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Beech Bark Disease

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Beech bark disease (BBD) is a devastating disease of American beech (*Fagus grandifolia* Ehrl.) caused by a combination of damage to the bark and vascular tissue by the beech scale insect (*Cryptococcus fagisuga*), followed by infection with several fungal species (*Neonectria faginata*, *Neonectria ditissima*, and *Bionectria ochroleuca*). Beech scale was introduced into Nova Scotia from Europe in the 1890s and has been slowly progressing through the range of American beech since then (Figure 1). It was first found in Ohio in the 1980s and is now identified in several counties in the Northeastern part of the state. Disease progress projections show that it will likely be found throughout Ohio by the mid 2020s.

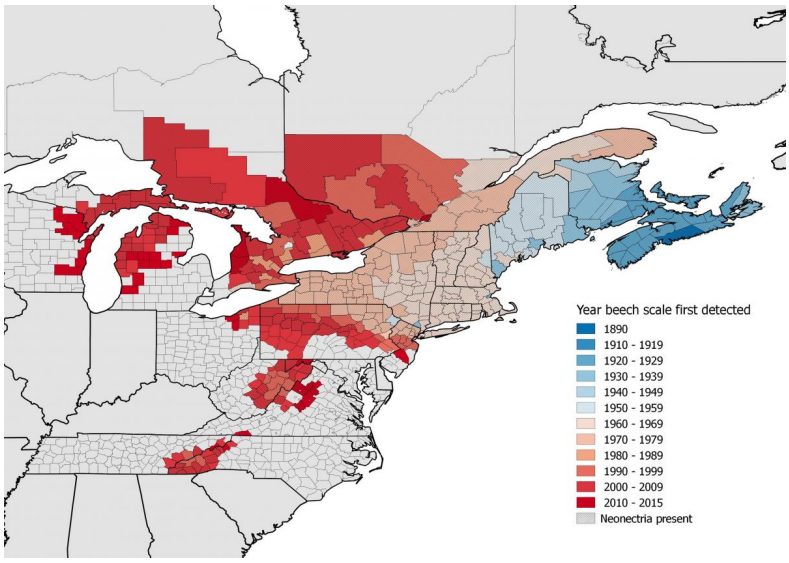

Figure 1. First detection of beech scale by county in United States and Canada. From Cale et al. 2017.

Figure 2. Scale insects on a beech trunk. Photo by Dan Herms.

Disease Development and Symptoms

The scale insects appear as “white wool” on the trunks of infested trees, either sporadically—especially in rough bark or cracks on the bole—then in increasing density, to the point that the tree can appear covered with them (Figure 2). The trees are usually not killed by the scale, but the damage (especially with high infestation levels) may weaken them. Scale insects may be present on the trees for several years before the fungal infection occurs. Once the *Neonectria* spp. infections become established, diseased trees will show smaller, yellowing leaves and reduced canopy. Eventually, cankers will manifest on the trunk (Figure 3).

Figure 3. Small tree with severe cankers. Photo by Esther Kibbe.

Figure 4. Fruiting bodies of the fungus appear on the bark in the fall. Photo by Ontario MNR.

In the late summer and fall, fruiting bodies (perithecia) of the fungus will appear as small red dots in a roughly circular shape in the cankers (Figure 4). Cankers will keep enlarging and become progressively worse until the tree is girdled and killed. Trees weakened by BBD are prone to breaking over in windy conditions, a tendency known as “beech snap,” and represent a hazard near homes or recreation areas (Figure 5). Initial beech scale infestations in Michigan, West Virginia, and Ohio centered on campgrounds and recreation areas, giving the suspicion that human activity was responsible for the spread of the insects, probably on infested beech firewood.

Insect and Pathogens

In North America, beech scale insects are only female and they reproduce parthenogenically (without fertilization). They produce one brood of eggs per year in June or July. The eggs hatch in August or September and the crawlers, which have legs and antennae, disperse by crawling to a new spot on the same tree or by being blown by the wind or carried by birds to new trees before settling in and secreting a waxy coating under which they molt and overwinter as second instars. They seem to prefer trees with rough bark, which may be easier for them to hold on to. Heavy rains can wash crawlers off the trees and delay infestation. Scale adults are sessile (non-mobile), about 0.5-1.0 mm long and their soft bodies are covered by a protective white wax layer. They use a long stylet to pierce into the phloem cells of beech trees and suck out the contents. These cells die, and if enough are damaged, small cracks will form in the bark.

Figure 5. "Beech snap" presents a safety risk in areas with affected trees. Photo by Dan Herms.

The two species of *Neonectria* that cause BBD can only be distinguished by examining the length of the ascospores. Both species can be found on the same trees, so it can be difficult to separate the contribution to the disease of one versus the other species. *N. ditissima* is native to North America and is known to infect other tree species on which it also causes cankers. *N. faginata* is not known on other North American tree species, nor is it known in Europe, so it is unclear where this fungus originated; it is now effectively considered a North American species. *Bionectria*

ochroleuca is another fungus that has been frequently isolated from trees with BBD in Pennsylvania and New York, but it appears to be less aggressive than the two *Neonectria* spp. However, all three have taken advantage of the damage from beech scale to ravage beech stands in North American forests.

Disease Cycle

Neonectria ditissima and *N. faginata* produce ascospores in the late summer or autumn. *Neonectria* cankers can be found on other hosts throughout the range of American beech and opportunistically infect the wounds caused by beech scale, but are not actively vectored by it. New infections are initiated in the autumn, almost always from ascospores. *Neonectria* spp. can have an asexual phase in the summer that produces conidia in pinkish cushions called sporodochia, but it is not known what role conidia play in disease spread. Both ascospores and conidia are windblown and will cause infection if they reach susceptible plant tissue. Tarry spots can be a symptom of infection with *Neonectria* spp. and sometimes perithecia will form around these spots.

Distribution and Impact

American beech is an important tree in the forests of the Northeastern United States and Canada, with a range into the Midwest and Southeast, as shown in Figure 6. As one of the few mast (nut) producing trees in these forests, it is a significant food source for wildlife, especially black bear, and the wood of mature trees—while not particularly sought after—is valuable for lumber, possessing a beautiful, fine and even grain. BBD is well established in areas where beech is a major component of the tree species mix, though on less than 30 percent of the potential host range. The stages of progression of BBD as it spreads across the native range of American beech have been identified as follows:

1. Advance front—beech scale arrives and reproduces on the beech trees in an area. The increase of the scale insect can be slow, taking up to 10 years, but may reach densities of 270 scales/cm^2. Trees generally show no greater rate of mortality than before beech scale arrived. The spread of the advance front is usually just a few miles per year.
2. Killing front—usually three to six years after the scale first arrived, the infestation is now very high and the *Neonectria* spp. infections appear. Larger trees usually die before smaller diameter trees. Mature trees can reach mortality levels of 50 percent within 10 years, with higher rates seen in some areas (Figure 7). Up to 90 percent of beech trees will eventually succumb. Drought, poor nutritional status, or activity of other pests can predispose trees to beech scale and *Neonectria* spp. infection.

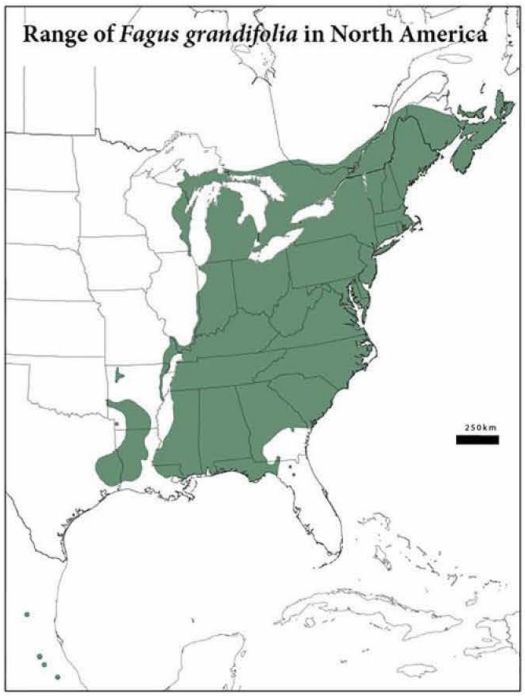

Figure 6. Range of American beech. Photo from Stephenson and Coe, 2017.

Figure 7. The "killing front" in a beech forest after the arrival of BBD. Photo by Dan Herms.

3. Aftermath—once most of the susceptible trees have been killed, the forest now shows lower but consistent levels of beech scale and *Neonectria* spp. presence. Trees continue to show cankers and eventually die, but at a lower rate. Beech are now a lower percentage of the overstory, as large trees die first, but thickets of shade-tolerant young beech choke the forest floor, preventing regeneration of other tree species.

Management

Management of BBD requires control of or resistance to the beech scale. This can be done at the level of a single tree by using brushes or a blast of water to wash the insect off the tree, or by application of insecticides or insecticidal oils when crawlers are present, but control must be maintained every year. A small percentage of trees that appear to be resistant to beech scale have been identified, and researchers are using these trees to identify genes for resistance, and to start breeding programs to develop resistant selections that could be planted to repopulate the native range of beech. Resistance is probably due to biochemical or structural factors that make the trees unattractive or impenetrable to beech scale. Biological control of the beech scale does not appear to be a viable management option.

Selective harvesting to remove diseased beech trees can salvage trees before they fall, and may reduce the levels of beech scale, to allow resistant or partially resistant trees a better chance of survival. Forests dominated by beech will be particularly susceptible to BBD, especially if trees are mature or stressed. For stands not yet affected by BBD, managers should consider the health and composition of tree species and remove aged, defective or rough-barked beech, which are more susceptible to beech scale attack. Once the advancing front has arrived, managers should watch for trees that remain scale free and mark and save them as being potentially resistant. Individuals should be careful not to transport infested wood or firewood out of the area.

When beech trunks die or their roots are disturbed, they produce root suckers, forming beech thickets which can choke the understory of the forest. These new trees will also be susceptible to BBD and should be reduced by minimizing root disturbance and by use of herbicides and brush cutting, to encourage more desirable species, like maples and oaks.

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