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Historical (1749-1899) vs. Present-Day Sugar Maple and Beech Diameter Growth in the Northeast

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Abstract: Possible environmental impacts in the Northeast from climate change, acid deposition, nutrient depletion, and other factors could retard tree growth and development in the Northeastern United States. To gain insight into growth trends before the 20th century, approximately 150 years of radial growth records taken in 1899 on sugar maple and beech were examined and compared with recent published growth rates. Although additional comparative research is needed, there is little evidence of declines in growth rates since 1899.

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INTRODUCTION

Concern is growing over the possible impacts of climate change, acid deposition, nutrient depletion, and other environmental factors on the growth and development of forest stands in northeastern United States (e.g., Likens and Franklin 2009). However, very little historical information is available to assess the impacts on tree growth. In the files of the U.S. Forest Service, Northern Research Station at Durham, N. H., is a series of stem analyses (Form 558a, revised November 1928) containing stem measurements and 10-year radial growth measurements from inside the bark to the pith (if present). These measurements were taken at stump height as well as at the tops of several logs. One folder had records for 438 trees, apparently from one stand in Township 14, Saint Regis Tract, New York (Hamilton County). Of the 438 individuals, 59 percent were sugar maple (*Acer saccharum*), and 22, 15, and 4 percent were yellow birch (*Betula alleghaniensis)*, beech (*Fagus grandifolia)*, and basswood (*Tilia americana*), respectively. There were also a few records for black cherry (*Prunus serotina*), soft (red) maple (*Acer rubrum*), and elm (*Ulmus americana*). The records were dated 1899, apparently copied from earlier stem analysis records titled USDA Stem Analysis forms and dated July 1899. (A few original copies are available.) To provide some indication of tree growth rates prior to the 20th century, the data from this stand are analyzed below. Additional 558a forms are available and will be examined and analyzed in the future.

METHODS

The species composition of the stand in Township 14 reflects excellent site conditions for northern hardwoods. This mature/overmature stand had been harvested, providing access to growth measurements at the stump and upper logs. Radial growth inside bark (ib) (10-year increments) had been measured at stump height and at the top of several logs. Measurements were to the nearest 0.05 inches along one radius, apparently along a radius equal to half the diameter at the point of measurement (see Spurr 1951). Field measurement raises the possibility of false rings (which underestimates periodic growth) or missing rings (which overestimates periodic growth); the use of dominant trees tends to minimize these problems. Therefore to ensure both maximum accuracy and maximum growth rates, this analysis was restricted to the trees described as dominant and healthy: 42 sugar maple and 5 beech with diameters at breast height (d.b.h.) between 14 to 27 inches and ranging in age up to 280 years old.

The growth analysis described below shows 10-year diameter growth inside bark by year at stump height (average 2.8 feet) and, for sugar maple, at the top of the first log (average 15.2 feet above ground). A common growth period was used: all of the sugar maple had at least 150 years of measurements at the stump and 130 years at the top of the first log. Beech had 140 years. Also shown is the relationship between the last 10 years' growth of sugar maple and total age and d.b.h.

RESULTS

Both sugar maple and beech had a gradually increasing average diameter growth at stump height in relation to year, leveling off at about 1.5 inches per 10 years. The standard error is narrow for sugar maple, about 0.1 inch, and somewhat wider for beech (Figs. 1 and 2). These are fairly standard growth curves for mature, uneven-aged stands where the trees, although currently dominant, have gone through periods of suppression, side-competition, and release.

Although growth rates (last 10 years) of most sugar maple trees followed a fairly narrow band (at about 1.2 to 1.3 inches) regardless of tree age, five younger trees had rates of 2 to 3 inches (Fig. 3). A somewhat similar pattern is evident when measurements during the last 10-year period are plotted versus tree d.b.h. (Fig. 4). These high rates were not treated as outliers. It should be remembered that these growth records were taken at stump height, which could add to the variability because of the effects of root swell. Previous work (Leak and Graber 1976) and analysis of the St. Regis stand records showed that diameters at d.b.h. (outside bark)

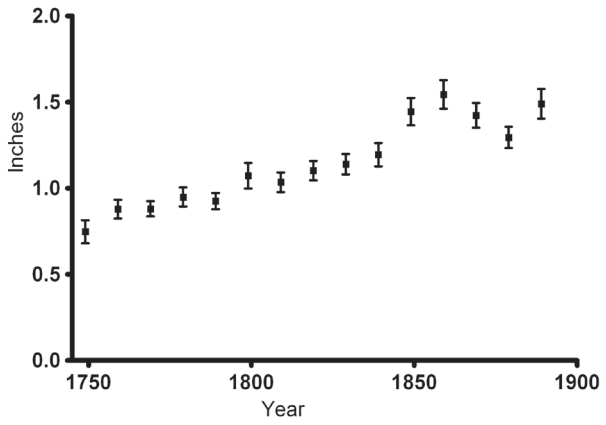

Figure 1.—Mean 10-year inside bark diameter growth (plus/minus one standard error) at stump height of dominant sugar maple from 1749 to 1889. N=42.

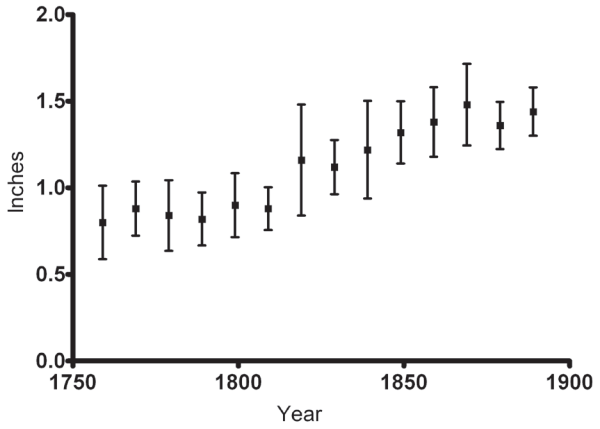

Figure 2.—Mean 10-year inside bark diameter growth (plus/minus one standard error) at stump height of dominant beech from 1759 to 1889. N=5.

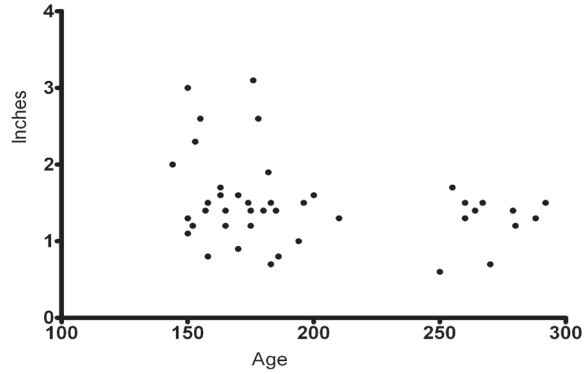

Figure 3.—Mean inside bark diameter growth at stump height for the last 10-year growth period (1889-1899) related to tree age for sugar maple. N=42.

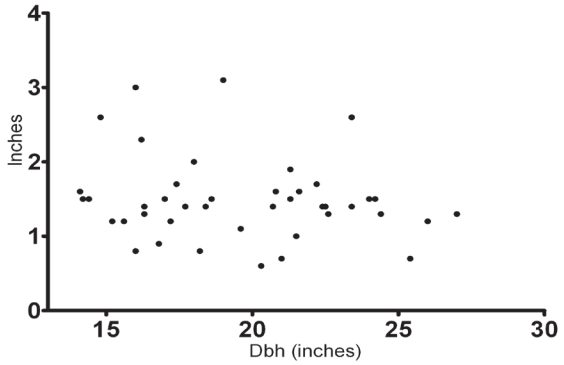

Figure 4.—Mean inside bark diameter growth at stump height for the last 10-year growth period (1889-1899) related to d.b.h. for sugar maple.

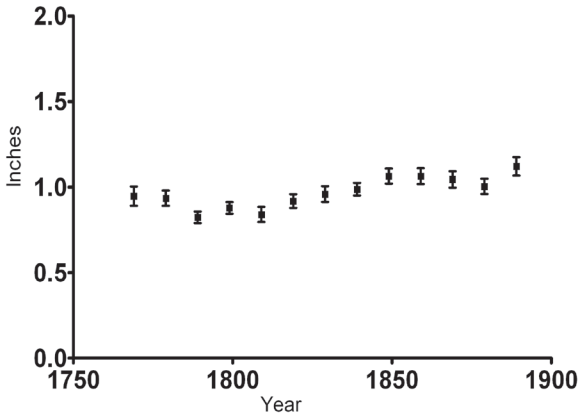

Figure 5.—Mean 10-year inside bark diameter growth (plus/minus one standard error) at top of first log for dominant sugar maple from 1769 to 1889. N=42.

average about 94 percent of those at stump height, and presumably growth rates would follow the same proportion.

Sugar maple diameter (ib) growth at the top of the first log was uniform over time averaging about 1 inch per decade (Fig. 5). Apparently, upper-log growth, in contrast to growth at stump height or d.b.h., is less affected by side competition or periods of suppression.

DISCUSSION AND IMPLICATIONS

A central question is whether these growth rates are similar to current rates of growth. In other words, has growth declined appreciably due to recent environmental impacts?

A complete and final answer cannot be provided here, partly because much of the recent available information lacks details about site conditions, stand conditions, stand density and crown classes. However, some comparative data from older, overstory sugar maple and beech in apparently well stocked stands are available. Ten-year diameter growth rates for dominant/codominant sugar maple growing under adequate levels of calcium and magnesium in the Pennsylvania/New York region averaged about 1.3 inches based on 2200 mm^2/year basal area increment (3.4 in^2) inside bark for trees averaging 39.9 cm (15.7 inches) at d.b.h. (Long et al. 2009). Measurements on large beech and sugar maple in well stocked stands used for simulation studies in New York averaged approximately 1.5 inches in 10-year d.b.h. (ib) growth (based on 1.9 cm per 5 years) (Hansen 1984, Hansen and Nyland 1987). Beech sawtimber on granitic till (low nutrient status) in the southern White Mountains of New Hampshire grows up to about 1.2 to 1.6 inches d.b.h. (ib) in 10 years (Leak 2004, Leak and Gove 2006). Dominant, large sugar maple on granitic till (low nutrient status) may attain rates of 1.0-1.1 inches in 10-year d.b.h. (ib) growth (based on 0.27 to 0.28 cm per year); average growth of sawtimber (crown class undetermined) may be less (Leak 1987, Leak 2004). Growth rates of dominant/codominant sugar maple in younger (75-year-old) managed stands on granitic till will, of course, be much higher—up to 1.7 inches or more in 10 years (Leak 2007).

Based on this analysis, declines in growth since 18th and 19th centuries are not readily evident on the productive site represented by these historical data. However, managers, scientists, and other readers must arrive at their own conclusions, especially as additional information becomes available.

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KEY WORDS: D.b.h., growth, sugar maple, beech, growth decline, historical growth rates

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