Red Spruce in the Bowl Research Natural Area: stand dynamics and structure.

1996 North American Dendroecological Fieldweek
Bartlett Experimental Forest
White Mountain National Forest
New Hampshire

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INTRODUCTION

During the 1996 Dendroecological Fieldweek, a stand structure analysis was conducted in the Bowl Research Natural Area (RNA), White Mountains National Forest, New Hampshire. The Bowl RNA is comprised of low-elevation northern hardwood (<780 m) and high elevation spruce-fir (780≥1200 m) forest types of reported old-growth character and age (Oosting and Billings 1951, Leak and Graber 1975). Although elevation -species relationship and age distributions of virgin red spruce (*Picea rubens* Sarg.) in the Bowl RNA have been developed (Leak and Graber 1975, Leak 1975) no dendroecological studies have been conducted investigating stand dynamics of high elevation red spruce forests. Thus, the objectives of this study were to 1) determine whether the study stand is indeed old-growth, and 2) establish temporal and spatial stand dynamics of red spruce forests above 880 m.

A common definition of eastern old-growth stands was accepted including: an uneven-aged structure, successional dynamics, high amounts of coarse woody debris, both dead and down, and an absence of catastrophic disturbance (Carbonneau 1986, Cogbill, pers. comm.). These criteria were used to compare the Bowl-Wiggin Trail site with the documented Nancy Brook old-growth spruce-fir Natural Area also located within the White Mountains National Forest (Carbonneau 1986). According to these criteria we hypothesized that the Bowl-Wiggin Trail red spruce stand is old-growth and thus designed and conducted a stand structure analysis to investigate this possibility.

STUDY AREA

The Bowl-Wiggins Trail site is a 0.10 ha permanent plot established on the 880 m contour of the southeast facing spur of Mt. Whiteface (lat. N43° 55.61', long. W 71° 23.48'). The study area lies within the White Mountain section of the New England physiographic province (Fenneman 1938). Soils within the area are lithic Histosols characterized by a thick organic mat overlying a thin sandy loam till of Wisconsin glacial origin (Bailey, pers. comm.). Mean monthly temperatures range from -9.2° C in January to 17.2° C in July while mean annual precipitation is 145 cm, with annual snowfall averaging 4.2 m (Byers and Goodrich 1977). The average growing season from the last spring frost to the first fall frost is 96 days.

Low elevation forests of this region have been classified as hemlock-northern hardwood while high elevation sites are typified by spruce-fir forest types (Braun 1950, Kuchler 1975). The Bowl area was proposed as a Natural Area in July 1931 to protect "one of the few readily accessible areas which still contain virgin forests representing all the principal timber types of the region including spruce and hardwood mixtures" (USFS 1931). Original cruise reports cite "a tract of young spruce resulting from the great landslide of 1820" along the southern slope of MT. Whiteface, apparently near the current study site (USFS 1931). Other significant historical events include severe windstorms in 1815 and 1881 as well as the 1938 hurricane which caused extensive damage consisting of moderate to large patch sizes (≤10 ha) (USFS 1931). In addition, several authors have noted various amounts of charcoal on side slopes of Mt. Whiteface suggesting at least sporadic fire occurrence. However, little historical evidence reports fire activity in the study area.

METHODS

Vegetation Sampling

On 18 August 1996, stand structure analysis data was collected in a permanent 0.10 ha grid (20X50 m) established on the upper slope of Mt. Whiteface at 880 m with the center line oriented 40° magnetic. Within each 10x25 m quadrant, overstory data collected included diameter at breast height (1.37 m) by species for all trees (DBH ≥ 5 cm) living and dead as well as location within the stand. All trees were cored at 1 m on the uphill side (to facilitate coring through the pith) using standard increment borers for age determinations and radial growth analysis. In addition, all dead wood (standing and down) was mapped. For each dead stem species, diameter, decay class, and mode of mortality were noted. These measurements were made to calculate density and basal area by decay class to describe the dynamics of the stand in the recent past. Other descriptors such as crown vigor and crown height were noted for each tree surveyed as well as environmental characteristics of the stand. Understory vegetation was sampled in fourteen 1x1 m plots at 4m intervals along the center (50 m) axis of the plot. Understory data comprised percent cover of all vascular plants.

Radial Growth Analysis

Individual cores (n=85) were taken to the laboratory then dried, mounted, sanded, and skeleton-plotted to determine calendar year dates where possible (Phipps 1985). After cross-dating using signature years (Fritts 1976) against the Nancy Brook chronology developed by Fritts and Siccama (1972), dates were assigned to each ring. Annual growth increments were measured to the nearest 0.01 mm with the Velmex tree-ring measuring device and recorded using the PJK5 Ver.5 microcomputer program (Krusic 1991). Further, a standard ring width index was created by dividing yearly measured growth values by expected values obtained from fitting a negative exponential curve or linear regression to measured values (Fritts and Swetnam 1989). All cores were examined for periods of suppression and release based on criteria established by Lorimer and Frelich (1989). They defined a major sustained release as a ≥100% average growth increase lasting at least 15 years. This criteria, coupled with tree establishment dates, were used to identify disturbance events affecting regeneration and recruitment of species into the overstory. Stand age structure was determined for synchrony of establishment dates as well as spatial patterning within the stand. Spatial dispersal was determined from the grid map used in sampling the stand.

RESULTS AND DISCUSSION

Age Structure

The age structure of the Bowl-Wiggins Trail stand exhibits an un-even aged structure with all age classes represented. However, red spruce in this stand appear to be more even aged and younger than those at Nancy Brook with a mean age of 117 (s=30 years) and 272 (s=70 yr), respectively. In contrast, a stand 200 m north of the current study site yielded an average age of 212 (s=58 yr) one much closer to the expected age structure of high elevation red spruce (Table 1). Age data suggest that regeneration exhibited an increase after the 1830s, peaking in the 1850s and gradually declining until a dynamic equilibrium was met in the 1890s (Figure 1) (Bormann and Likens 1979). While Bormann and Likens (1979) identified the shifting-mosaic steady state as an array of irregular patches composed of different ages, mapping stem ages in this study stand illustrates a single-tree replacement dynamic with no clear cohort structure (Figure 2). Nonetheless, the stand does exhibit an un-even aged structure representative of a stand moving toward an old-growth age structure.

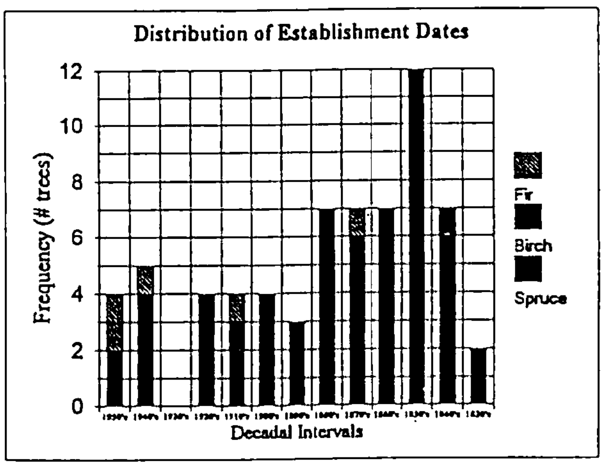

Figure 1. Estimated establishment dates by species for Bowl-Wiggins site, Bowl RNA.

Table 1. Comparative age structure of red spruce at three sites within White Mountains National Forest.

Stand name	Bowl-Wiggins Trail south	Bowl-Wiggins Trail north	Nancy Brook
number of cores	36	6	89
ave. inner ring age	117	212	272
standard deviation	30.2	58.7	69.6

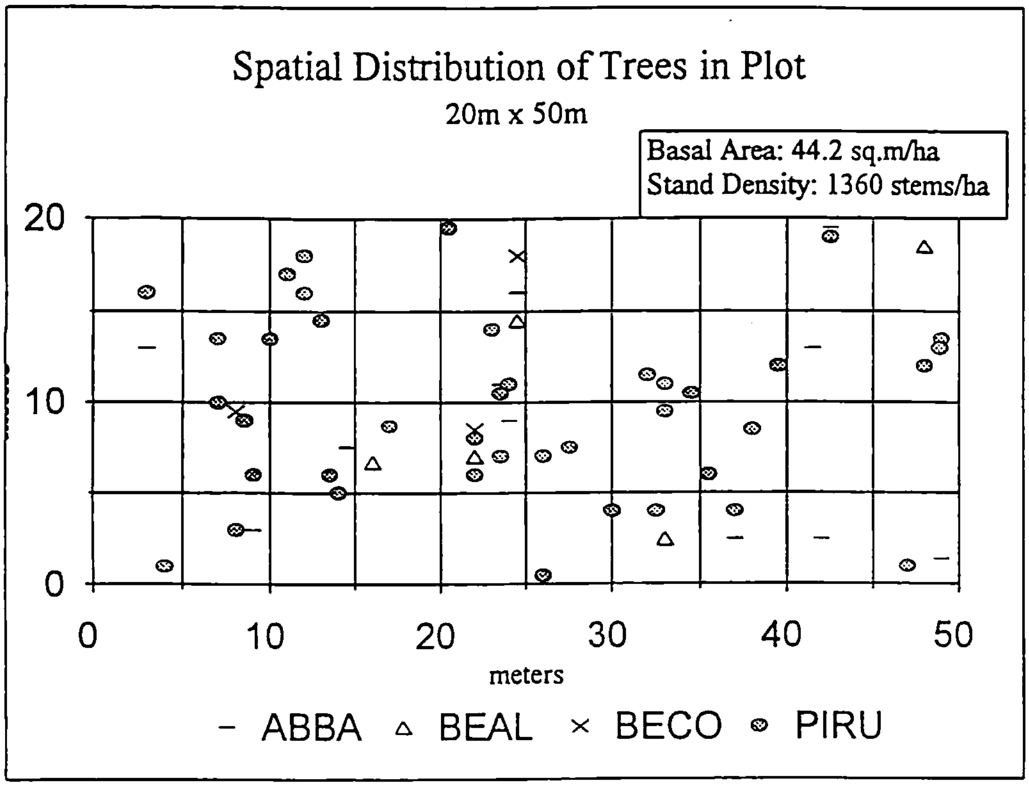

Figure 2. Spatial distribution of trees in Bowl-Wiggins trail plot, Bowl RNA.

<u>Overstory Structure</u>

The Bowl-Wiggins Trail (south) stand was dominated by red spruce (60.7% relative dominance and 56.6% relative density) (Tables 2 and 3). Next in importance was balsam fir (*Abies balsamea* (L.) Mill.) representing 29.4% of stand density comprising only 5.13 m^2/ha of basal area (11.16% relative dominance). Other minor species in the stand include yellow birch (*Betuala alleghaniensis* Britton) (9.64 m^2/ha of basal area and 150 trees/ha) and white birch (*B. cordifolia* Regel) with 2.57 m^2/ha of basal area and 40 trees/ha. In contrast, species were more equally represented in Nancy Brook with balsam fir comprising 43.2% of the basal area and 54.4% relative density. Red spruce was somewhat lower with 51.3% dominance and 37.6% relative density possibly suggesting that the Nancy Brook stand is undergoing spruce replacement by balsam fir. Both red spruce and balsam fir are important components of the transitional forest studied here as well as the Nancy Brook old-growth reference stand. However, the higher proportion of red spruce in the Bowl-Wiggins Trail site may be characteristic of younger transitional stands.

Table 2. Basal area and relative dominance for each species in the Bowl-Wiggins Trail study area compared to Nancy Brook RNA.

	basal area (m^2/ha)		relative dominance	
Species	Bowl-Wiggins	Nancy Brook	Bowl-Wiggins	Nancy Brook
Abies balsamea	5.13	11.16	11.16	43.2
Betula alleghaniensis	9.64	0	21.8	0
B. cordifolia	2.57	1.27	5.8	4.8
Sorbus decora	0	0.17	0	0.7
Picea rubens	26.82	13.25	60.7	51.3
Totals	44.16	25.84	100	100

Table 3. Density of stems per hectare by species at Bowl-Wiggins Trail study area and Nancy Brook RNA.

	basal area (m^2/ha)		relative dominance	
Species	Bowl-Wiggins	Nancy Brook	Bowl-Wiggins	Nancy Brook
Abies balsamea	400	513	29.4	54.4
Betula alleghaniensis	150	0	11.0	0
B. cordifolia	40	65	2.9	6.9
Sorbus decora	0	10	0	1.1
Picea rubens	770	355	56.6	37.6
Totals	1360	943	100	100

Stand Dynamics

Results of the negative exponential standardization program were selected for further release and suppression analysis because it retained most of the high frequency variation (Figure 3). While most major releases occurred sporadically through time, twelve occurred in the 1950s (Figure 4). At first this might suggest a major disturbance event in the 1950s. However, assigning a criteria of 100% growth increase sustained over fifteen years (cf. Lorimer and Frelich 1989) reduces the ability to identify the actual year of disturbance. Thus, a release identified as a 100% growth increase in year 1953 might have begun increasing growth as many as 10 to fifteen years ago. Therefore, we believe many of those 1950 releases actually reflect the 1938 hurricane and its effects on opening the canopy up for subsequent releases of standing trees and regeneration of the balsam fir generation.

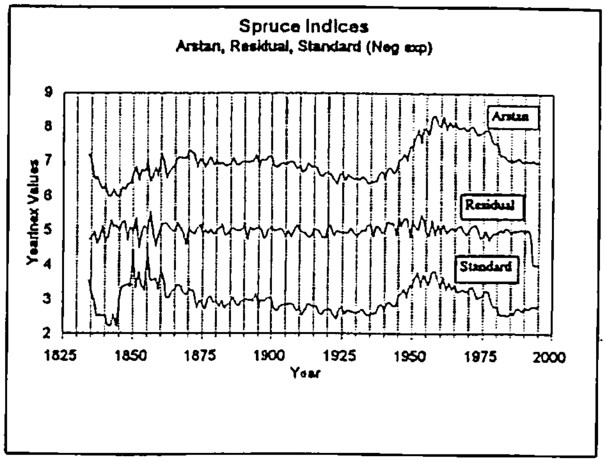

Figure 3. Standardized ring width indices for spruce in the Bow-Wiggins site, Bowl RNA.

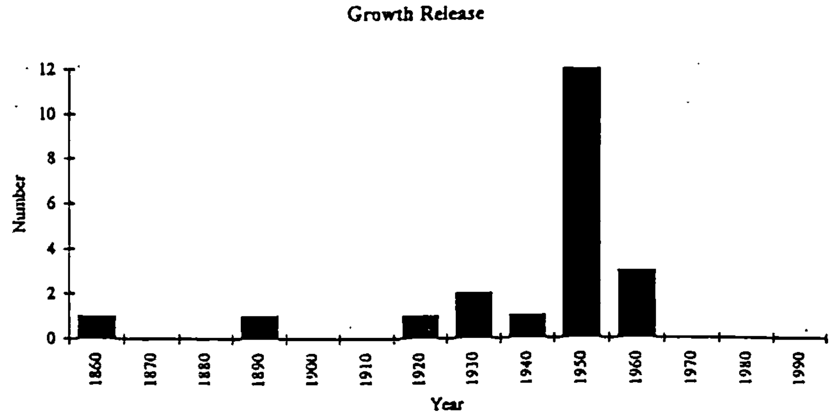

Figure 4. Major growth releases in spruce by decade. Major release represents a 100% growth increase sustained over 15 years.

Dead wood Distribution

Coarse woody debris was represented by white birch (300 trees/ha, 12.5 m^2/ha basal area), balsam fir (590 trees/ha, 7.9 m^2/ha basal area), and red spruce (180 trees/ha, 4.2 m^2/ha basal area). Species composition of dead wood in old-growth forests reflects the species composition of live trees and patterns of longevity, mortality, and decay. Thus, the authors believe it is possible that the white birch colonized the site following the 1820 landslide and are falling out due to limited longevity and competitive mortality. This suggests that the 1820-1850 birch generation is dying off and being replaced by those red spruce from 1875-1925. In addition, many balsam fir appear to be regenerating and will probably increase in importance sharing stand dominance with red spruce. Much more research should be done concerning the landslide of 1820 and the future species composition within the study stand.

CONCLUSION

The Bowl-Wiggins stand meets three of our criteria for old-growth spruce/fir stands in the White Mountains National Forest. First, the stand clearly has an un-even aged structure. While there are no spatial cohorts within the stand, there are temporal cohorts including the 1820-1850 birch stems, the 1875-1925 red spruce stems, and the 1940-present balsam fir stems. Second, single tree replacement stand dynamics seemingly drive regeneration and mortality in the stand as illustrated by the dispersed nature of temporal releases. Third, there is a high percentage of dead wood, both standing and fallen, occurring in all diameter classes. We must accept the high number of releases following the 1938 hurricane as a minor form of catastrophic disturbance, thus failing to meet the final criteria. The authors feel however, that the Bowl-Wiggins stand does exhibit many old-growth characteristics and in time, barring another catostrophic disturbance, will become true old-growth much like that found in Nancy Brook Natural Area.

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