Diameter Growth in Even- and Uneven-Aged Northern Hardwoods in New Hampshire Under Partial Cutting

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ABSTRACT: *One important concern in the conversion of even-aged stands to an uneven-aged condition through individual-tree or small-group cutting is the growth response throughout the diameter-class distribution, especially of the understory trees. Increment-core sampling of an older, uneven-aged northern hardwood stand in New Hampshire under management for about 50 years established the baseline diameter-growth responses of the sapling, pole, and sawtimber strata. Growth responses of the poletimber and sawtimber in a 70-year-old even-aged stand were comparable to the uneven-aged stand after an initial partial cutting treatment; growth of the understory began approaching comparable rates after the second entry about 25 years after the first cut. North. J. Appl. For. 21(3):160–163.*

Key Words: Northern hardwoods, diameter growth, uneven-aged management.

Conversion of even-aged stands to an uneven-aged condition through the use of single-tree and small-group cutting raises concerns over diameter-growth responses (Nyland 1998, 2003, Kelty et al. 2003). In a previously unmanaged even-aged northern hardwood stand, the understory trees may be the same age as the overstory. Due to their age (Nyland et al. 1993) and many years of suppression, these smaller trees may not respond adequately to release, thus causing low rates of ingrowth and resulting gaps in the gradually developing diameter distribution. It also is possible that the understory trees in even-aged stands are those that are inherently slow-growing.

Patterns of diameter growth across a range of size classes in northern hardwoods are variable. Nyland (1987) showed that under light selection cuttings or high stand densities in uneven-aged stands, diameter growth tends to increase with tree diameter up through the medium-sized sawtimber and then may decline in the largest sizes. Under low stand densities, however, the smaller trees grow more rapidly than the large ones due to the increased growth responses of the poletimber. In even-aged northern hardwoods about 60–70 years old, both Solomon (1977) and Wilson (1953) showed that diameter growth by size class follows similar patterns to those described by Nyland (1987). However, neither of these two studies documented diameter growth responses in the sapling sizes. An assessment by Nyland et al. (1993) in even-aged hardwoods indicated that post-thinning growth rates of saplings and small poles of sugar maple (*Acer saccharum*) were much less than those of larger trees in higher crown classes.

To provide a more complete assessment of diameter-growth responses in even-aged northern hardwoods in New Hampshire, as compared to baseline values from long-term management of an uneven-aged stand, an increment-core analysis was conducted in two stands on the Bartlett Experimental Forest, New Hampshire, in the spring and summer of 2002.

Methods

The uneven-aged stand was initially typical of the older northern hardwood stands on the Bartlett Forest with trees ranging up to 200 years old (Blum 1961). The stand, 32 ac in size, contained about 50% beech (*Fagus grandifolia*) and 20–25% sugar maple (*Acer saccharum*). It was harvested by single-tree selection in 1952, 1975, and 1992 (Leak and Sendak 2002) by marking through all size classes and leaving about 75–80 ft^2 of basal area. An attempt was made to leave a reversed J-shaped diameter distribution with a Q of about 1.5; the harvests left about 50–55% of the residual basal area in sawtimber sizes. In Spring 2002, 119 trees—well-spaced throughout the stand—were cored. Only seven cores were damaged or incomplete, leaving a usable sample of 68 beech, 25 sugar maple, and 19 hemlock. Diameter growth was measured by 5-year increments for between 1 and 10 periods depending on the integrity of the core. Growth was measured to the nearest 0.01 in.

The comparative even-aged stand, described by Solomon (1977), was about 70 years old at the time of treatment in

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1964. The sawtimber and poletimber were probably about the same age. Although we might expect the saplings also to be of the same age, a limited number of increment borings (described below) indicated that the saplings might have been no more than 25–30 years old at dbh in 1964; based on outside information (Donoso et al. 2000), up to about 15 years might be required to reach 4.5 ft. This covers the age range when pin cherry (*Prunus pensylvanica*) might decline, leaving space for the regeneration or recruitment of seedling-sized tolerant species. [Note, however, that ring counts are somewhat suspect in suppressed trees due to missing and false rings (Lorimer et al. 1999).] This stand had been completely clearcut in the late 1800s for railroad fuel and timber except for a few holdovers. The 1964 treatments, applied to one-third-acre plots with buffers, consisted of a range of residual stand densities (40, 60, 80, and 100 ft^2/ac) and percentage of basal area in sawtimber (30, 45, and 60%). Then, the plots were retreated in 1990 to various combinations of stand density and percentage of sawtimber. Diameter growth was reported for trees 4.5 in. and larger over the 10-year period from 1964 to 1973 (Solomon 1977). To supplement this record, increment cores were taken in late summer of 2002 from 17 sapling-sized (2- to 4-in. class) stems in the borders between the buffer zones and plots that had been treated in 1964 and 1990 with 60 and 80 ft^2 of residual basal area and 45% sawtimber, the recommended conditions for this type of stand (Leak 2003). All were beech, because this was the predominant understory stem. Again, diameter growth was measured by 5-year intervals.

Results

The uneven-aged stand, which had been managed for about 50 years, provided baseline values on diameter growth trends under long-term uneven-aged management. Based on all of the usable increment cores (Figure 1), annual dbh growth over the period 1997–2001 (allowing time for response to the 1992 cut) was greatest for beech, hemlock poles, and hemlock sawtimber, and least for sugar maple and sapling-sized hemlock. Note that beech growth was fairly constant among saplings, poles, and sawtimber. Saplings of sugar maple and hemlock grew much slower than the poles and sawtimber of these species. These numbers would vary by site: on better soils, sugar maple could easily grow as fast as beech. Examination of growth responses after the 1992 cut showed that beech saplings responded appreciably by the second 5-year period (1997–2001) after cutting while beech poles and sawtimber showed minor or negative responses (Figure 2). Hemlock saplings showed no response to the 1992 cut, while hemlock poletimber responded appreciably (Figure 3). Numbers of sugar maple sapling cores were insufficient for analysis.

For comparison, published annual diameter-growth figures over a 10-year period (1964–1973) for the beech poletimber and sawtimber in the even-aged stand were, as expected, fairly comparable to those for the uneven-aged baseline stand (Solomon 1977) (Figure 4), although in this case the poletimber grew a little slower than the sawtimber. Based on the increment-core data, annual diameter growth of the saplings (these were small saplings at the time) for the period 1968–1977 (allowing some response time to the treatment in 1964) was 0.067, about 55 to 60% of the poletimber/sawtimber rates. During the next 10-year period (1978–1987), sapling growth dropped to 0.049 inches—less than half the poletimber/sawtimber rates. (The sapling data are based on 7 and 14 cores, respectively, with standard errors of 0.01 and 0.005 in.) This tends to support the hypothesis that even-aged understories may be somewhat unresponsive. However, for the period 1993–2002, annual sapling diameter growth was 0.091 (17 cores), about 70–80% of the poletimber/sawtimber growth. Apparently, responsiveness of the saplings improved appreciably over time with the additional release in 1990.

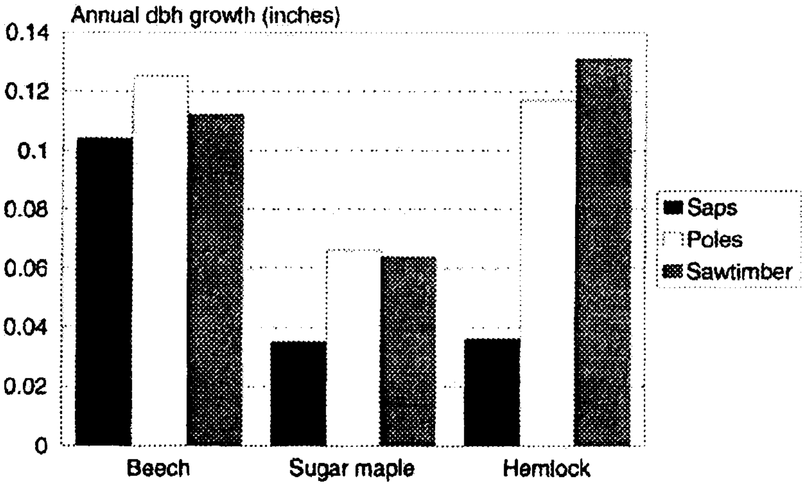

Figure 1. Annual diameter growth of beech, sugar maple, and hemlock over a 5-year period, 1997–2001, in an uneven-aged northern hardwood stand harvested in 1952, 1975, and 1992. One hundred twelve increment cores.

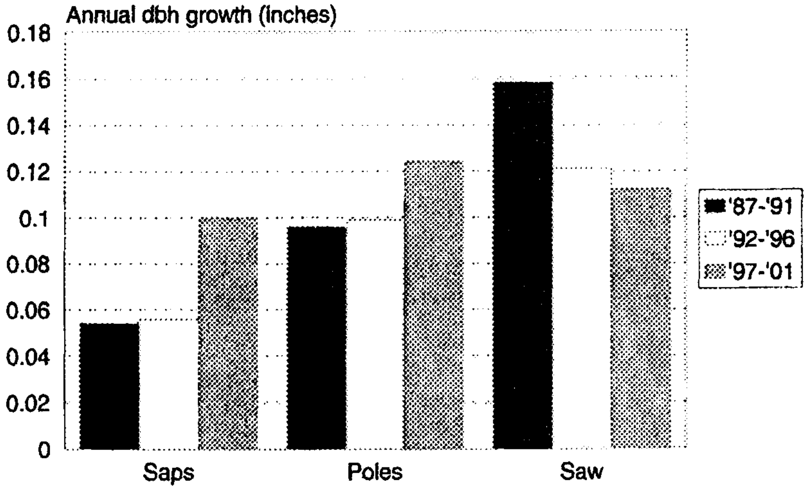

Figure 2. Annual diameter growth of beech by 5-year periods in an uneven-aged northern hardwood stand managed for 50 years. Latest harvest in 1992. Forty-seven increment cores.

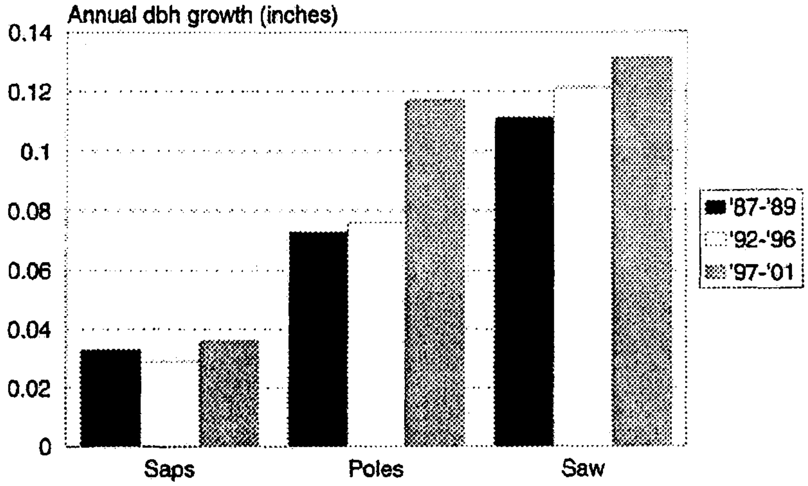

Figure 3. Annual diameter growth of hemlock by 5-year periods in an uneven-aged northern hardwood stand managed for 50 years. Latest harvest in 1992. Nineteen increment cores.

There were consistent differences in diameter-growth responses between the 60- and 80-ft^2 densities, although the numbers of observations were too few to assure adequate confidence. The 60-ft^2 treatment exhibited consistently higher growth rates during the 1968–1977 and 1978–1987 periods, although the responses were parallel to those under 80 ft^2. During 1993–2002, beech saplings under both densities grew at the same annual rate of about 0.09 in. per year. In converting even-aged stands to an uneven-aged regime, stand densities at the lower end of the acceptable range might work best, although this suggestion is tentative.

Applications

This study showed that beech sapling diameter growth is somewhat unresponsive after initial partial-cutting treatments that left residual basal areas of 60–80 ft^2/ac in a 70-year-old, even-aged northern hardwood stand in New Hampshire. Poletimber and sawtimber growth was similar to that of an uneven-aged stand managed for about 50 years. After a second treatment about 25 years after the first, sapling growth in the even-aged stand about doubled. Possibly, responses are more rapid under 60 ft^2 residual basal area as compared to 80 ft^2. Apparently, partial cutting in even-aged stands of the type described in this study will gradually lead to adequate diameter-growth responses throughout the size-class distribution. Sapling responses were better in this study than in previous work with sugar maple (Nyland et al. 1993), possibly because the beech saplings in this study appeared to be about half the age at dbh of the overstory trees. Additional work on age effects is needed.

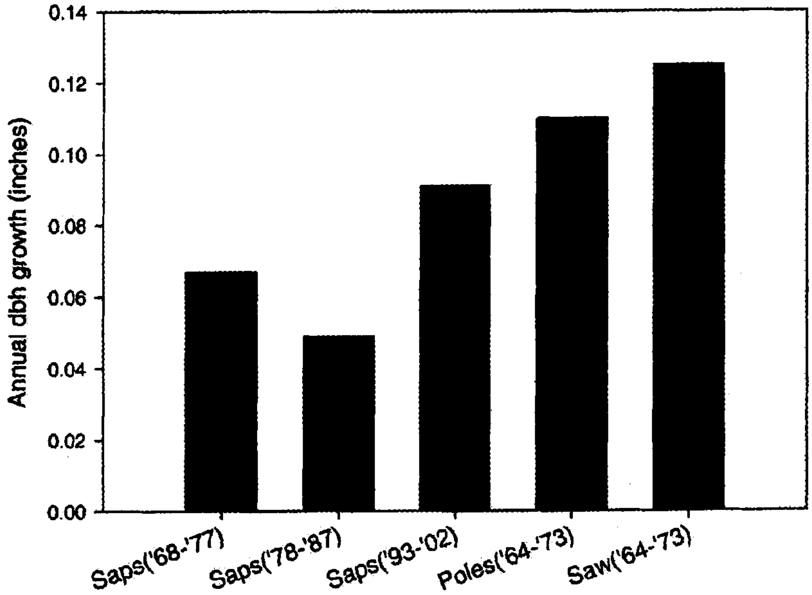

Figure 4. Annual diameter growth of beech in an even-aged northern hardwood stand over 10-year periods after single-tree selection treatments in 1964 and 1990. Poletimber and sawtimber growth based on published data (Solomon 1977). Sapling growth based on 7, 14, and 17 increment cores for the three 10-year periods with standard errors of 0.01, 0.005, and 0.005 in., respectively.

The stands in this study had a high proportion of beech. The even-aged stand, in particular, was on a site (sandy till of granitic origin) that produces a high beech component and little sugar maple. Results could be different on other sites with different species.

Beech is not currently highly regarded for timber in the New England region. However, there is a growing interest in beech stands for mast production, managed under some form of single-tree selection. For timber production on such sites, group/patch selection or even-aged management commonly is prescribed to increase the proportions of yellow and paper birch.

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