bark largely intact. These stems all lie oriented from NW to SE.

Discussion

One of the objectives of the study was to compare the vegetation of the reserved area (I) of the Bowl, known to be a virgin forest, with the rest of the valley. There were no statistically significant differences in basal areas per hectare among the four areas of the Bowl (Table 1). The mean basal area for the Bowl as a whole was

28.2m²/ha. Data from the nearby Bartlett Experimental Forest indicate that 29m²/ha is about the maximum that can be maintained in an old-growth northern hardwood stand (Filip et al. 1960).

The solutions to the dry weight aboveground biomass regression equations (Whittaker et al. 1974) were:

Area	*Aboveground dry biomass/(metric tons/ha)*
I	262
II	254
III	230
IV	217

These data also indicated very little difference between the areas of the Bowl.

Within the Bowl, however, there were individual stands that were quite different from the average. One stand of sugar maple and beech averaged 35m²/ha of basal area and 350t/ha of dry biomass, while another stand of beech averaged only 2m²/ha and 8t/ha. Leak (1974, 1973) discussed one 18-ha stand in the southeast corner of the Bowl in depth.

A 13-ha northern hardwood stand at the Hubbard Brook Experimental Forest, heavily logged before 1920, averaged only about 23m²/ha of basal area (Bormann et al. 1970) and about 140t/ha of dry aboveground biomass (Whittaker et al 1974). In spite of these differences, there were several similarities between the stands at Hubbard Brook and the Bowl. Sugar maple was the major species at both locations at lower elevations, but began to drop out at 700m. In both forests, yellow birch was quite evenly distributed throughout the elevational range. In the 60-year-old stand, beech seemed to be evenly distributed over the forest as a whole and was a major component above 732m. At the Bowl, however, basal area in beech decreased with elevation and beech essentially dropped out above 850m (Table 3). Red spruce, balsam fir, and paper birch were found at all elevations in both forests and increased in importance rapidly with increases in elevation.

There seemed to be major differences in the sapling populations between the 60-year-old forest at Hubbard Brook and the mature forest at the Bowl, but these differences may be edaphic. At Hubbard Brook, beech saplings are dominant, while red spruce and balsam fir saplings are minor constituents. In the Bowl, conditions were reversed, with 42 percent of the saplings in spruce and fir, while beech make up only 13 percent of the basal area in stems 0 to 12 cm (Table 2). Again, these are area-wide data; individual stands in the Bowl differ from the average.

Conclusions

The Bowl Research Natural Area is one of the few remaining examples of forests that have never been logged in the eastern United States. It is a mixed forest, stocked mainly with yellow birch, beech, and sugar maple at the lower elevations; red spruce and balsam fir at higher elevations. Contrary to popular opinion this "virgin" forest is not homogeneous; wind and disease have created a mosiac of stands. Some have as little as 2 m²/ha of basal area and 8 t/ha of above-ground dry biomass; others have as much as 35 m²/ha and 334 t/ha.

Accumulated biomass, basal area per hectare and species composition do not differ significantly between the slopes of the West Branch watershed. Therefore, I feel it is reasonable to conclude that none of the western watershed has been logged.

We know that the eastern watershed was logged to some degree 90 years ago. The forest there now has 27 m²/ha of basal area, which is not statistically different from that of the undisturbed forest. The eastern watershed has accumulated about 220 t/ha of biomass, less than the 262 found in the undisturbed forest but much more than the 140 t/ha reported from a nearby 60-year-old northern hardwood forest. Thus, it seems that the eastern watershed has recovered from the logging of 90 years ago.

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