THE EFFECTS OF LAND-USE HISTORY ON BEECH BARK DISEASE SEVERITY

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Abstract

While an increase in American beech (*Fagus grandifolia* Ehrh.) sapling density has been noted throughout the northeast, few studies have examined the causes of the increase. To examine the role of beech bark disease in the increase of beech sapling density, I assessed adult beech trees for beech bark disease damage, and measured beech sapling density surrounding the adult. I also investigated the effects of land-use history on beech bark disease severity and beech sapling density. Adult beech trees with more severe damage from beech bark disease had more saplings around them. Former sugarbushes had less damage from beech bark disease and lower densities of beech saplings than areas that were formerly logged, and beech was mostly absent from former agricultural sites.

Introduction

Since the introduction of beech bark disease, American beech (*Fagus grandifolia* Ehrh.) has declined in overstory abundance but increased in dominance in the understory of many affected stands in the northeastern United States and southeastern Canada (Twery and Patterson 1984, Houston 1994). The formation of dense understory thickets of beech is in part due to physiology of the species, and in part due to the aftereffects of beech bark disease. The ability of beech to sprout from root suckers can lead to areas of very high density in the understory. Generally the suckers are thought to form after the parent tree incurs an injury on a shallow root due to freeze-thaw cycles or logging practices (Jones and Raynal 1986, Jones *et al.* 1989). The prolific sprouting can also follow in the aftermath of beech bark disease, as canopy trees are decaying and dying (Houston 1975, Fahey 1999). Beech physiology in the form of shade tolerance also contributes to the formation of dense thickets, as beech is extremely shade tolerant and can survive for decades in deep shade (Canham 1988). Beech sapling density is an important component of forested areas, particularly because increased competition from beech root suckers can suppress the survival of other desirable species in some forests (Hane 2003).

Few studies have been done to determine the factors that contribute to both the severity of the disease and the subsequent formation of these understory thickets, though management of the thickets has been examined (Bohn and Nyland 2002). Beech density has been shown to impact the disease severity at the landscape level, but not on the level of the individual stand (Griffin *et al.* 2003). Due to the wide variation in stand site conditions, controlling for factors such as aspect, slope, elevation, and soil can be difficult and each of these factors may contribute to disease impact. Additionally, human land-use impacts on the stand may also be highly variable. To date, no studies have been done to investigate the effect of past land-use on the severity and impact of beech bark disease. The main interaction of land-use and beech bark disease is likely to be through the impacts of variable land-use on beech density and subsequent variation in infestation of beech bark disease. In forests with land-use histories that result in compositions with limited representation of beech, the effects of beech bark disease are likely to be limited.

Questions:

1) Do more heavily damaged trees have more vegetatively reproduced saplings?
2) Does land-use history have an effect on the severity of beech bark disease and the density of the resulting beech suckers?

Methods

Site descritptions:

Both formerly logged areas and former sugar bushes were utilized for this study. Sugar bushes are areas that have been selectively cleared to encourage growth and regeneration of sugar maple for tapping for maple sugar production. While the boom for the sugaring industry in New England was between 1790 and 1840, many farms in northern New England had sugar bushes as part of their income into the late 1800's (Hamburg 1984, Waldbauer 1999). The land-use impacts are very much like those of selective cutting, with the caveat that sugar maple was selected for rather than removed, and regeneration of the species was encouraged. Thus, in areas that were once used for sugar bushes, today we see a greater proportion of sugar maple, and much lower densities of beech.

Seven sites across the southwestern White Mountain National Preserve (NH) were selected. I chose sites based

Table 1.—Sites used in this study, along with their land-use history, age and location

Site	Land-use	Age	Location	Coordinates
Hubbard Brook Exp. Forest	Logged	80	West Thornton	43° 56' N, 71° 45' W
Hubbard Brook Trail	Logged	100	Warren	43° 57' N, 71° 49' W
Shadow Lake	Logged	85	Lincoln	44° 5?' N, 71° 41' W
Bald Mtn	Sugarbush	70	Campton	43° 51' N, 71° 41' W
Chickenboro Brook	Sugarbush	100	Campton	43° 52' N, 71° 35' W
Goose Hollow	Sugarbush	80	Thornton	43° 53' N, 71° 35' W
Bowl Research Natural Area	None	mature	Sandwich	43° 56' N, 71° 23' W

Table 2.—Results from the mixed-model ANOVA, which examine the effects of Beech Bark Disease Damage severity and Land-use History on beech sapling density

Effects Test	P-value
Beech Bark Disease Damage Score	<0.001
Land-use History	0.047
BBD x Land-use history	0.113

on uniformity for age, elevation, soil, slope and aspect. All sites were last cut > 70 years before the study, and the Bowl Research Natural Area was never cut.

Inventory:

At each site, an inventory of trees, saplings and seedlings was done. At each site, a total of sixteen 25 m x 25 m plots for trees (> 10 cm dbh) were inventoried. Within each of these plots, two 2 m x 25 m transects were done for saplings (< 10 cm dbh, > 2 cm dbh). Within each plot, we also examined seedling populations in five 1m x 1m subplots. Seedlings were identified as either germinants (with cotyledons still attached) or > 1yr old seedlings. In the Bowl Research Natural Area, we surveyed two distinct areas, one with sugar maple as the dominant in the overstory and one that was dominated by beech. These two areas are designated as "low beech" and "high beech" in the results.

At each site, 20 isolated beech trees (> 20 m from nearest conspecific) were identified and assessed for damage from beech bark disease using a 0-3 scale (Houston and O'Brien 1983). I also counted and identified the seedlings and saplings within a 5.6 m radius of each adult beech tree.

Results

I found that beech sapling density was predicted by the severity of beech bark disease ($p < 0.001$; Table 2). Trees with the highest degree of damage had the highest densities of saplings around them (2300/ha), while undamaged trees had much lower densities (800/ha).

Additionally, land-use history had an effect on beech sapling density ($p = 0.047$; Table 2). Trees in areas that were formerly managed as sugarbushes have fewer beech saplings than logged areas (Figure 1). Furthermore, beech in sites that were formerly sugarbushes had less severe damage from beech bark disease than sites that had been previously logged ($p = 0.03$, Figure 2). There was also a negative relationship between beech understory density and sugar maple understory density (Figure 2). Stands with dense thickets of beech, largely previously logged stands, had many fewer sugar maple saplings than stands without dense thickets.

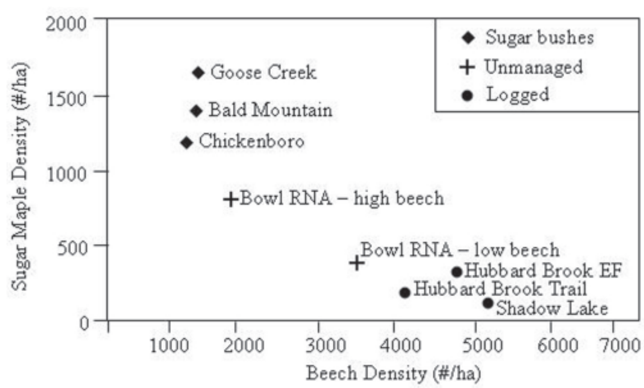

Figure 1.–Beech vs. sugar maple densities at sites with two different land-use histories (sugar bush or logged), and two areas of a site that has not been heavily impacted by human use (virgin).

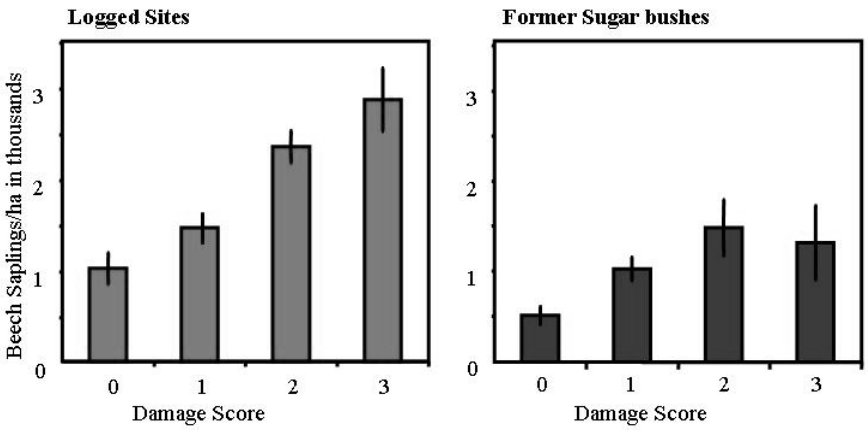

Figure 2.–Density of beech saplings as predicted by damage class in each land-use type. Damage class was assessed visually following methods from Houston and O'Brien (1983). The categories ranged from 0 (undamaged) to 3 (severely damaged).

Discussion

Disease severity appears to vary by land-use history in the northern hardwood stands I examined (Fig 2), and in turn, the disease severity seems to contribute to higher beech sapling densities (Fig 1). Land-use is particularly interesting as a predicting factor, because management practices from > 80 ybp have an effect on the patterns of regeneration that we see today. The removal of species other than sugar maple has resulted in stands with reduced beech density, which results in both less damage from beech bark disease and lower beech sapling densities.

As predicted, the sugarbushes had much higher densities of sugar maple saplings than forests with high levels of beech present (Fig 1). The sugarbushes examined had similar elevation, slope, aspect, and time since disturbance to the logged areas, however whether sugarbushes were randombly distributed on the agricultural landscape is unknown (Waldbauer 1999). The results of the survey demonstrate that the presence of beech in the overstory has an apparent impact on the density of young sugar maple in the understory. The sugarbushes had higher regeneration of sugar maple than any other area, and also had the lowest density of beech saplings of any area, although the relationship may also be related to greater seed sources in areas of high maple density.

In forests with land-use histories that result in compositions with limited representation of beech, the effects of beech bark disease appear to be limited. These areas have little root suckering or canopy thinning in the form of branch or individual tree death. At the Bartlett Experimental Forest, the severity and impact of beech bark disease varied with species composition and stand age, both strongly influenced by the logging history of a site (Twery and Patterson 1984). Older stands with more mature beeches had a higher mortality rate than stands with smaller, younger trees. This result is not surprising, given that tree age plays a key role in determining susceptibility to beech bark disease. In the logged stands in this study, beech was a major component of the overstory (trees > 10 cm dbh; 39-43% by density) and made up the largest proportion of the understory regeneration. Beech recovered in these stands from the effects of logging, and beech bark disease and its subsequent effects are evident in all three stands. In contrast, nearby younger stands have much lower densities of beech, many of which are not yet large enough to be infected with the disease (trees need to be approximately ≥ 15 cm dbh), and stands logged < 60 years before had only minor effects from beech bark disease. Therefore, areas that have been previously logged and are now mature are susceptible to beech bark disease and ice damage, and the indirect effects of these factors are contributing to the reduction of regeneration of sugar maple in these areas.

Due to the absence of mature beech on former plowed sites, even after 55-60 years of forest succession (Hamburg 1984), the incidence and impact of beech bark disease on sites with such a land-use history is likely to be minimal. However, the stand may be infected later, if a new outbreak occurs after beech has established itself in the stand. In the three abandoned sugarbushes (year of abandonment approx. 50-70 years ago), density of adult (> 10 cm dbh) beech was less than half that of undisturbed or logged forests of comparable age and soil type. In addition many of the beech present were not yet large enough to be affected by the disease. The very few large (> 20 cm dbh) adult beeches that were present did have evidence of beech bark disease, but the areas of root suckers were confined to the areas around individual infected trees, rather than pervasive through the understory, as they are in some undisturbed and logged forests. The density of sugar maple saplings (< 5.0 cm dbh) was higher than densities in undisturbed or logged forests (Figure 1). This difference further indicates that the decline in sugar maple regeneration noted elsewhere (Twery and Patterson 1984, Jenkins 1997) is likely due, at least in part, to competitive effects due to the presence of beech and the effects of beech bark disease (Hane 2003).

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Contains invited papers, short contributions, abstracts, and working group summaries from the Beech Bark Disease Symposium in Saranac Lake, NY, June 16-18, 2004.

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