Growth comparison of northern white-cedar to balsam fir and red spruce by site class

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Abstract

Though northern white-cedar is a common and economically important component of the Acadian Forest of Maine and adjacent Canada, there is little regional data about the growth and development of this species. Sixty sites in northern Maine were used to compare growth of cedar to that of red spruce and balsam fir along a range of site classes and light exposures. On average, cedar grew faster than spruce but slower than fir, however species-specific basal area growth rates were affected differently by site class and light exposure. Balsam fir was the only species showing strong growth responses to increased crown light levels. Decay was present in all species, but a higher proportion of cedar stems were decayed. The proportion of decayed balsam fir stems increased as site drainage improved. Our data suggest that cedar in Maine often exceed 150 years of readable rings at breast height.

Introduction

Northern white-cedar (*Thuja occidentalis* L.) is arguably the least-studied economically important conifer in the northeastern North America. It has important niche market value as shingles, shakes, fence posts, and mulch, and provides winter yarding habitat and browse for wildlife species such as white-tailed deer (*Odocoileus virginianus*). Northern white-cedar composes approximately 10% of the Maine forests (McWilliams et al. 2005). Recent forest inventory data suggest that cedar growth since 1995 has been approximately 15 million cords, while removals have totaled nearly 25 million cords. Due to the lack of research into cedar ecology and responses to silviculture in this region, land managers are forced to enter stands with sparse knowledge of regeneration dynamics, growth responses and stand structural characteristics that would favor cedar on a sustainable basis. As such, cedar stands are commonly exploitatively harvested.

The goal of this research is to inform the management decisions made by field foresters who desire to maintain or increase cedar as a component of mixed-species stands. The objective of the study reported here was to compare the most recent complete five years of growth of northern white-cedar to two commonly associated species, red spruce (*Picea rubens* Sarg.) and balsam fir (*Abies balsamea* L.), along a range of site classes and light exposures.

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Methods

Sixty sites throughout northern Maine were selected for this study (Figure 1). Sites were provided by many private industrial cooperators as well as the Maine Bureau of Parks and Lands, the Nature Conservancy, and the Baxter State Park Scientific Forest Management Area. This covers a wide range of landowners and associated management strategies common to the region.

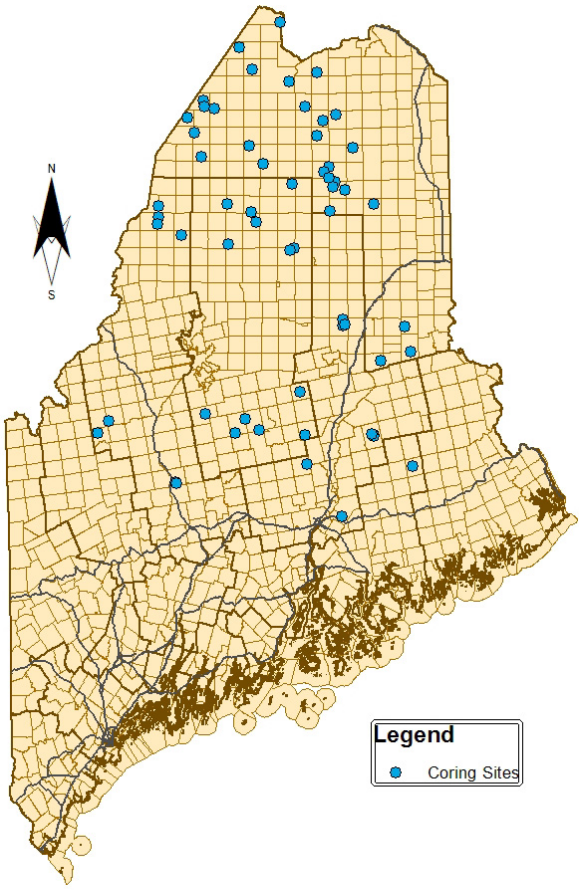

Figure 1. 60 mixed-species stands selected for growth comparison study.

At each site, five upper canopy northern white-cedar were selected, as well as five balsam fir or red spruce. If all three species were present on the same site in sufficient numbers, all three species were sampled. To be selected, each tree had to be outwardly sound and free from obvious crown damage. Light exposure (LE) class was assigned to each tree on a 1-5 scale, with class 5 being analogous to a dominant crown class, and class 1 being analogous to an intermediate crown class (after Bechtold 2003). No overtopped (LE class 0) or outwardly defective trees were sampled. Two soil pits were excavated at each site to determine site class. Site class was described using Briggs' (1994) site classes. This is a five-class scale ranging from class 1 (well drained; mottling depth >24") to class 5 (very poorly drained; mottling within four inches of mineral soil). No sites sampled had drainage exceeding site class two. In addition to these, organic or muck soils were parsed out for analysis due to inability to determine depth to mottling.

Two cores to the pith were extracted perpendicular to one another at breast height (1.3 m) of each sample tree. Cores were mounted on boards in the field, dried, sanded with 300-grit sandpaper, and read using WinDendro software. Other tree-level information obtained in the field included sapwood length for each core, diameter at breast height, total height, height to the lowest live branch, height to the base of the live crown and bark thickness. Sample data by species are provided in Table 1.

Site information was collected during the summers of 2005 and 2006. Only the most recent complete five years of growth data were used for analysis. Analysis of Covariance (ANCOVA) was used to compare basal area growth using site class, species, LE class, and sapwood area as variables with an alpha of 0.05. SYSTAT version 11 was used for all analyses.

Table 1. Tree selection by site class.

	Number of Observations		
Site Class	BF*	RS	NWC
2	28	10	32
3	30	15	40
4	20	30	50
5	63	58	105
Organic	30	45	70
Total	171	158	297

* Species abbreviations: BF-balsam fir, RS-red spruce, NWC-northern white-cedar

Results

Decay was present in all species across all drainage classes; however, there were significant differences among the species (Table 2). With such a high proportion of decay in some of the samples, it was difficult to age the increment cores. Nevertheless, we were able to detect differences in age among species. The oldest cedar observed had 222 years of readable rings at breast height, with many trees exceeding 150 years. The oldest red spruce was 201 years, with ages commonly 100-130 years. Balsam fir rarely exceeded 100 years in age, with the oldest specimen being 109 years.

Table 2: Mean proportion of cores decayed by site class (LS mean scores, SE in parentheses).

	Proportion of sample decayed		
Site Class	BF	RS	NWC
2	0.57(0.09)^{a}	0.10(0.10)	0.97(0.07)^{a}
3	0.40(0.08)^{ab}	0.13(0.08)	0.88(0.07)^{ab}
4	0.40(0.10)^{ab}	0.13(0.06)	0.64(0.06)^{b}
5	0.19(0.06)^{b}	0.07(0.04)	0.73(0.04)^{b}
Organic	0.23(0.08)^{b}	0.13(0.05)	0.74(0.05)^{ab}
Mean	0.34(0.03)^{b}	0.11(0.02)^{c}	0.80(0.03)^{a}

* Means of the same species followed by different letters are significantly different at α=0.05 level. Species' means were also significantly different.

Basal area growth significantly differed among species when other variables were held constant (Figure 2). For all species, sapwood area as a covariate contributed significantly ($p<0.001$) to differences in basal area growth. In the ANCOVA model, site class was marginally nonsignificant when all species were included ($p=0.058$). Balsam fir was the only species that had significant differences in basal area growth among site classes ($p=0.013$) (Figure 3) and light exposure classes ($p=0.015$) (Figure 4).

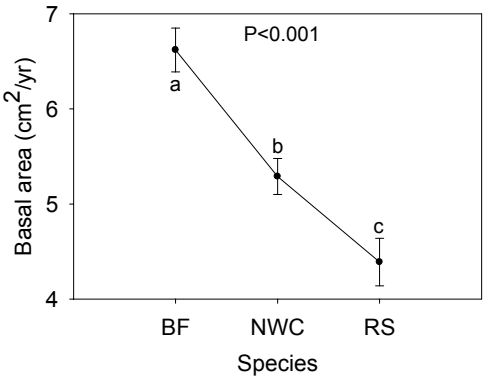

Figure 2. Basal area growth LS means by species.

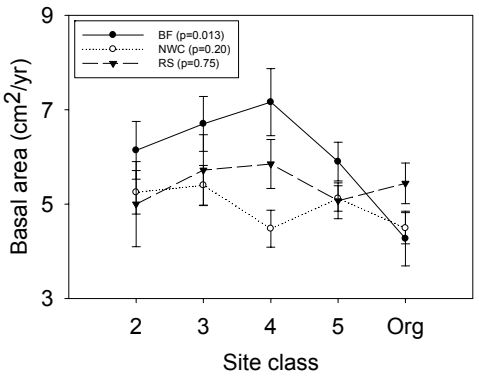

Figure 3. Basal area growth LS means by site.

Discussion

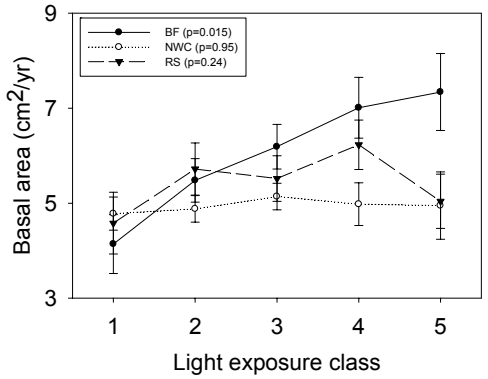

Figure 4. Basal area growth LS means by light exposure.

Conventional wisdom in Maine is that cedar trees growing on upland sites have higher growth rates and better quality (e.g. Curtis 1941). However, results from this study do not support that conclusion, at least in terms of basal area growth and soundness across site classes. A significantly lower proportion of cedar were decayed on site classes 4 and 5 than on site class 2. In Maine, upland sites are frequently partially cut, this may lead to increased root and crown damage and create entry points for fungal infection. However, a study in the Adirondacks of New York comparing bog community cedar to limestone outcrop community cedar found that approximately 80% of the stems had central decay, independent of site (Harlow 1927). Partial harvesting may also have driven species selection for the present study. Because red spruce is highly sought after, it is commonly targeted for removals on easily entered sites. Sparse upper canopy red spruce limited the number of sites useable for this comparative study, leading to a relatively small sample size that may not be fully representative of the red spruce population in Maine. Similarly, these results are biased to outwardly sound individuals of all species, which might have different mean growth rates than the Maine populations.

ANCOVA, with species, light exposure, site class, and sapwood area as variables, suggests that balsam fir will outcompete cedar and red spruce. This was not true across all site classes and light exposure classes when analysis was done by species. Additionally, cedar had a higher mean growth rate than red spruce, which was not expected. This belies the common belief that cedar has poor growth rates and thus limited management potential. Lastly, our data suggest that northern white-cedar basal area growth is not responsive to increased crown light levels. This could have major implications for managing mixed-species stands where cedar is an important component of the understory and midstory strata, and might allow foresters to take advantage of advance growth effects.

Conclusions

Northern white-cedar in Maine seem to be much older than once considered; in the present study cedar was commonly the oldest species on a given site. A high proportion of the sampled cedar was decayed (approximately 80%) with amount of decay on site classes 4 and 5 significantly lower than site class 2. Mean proportion of decay was lower in balsam fir, but increased with improved drainage. Holding all other factors constant, balsam fir had higher basal area growth rates than red spruce and northern white-cedar, and cedar growth was higher than that of spruce. This may be a function of past harvesting that left inferior spruce as residuals, but that is speculation. Overall, basal area growth was not strongly correlated with site class for red spruce and northern white-cedar. Balsam fir growth rates were influenced by light exposure class and site class, while the remaining species were not. Ongoing research is investigating northern

white-cedar leaf area – sapwood area relationships, growth efficiency, and early stem development.

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