# BEECH STATUS IN NEW ENGLAND'S AFTERMATH FORESTS

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**Abstract.**—American beech (*Fagus grandifolia*) is one of the three most dominant tree species occupying the northern hardwoods forest of New England. We studied Maine, New Hampshire, Vermont, and New York to capture those areas with higher concentrations of beech. The status of beech in the northern hardwood forests is important because of the long-term impacts of beech bark disease (BBD) (*Neonectria* ssp.) on the composition and regeneration of aftermath forests within the region. We assessed the current conditions of beech trees at the stand level by comparing 2011 Forest Inventory and Analysis survey data with the previous survey conducted on the same set of plots (2006). To understand the current impacts of BBD on forests, we compared the number of growing-stock trees, number of rough cull trees, number of rotten cull trees, number of standing dead trees, and number of mortality trees with an important associative species, sugar maple (*Acer saccharum*). To evaluate the impacts of BBD on stand regeneration, we also assessed the number of sapling-size trees of American beech and three of its close associates, sugar maple, yellow birch (*Betula alleghaniensis*), and eastern hemlock (*Tsuga canadensis*). Beech trees had 40 percent of their stocking classified as defective or dead; sugar maple stocking had less than 15 percent. Mortality tree numbers for American beech were highest in the larger diameter trees (11.0 inches diameter at breast height and larger) where BBD had been detected for less than 37 years, but were more equally distributed in older aftermath forests where BBD had been present for more than 60 years. The number of beech saplings increased while the numbers of its three associate tree species did not change significantly. Net growth of beech was increasing as a proportion of net growth for sugar maple.

## INTRODUCTION

American beech (*Fagus grandifolia* Ehrh.) is an important component of the northern hardwood forests of the Northeast. It is more shade tolerant than most of its associates and can quickly regenerate in the form of sprouts (Jones and Raynal 1987). Unlike its common associates, beech has been impacted by the beech bark disease (BBD). BBD is an insect-fungus complex involving the scale insect (*Cryptococcus fagisuga* Lindinger) and the exotic canker fungus *Neonectria faginata* (M.L. Lohman and A.M.J. Watson; Castlebury, Rossman and Hyten) or the native *Neonectria ditissima* (Tul. & C. Tul.). BBD has been spread by the scale insect throughout New England since the early 1930s (Ehrlich 1934). Three stages of BBD development have been identified (Shigo 1972). The stages are the advancing front where forests with concentrations of beech trees are degraded by the scale insect during bark feeding and subsequent infection of *Neonectria* spp., the killing front where forests have widespread beech mortality as a result of the effects of BBD accompanied by high populations of the scale insect, and finally the aftermath zone where BBD-related mortality and scale insect numbers have declined and greater numbers of smaller beech trees occupy the stand (Cale et al. 2012, Munck and Manlon 2006). This analysis has focused on forest conditions within the aftermath zone. As the fungal-insect complex progresses toward its southern and western limits, how can we analyze Forest Inventory and

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Analysis (FIA) data to identify the current conditions of maple-beech-birch (northern hardwood) aftermath forests for any given locale? Can these same data be used to project temporal changes to BBD aftermath forests and their important associate tree species?

## DATA AND METHODS

This assessment focused on identifying FIA inventory attributes from the 2006 and 2011 surveys that can be used to determine the present stand-level conditions of BBD-infected beech forests within the northern hardwood region (Bechtold and Patterson 2005). BBD-infected stands were stratified by the number of years since first detection. County-level records of the year of initial scale insect establishment were provided by the U.S. Forest Service, Northeastern Area State and Private Forestry, and are available online (Jones et al. 2011). These county-level data were not based upon the FIA systematic survey; therefore, slight inconsistencies may exist between years and regions concerning scale insect detections. Two prior studies have used these data to examine the relationship between the spread of the scale insect and beech density (Morin et al. 2005, 2007). The northern New England region was studied because the BBD complex has been active there longer than anywhere else in the U.S. (Fig. 1). Areas in Maine, New Hampshire, New York, and Vermont were broken down into areas where scale had been detected for less than 37 years, areas where scale had been detected from 37 to 60 years, and areas where scale had been detected for longer than 60 years (Morin et al. 2007). We compared the number of growing-stock trees, number of rough (form defect) cull trees, number of rotten (decay defect) cull trees, number of standing dead trees, and mortality expressed as tree numbers to make comparisons between American beech and an important associative species, sugar maple (*Acer saccharum* Marsh.). We also compared net growth between these two species. On the landscape level, we compared these attributes as a whole within the northern New England region and by state (Maine, New Hampshire, New York, and Vermont). These data were stratified by two broad

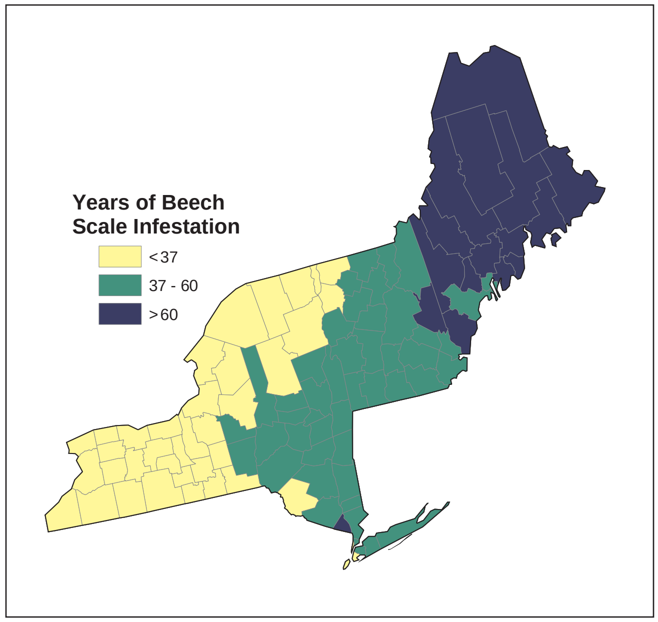


Figure 1.—Years of scale insect infestation by county in New England (ME, NH, NY, VT), 2011.

diameter classes: all trees greater than or equal to 7.0 inches diameter at breast height (d.b.h.) versus all trees greater than or equal to 11.0 inches d.b.h. Acreage was stratified by year of scale detection within a given county. All trees greater than 7.0 inches d.b.h. were chosen instead of 5.0 inches to reduce the influence of sprout stimulation caused by BBD on overall beech tree numbers. The number of saplings (all trees between 1.0 and 5.0 inches d.b.h.) was used to evaluate BBD impacts on regeneration while examining possible interactions between beech and three of its close associates, sugar maple, yellow birch (*Betula alleghaniensis* Britt.), and eastern hemlock (*Tsuga canadensis* Carr.).

## RESULTS

### Aftermath Forests

New England region: Beech inventory showed that 40 percent of all beech trees (5.0 inches d.b.h. and greater) are classified as rough and rotten cull trees or standing dead. By comparison, less than 15 percent of sugar maple trees are cull or dead (Fig. 2).

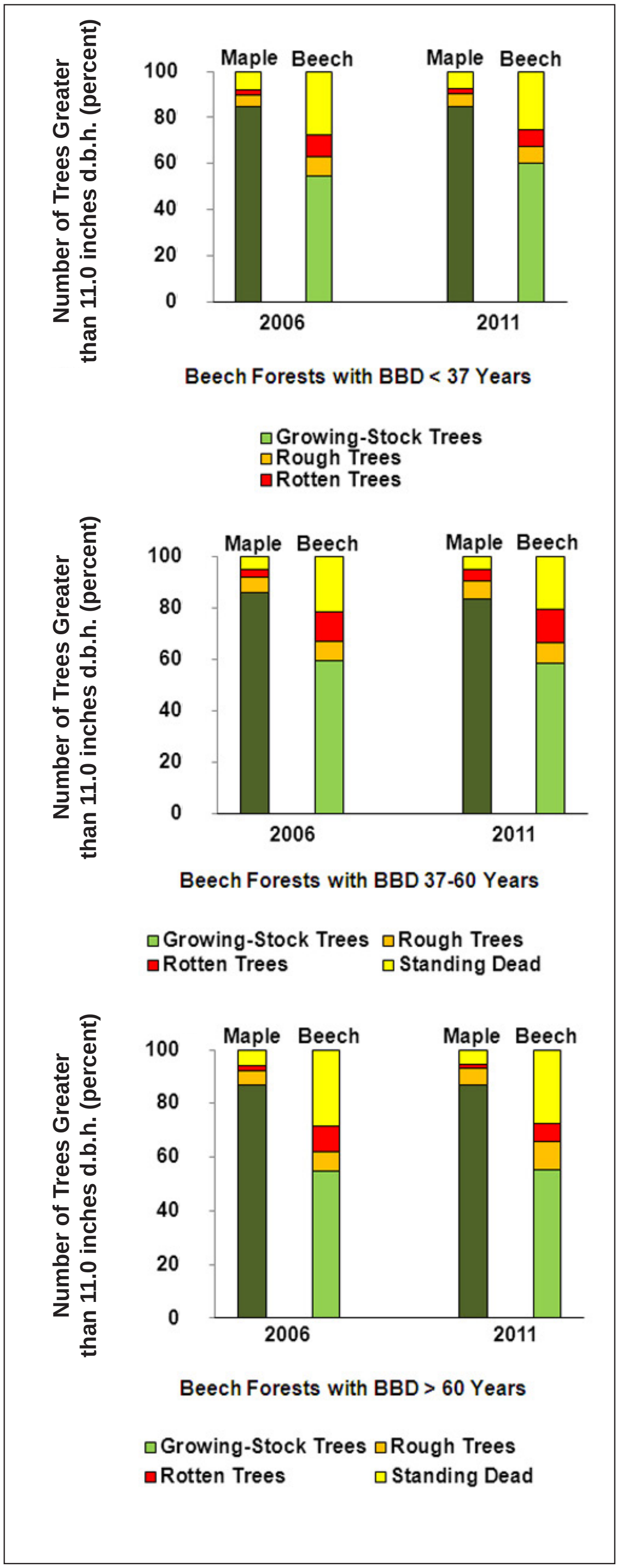


Figure 2.—Number of sugar maple versus beech trees 11.0 inches d.b.h. and greater in percent on forest land in New England (ME, NH, NY, VT), 2006 versus 2011.

## Infection Classes

New York, and to a lesser degree, Vermont made up most of the areas infected for less than 37 years. New Hampshire, Vermont, and to a lesser degree, Maine contain acreages infected from 37 to 60 years. Finally, Maine, and to a lesser degree, New Hampshire make up most of the acreages infected for longer than 60 years. Below are the numbers of defected or dead trees as a percentage of total tree numbers, including growing-stock trees (Table 1).

## Mortality and Standing Dead

Mortality trees differ from all standing dead trees because they represent only those trees that died since the last measurement (5 years). The mortality trees also include fallen trees or recently burned material. The greatest proportion of mortality beech trees were found in areas infected for less than 37 years when counting trees of 11.0 inches d.b.h. or greater. In those same areas, when the count included trees with diameters of 7.0 inches or greater, the mortality levels were lower, which was comparable to northern New England beech numbers as a whole (Fig. 3).

**Table 1.—Numbers of rough, rotten, mortality, and standing dead beech trees as percentage of total trees; classified by years since first scale insect detection.**

| Infection Class | Attribute | Tree Count (%) |
|---|---|---|
| Infection <37 Years | Standing dead trees | 25 |
| | Mortality trees | 6 |
| | Rough cull trees | 8 |
| | Rotton cull trees | 6 |
| Infection ≥37 and ≤60 Years | Standing dead trees | 21 |
| | Mortality trees | 1 |
| | Rough cull trees | 7 |
| | Rotton cull trees | 12 |
| Infection >60 Years | Standing dead trees | 28 |
| | Mortality trees | 3 |
| | Rough cull trees | 8 |
| | Rotton cull trees | 7 |

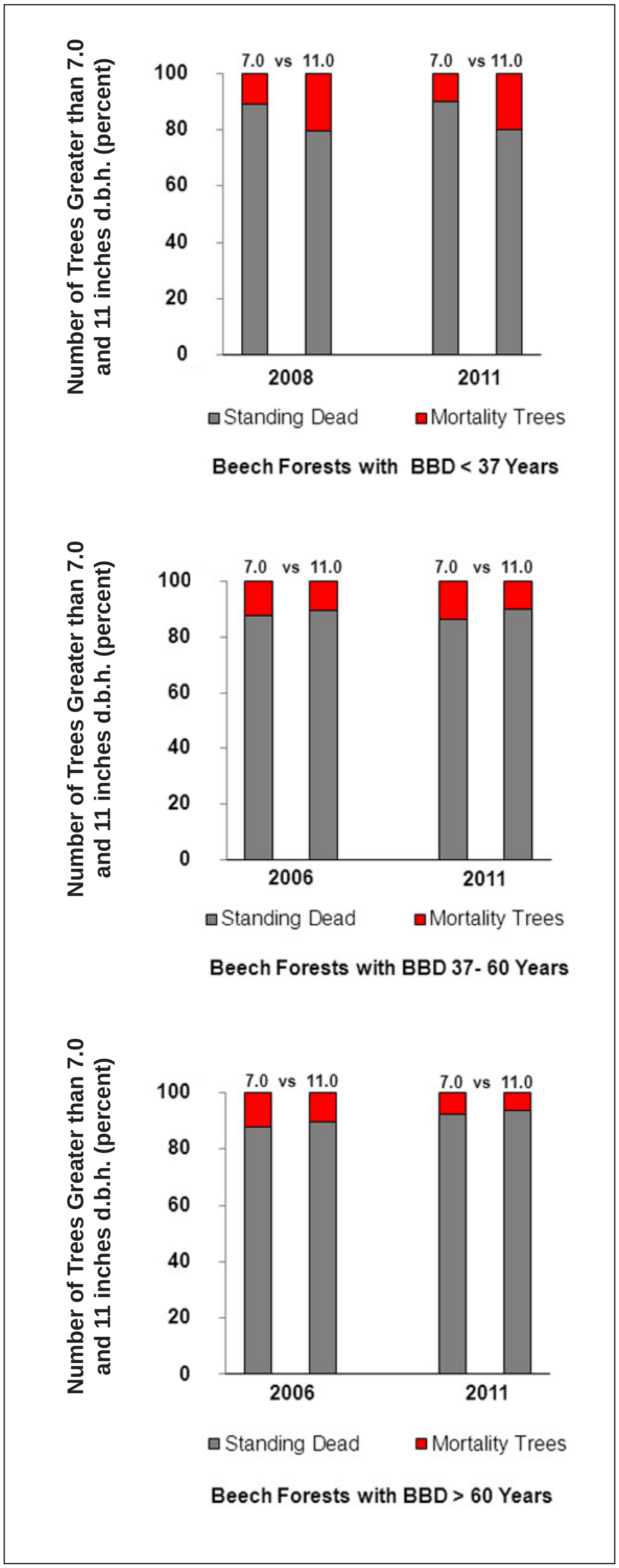


Figure 3.—Number of beech trees 7.0 and 11.0 inches d.b.h. and greater in percent on forest land in New England (ME, NH, NY, VT), 2006 versus 2011.

## Regeneration

The number of saplings increased in BBD-infested acreage because beech sprouting was stimulated by the BBD complex. Sugar maple and hemlock numbers did not statistically change (Fig. 4). In Maine, beech regeneration had a lower proportion of the total sapling numbers where higher yellow birch and hemlock stock were growing.

## Net Growth

The net growth of beech trees as a proportion of sugar maple growth is increasing. The largest proportions were found in the younger aftermath forests (Fig. 5).

## DISCUSSION

With the killing front comes the beginning of the aftermath forests. The effects are first seen on the largest beech trees (d.b.h. >16 inches). Gaps are created when these larger beech trees fall (snap) as a result of wood defects created by BBD infection. The new openings are filled by beech saplings as a result of BBD-stimulated sprouting and by some released yellow birch and hemlock trees. The beech sprouts form “thickets” creating understory shading while crowding out sugar maple (Gravel et al. 2011). Some researchers believe sugar maple saplings are suppressed by possible toxic effects of higher levels of beech leaf leachate excreted from these dense thickets, coupled with focused deer browsing (Hane et al. 2003, Runkle 2007). Scale populations eventually decline as aftermath conditions become prevalent (Cale et al. 2012). The beech thickets grow and cause increased shading, creating a nursery environment for young hemlock trees. The aftermath stand will contain greater numbers of smaller, defective beech trees. These smaller diameter beech trees will produce fewer sprouts than the larger diameter beech trees exposed to the killing front (Jones and Raynal 1987). The impact of greater numbers of beech saplings on the regeneration of sugar maple, yellow birch, and hemlock in upper New England is not yet clear based upon current FIA inventory data. But in areas where

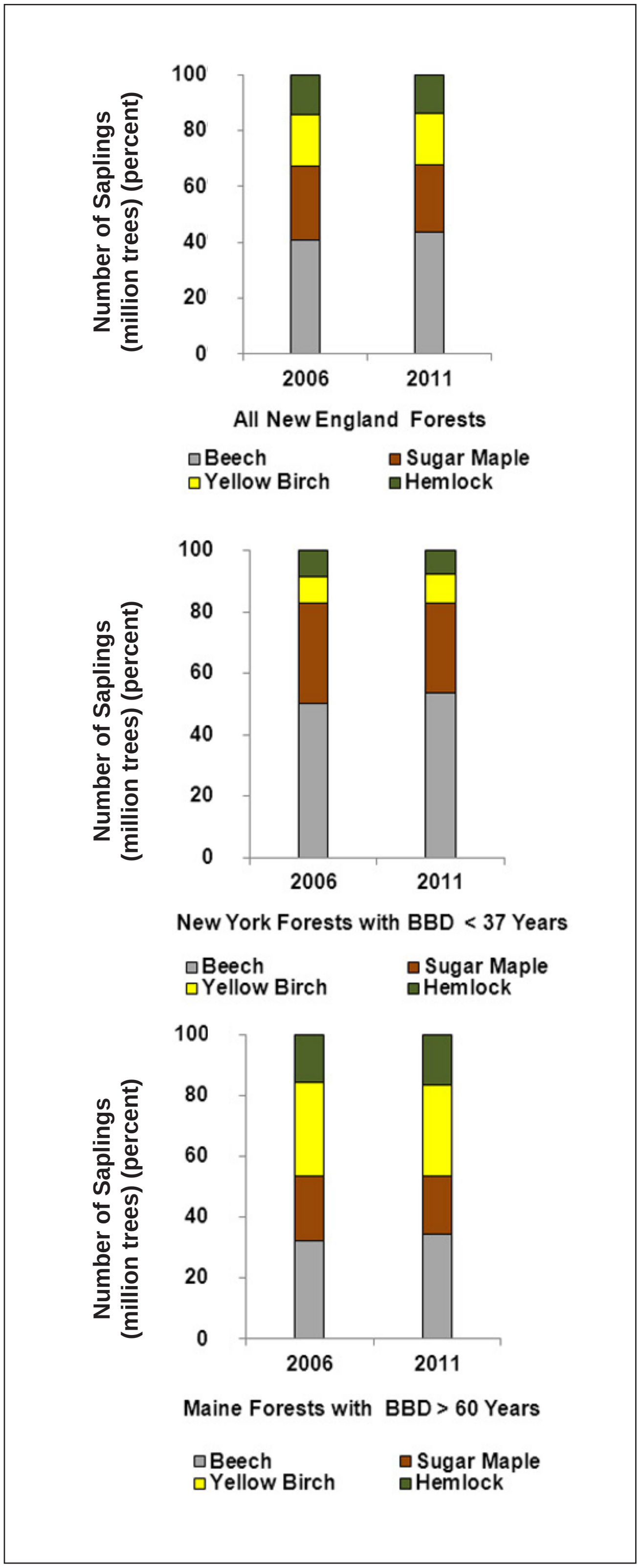


Figure 4.—Number of saplings (million trees) between 1.0 and 5.0 inches d.b.h. in percent on forest land in New England (ME, NH, NY, and VT), 2006 versus 2011.

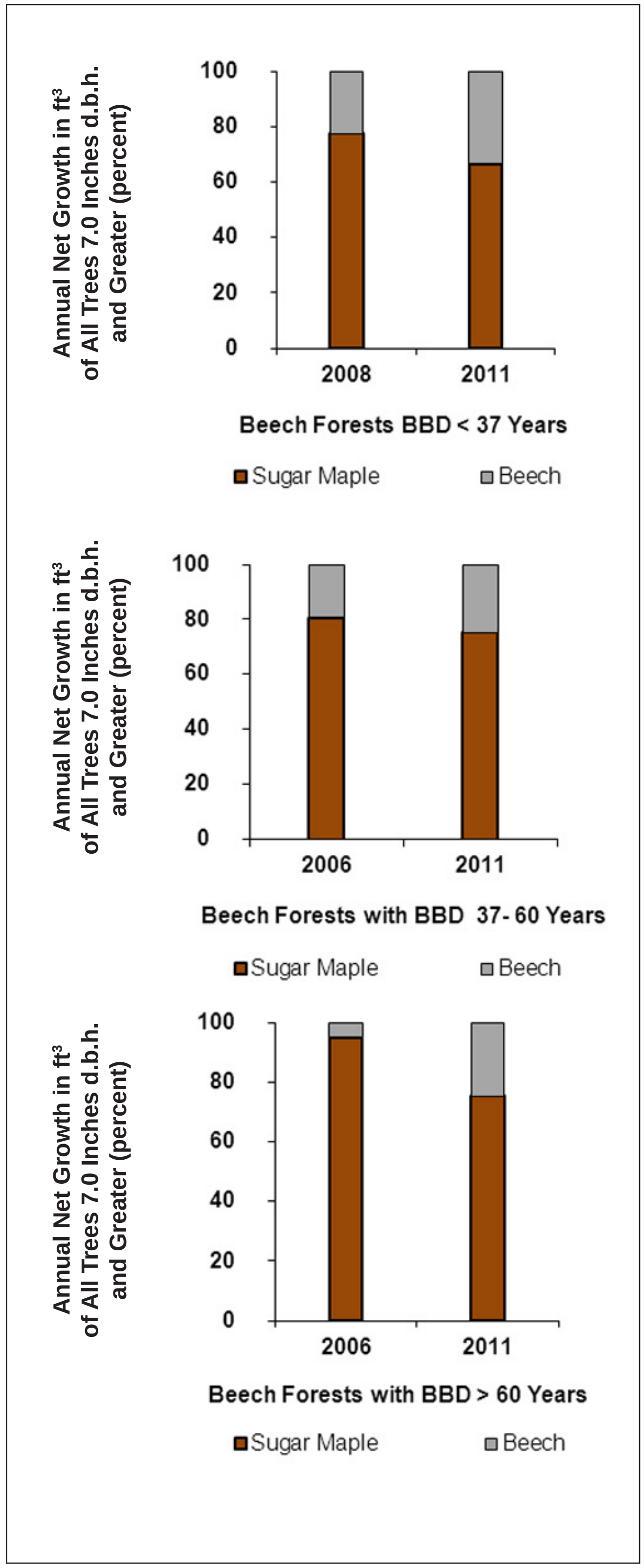


Figure 5.—Annual net growth of growing-stock trees 7.0 inches d.b.h. and greater (cubic feet) in percent by species (beech, sugar maple) on forest land in New England (ME, NH,NY,VT), 2006 versus 2011.

larger numbers of yellow birch and eastern hemlock saplings are growing, there may be a defense against stimulated beech sprouting through stiff competition for light and moisture.

## CONCLUSIONS

The condition of the northern hardwood forest varies based upon the number of years BBD has been infecting an area. Forests that have been infested for less than 37 years tend to have higher numbers of standing dead trees within the larger diameter classes as a result of high tree mortality during the killing front phase. They also tend to have an equal number of rough and rotten cull trees. Sprout numbers are high as BBD-induced breakage prevails in the larger beech trees. Beech forests infected from 37 to 60 years had fewer standing dead, fewer rough cull trees, and greater numbers of rotten cull trees, resulting in down woody debris accumulation. Beech mortality is no longer concentrated in the larger diameter trees. Where BBD has been present for longer than 60 years, beech forests tend to have larger numbers of standing dead trees in the smaller diameter classes and fewer rotten cull trees as breakage occurs earlier. The BBD-generated sprouts initiated during the killing front are now infected pole-size trees, facing death at a much earlier age than their parents. Tree mortality occurs across the diameter classes, and the number of beech sprouts tends to be lower in these smaller diameter beech trees.

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