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Beech Bark Disease in Ontario:
A Primer and Management Recommendations

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American beech

American beech (*Fagus grandifolia*) is one of the seven principal tree species comprising Ontario's tolerant hardwood forests. A dominant member of moist, late-successional forests, it can form pure stands, but more often is found in mixed stands with sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), and hemlock (*Tsuga canadensis*). In Ontario, beech can reach 250 years of age, with a maximum diameter of 80 cm and heights up to 27 m. A nut-producing species, its seeds are an important food source for black bears, deer, birds, and various rodents. Beech wood is used for flooring and furniture, railway ties, pulp, and fuelwood.

Beech bark disease

Beech bark disease (BBD) is a non-native insect-fungus complex caused by the beech scale (*Cryptococcus fagisuga*) and the canker fungus *Neonectria faginata*. The beech scale was introduced into North America in the 1890s on European beech (*Fagus sylvatica*) seedlings shipped from Europe to Halifax. *N. faginata* probably arrived in North America in a similar way. The beech scale and the ensuing disease have gradually spread through eastern North America. In 1999, BBD was officially confirmed in Ontario, and has since spread throughout most of the species' local range.

The disease is initiated when the beech scale feeds on the outer bark of beech trees. Usually the larger trees in a stand are attacked first. Although they do not kill trees, scale infestations reduce tree vigour and growth, and lower tree resistance to fungal infection. Within 2 to 10 years of the arrival of the scale insect, the feeding wounds become infected with *N. faginata.* The fungus grows into and can kill the tree's inner bark and cambium, creating many circular or lemon-shaped cankers (Figure 1). Infection usually occurs on the lower bole of the tree but cankers can extend into the crown. The cankers may develop into large vertical patches of dead bark (Figure 2) or encircle the entire bole (Figure 3). Branches above large patches of dead bark often show signs of decline, producing little to no foliage. Large trees are the first to become diseased and to exhibit crown dieback. Trees with BBD are more susceptible to invasion by decay fungi and insects and their combined effects can result in stem breakage during wind events.

Figure 1. *Cankers caused by* Neonectria faginata *on the stem of a beech tree.*

Figure 2. *The bark on the right side of this beech tree has been killed by beech bark disease.*

Figure 3. *Beech bark disease cankers can encircle the entire bole of a tree.*

The beech scale

Adult beech scale are small, oval insects about 1 mm long. During the summer, adults lay eggs on the bark of infested trees; in about 20 days the eggs hatch into the crawler stage. The crawlers (Figure 4) which are the only mobile life stage of the scale, search for new feeding sites in bark cracks and crevasses. Most crawlers do not disperse very far but some can be transported by wind, animals, birds, and people (for example, on firewood), causing long range dispersal. Once the crawlers begin to feed, they produce a protective coating of white wax filaments and remain stationary for the rest of their lives.

The following spring, crawlers moult into adults that continue to feed in place. Initial scale infestations are more common on larger trees (≥20 cm in diameter), possibly because their larger bole or crown provides a larger area to intercept tiny crawlers blown from other infested trees. Small scale colonies look like woolly white tufts in bark crevices (Figure 5); larger colonies can cover large areas of the bole (Figure 6).

Figure 4. *Crawler stage of beech scale (white wax filaments were removed to expose the insect).*

Figure 5. *Once established in bark crevasses, scale insects exude a white woolly protective covering.*

Figure 6. *In heavy infestations, large portions of the bole of the tree can be covered with scale.*

The canker fungus

Infection by the invasive canker fungus *Neonectria faginata* follows beech scale infestations. In addition, a native *Neonectria* species (*N. ditissima*) occasionally causes small cankers, but is not a significant contributor to BBD in Ontario. Initially, inconspicuous creamy white "cushions" appear on the dead bark of cankers. These fruiting bodies release minute spores in the fall that are dispersed by water. Soon after, the very conspicuous clusters of tiny (approximately 0.3 mm in diameter) bright red fruiting bodies, called *perithecia*, erupt through bark killed by the fungus (Figure 7). Spores produced in the perithecia are released during moist, above-freezing conditions during fall and winter. Spores are dispersed by wind and water to new infection sites either on the same tree or on nearby scale-infested trees.

Most cankers are produced in the fall, and continue to grow annually as the fungus invades more bark tissue. The cankers often have raised edges and cracks, although some are diffuse with imperceptible margins.

Spread of Beech Bark Disease

Three distinct phases in disease development may be observed as BBD spreads across the landscape.

- On the *advancing front*, previously unaffected beech trees are colonized by the beech scale; larger trees are usually the first to become infested. Damage caused by scale feeding ranges from superficial, localized necrotic bumps (Figure 8) to deep bark cracks. Scale infestations contribute to the decline of beech affected by other stresses such as root disease or drought.
- A few years after initial scale colonization, the disease progresses into the *killing front* phase during which scale populations rapidly build, *N. faginata* infects colonized trees, and cankers develop. Many beech die within 3 to 6 years of infection.
- After this first wave of beech mortality the disease remains endemic in the *aftermath forest*. In this phase, the remnant large beech trees continue to gradually decline and stem breakage is common. Younger trees also become infected and gradually decline.

Under certain climate conditions, additional waves of BBD may occur in aftermath forests, followed by extensive tree mortality. For example, winter temperatures that remain above -25 °C favour the build-up of beech scale populations. Several years of drought are also reported to increase beech susceptibility to BBD, resulting in increased disease and tree mortality levels.

Figure 7*. Clusters of red fruiting bodies of* Neonectria faginata *develop in cankers on beech trees.*

Figure 8. *Superficial necrotic bumps caused by scale feeding. Some outer bark has been removed to expose the associated small brown lesions; these do not extend to the inner bark and cambium.*

Beech Bark Disease in Ontario

The beech scale was first reported in Elgin County in 1966. In 1981, beech scale and cankers were observed in the Toronto area, but the causal fungus was not identified at the time. Although the fungus has probably existed in Ontario since the early 1980s, the presence of *N. faginata* was officially confirmed only in 1999. As of 2012, BBD has spread throughout most of the area in which beech occurs in the province (Figure 9). Satellite disease centres (those far from its main range) might be the result of moving firewood from infested sites.

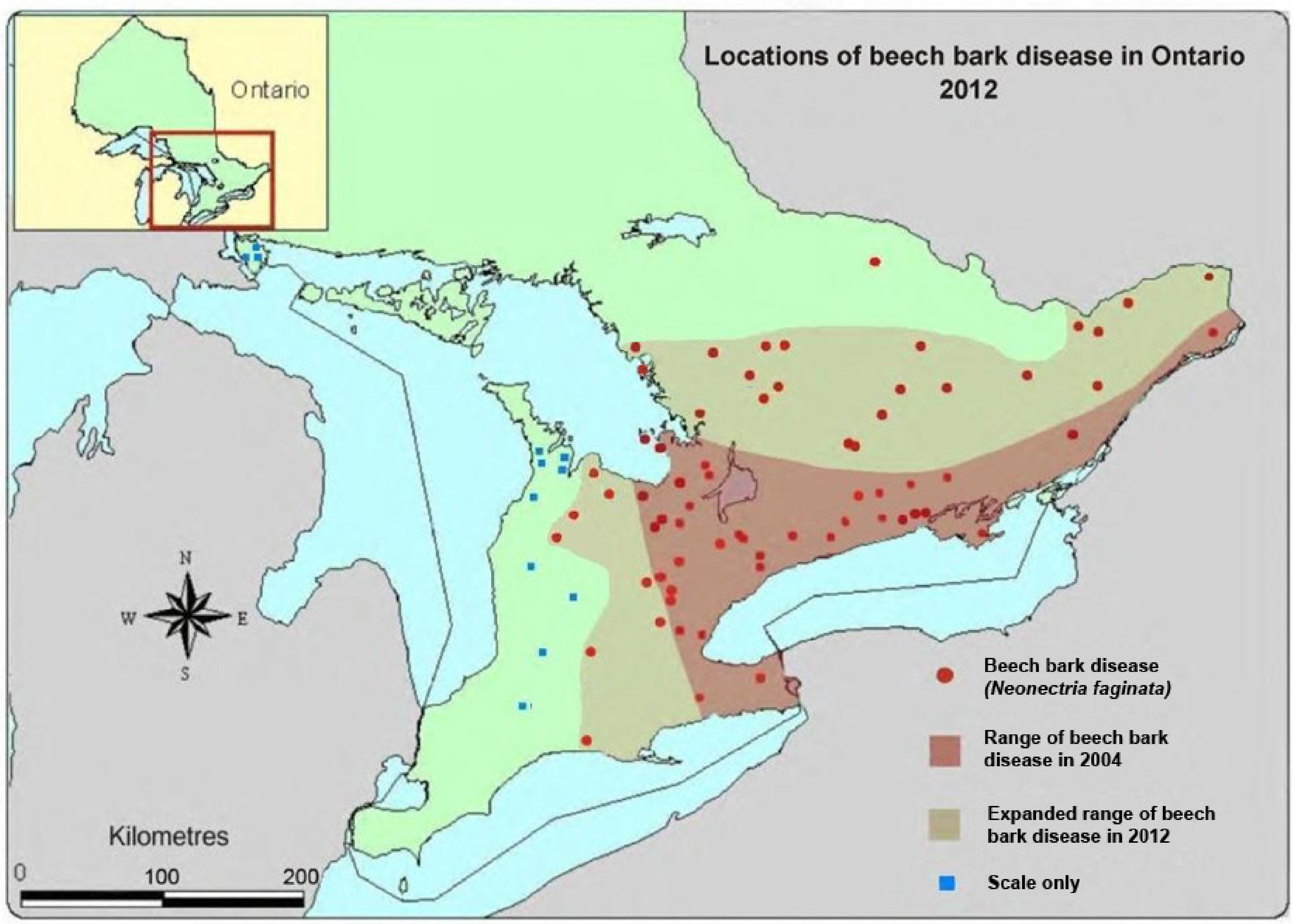

Figure 9. *The range of beech bark disease in Ontario as of 2012, showing progression since 2004 and locations of scale-only infestations. The lone red dot in the upper right is considered a satellite disease centre – an area to which the disease was transported, possibly via movement of firewood.*

Effects of Beech Bark Disease

On beech	On the ecosystem	On timber products
Rapid mortality of large, old trees girdled by cankers. Slow decline and death of beech with less serious infections and of regeneration in aftermath forests. Increased susceptibility to decay fungi and insects, leading to stem breakage. More beech sprouts and seedlings produced around dead trees, which also become infected. Decreased seed production from diseased trees that have lost >25% of their crown.	Potential changes in food availability for wildlife including bears, deer, and birds. Loss of habitat for cavity-nesting birds and mammals. If beech is a small component of a stand, it may be eliminated by beech bark disease. In stands with more beech stems, heavy root sprouting can occur around dead and dying trees, ensuring that beech remains in the stand, but these stems become infected and highly defective. Stem breakage during storms creates large canopy gaps, allowing less shade-tolerant species to grow.	Less wood available for beech products, including flooring, furniture, and fuelwood. External defects caused by cankers are superficial and have no effect on internal wood quality.

Disease Resistance and Tolerance

In Ontario's hardwood forests, scattered large beech trees are not attacked by the beech scale (Figure 10). These trees are *disease resistant*, as the canker fungus only infects scale-infested trees. Resistance is rare, found in approximately 1% of beech in North America. Since a scale-free tree may simply have escaped initial infestation, identifying resistant trees in beech stands is only possible once scale populations have been established for some years. A non-infested tree, or group of trees, surrounded by heavily infested and diseased trees is a good candidate for retention and further monitoring.

In rare cases, trees remain canker free even after more than 10 years of heavy scale feeding, suggesting resistance to the canker fungus. In other cases, only restricted canker growth is observed on infected trees, suggesting that they are *disease tolerant*. Such trees often survive for many years with only superficial damage. Although not well documented, disease tolerance is probably related to tree vigour and environmental conditions at the time of infection. Trees exhibiting tolerance during an initial infection phase may succumb to subsequent infections if they are subject to other stressors such as drought, insect defoliation, or root disease (Figure 11).

Figure 10. *The canker-free tree on the left is resistant to beech scale. The tree on the right is heavily diseased.*

Figure 11. *Older, inactive cankers on the right side of this beech tree did not penetrate through the living bark. A more recent infection on the left side produced active cankers that grew through the inner bark to the cambium.*

Managing Beech Bark Disease

In stands where beech is the dominant tree species, recommendations in Ontario's silvicultural guide for tolerant hardwoods are to retain them for nut production. However, because of its generally low timber quality, beech is usually marked for removal in improvement cuts, except for a few large stems retained as mast trees. Managing diseased beech stands requires some additional considerations.

How best to minimize BBD depends on the density of beech in the affected stand and the phase of the disease. Where beech forms a minor component, the effects of BBD on the overall stand will be limited because dead beech will usually be replaced by other tree species. Where beech is a major component of the stand and trees are heavily affected by BBD, management can be challenging. Removal of infected trees can result in prolific root sprouting, causing susceptible, low-value trees to regrow.

As the disease has existed for only a short period in Ontario, its long-term effects on stand composition and ecosystem function remain unknown. However, observations from other jurisdictions indicate that the effects will be variable. In parts of North America where BBD has been present for more than 50 years, tree- and stand-level effects of the disease and associated management practices vary. For example, harvest regimes can contribute to stands remaining highly susceptible to the disease. In Maine, harvest intensity, ranging from light partial harvest to clearcut in aftermath forests, did not affect subsequent stand composition: susceptible beech remained the main component. In addition, most of the potentially resistant trees retained in the clearcuts failed to survive. In contrast, in a forest in New Hampshire, single tree selection (removal of poor quality, diseased beech) over 50 years substantially improved the disease resistance and timber quality of forest stands.

Promoting retention of potentially resistant beech through gradual and selective removal of defective, diseased trees, plus suppression of susceptible beech regeneration might prove the most effective, long-term management approach.

Management Guidelines for Beech Bark Disease

<table>
<tr><th>On the advancing front</th><th>On the killing front</th><th>In the aftermath forest</th></tr>
<tr><td colspan="2">Identify, mark, and retain potentially resistant trees (nil or low scale, smooth bark).</td><td>Identify, mark, and retain resistant trees and their offspring.</td></tr>
<tr><td>Mark these trees for removal:
• large, overmature
• with rough bark
• low vigour
• with decay
• with other defects
• heavily infested trees in high-use areas (campgrounds, etc.)</td><td colspan="2">Mark these trees for salvage:
• dead and dying
• with sunken lesions
• with patches of dead wood</td></tr>
<tr><td rowspan="2"></td><td>Prioritize harvest of heavily scale infested and cankered trees. Consider mechanical stem girdling or basal bark herbicide applications to pole-size trees to reduce root sprouting.</td><td></td></tr>
<tr><td colspan="2">Consider treating root sprouts (e.g., herbicides, mechanical stem girdling, motor-manual cutting) to decrease susceptible beech in the future stand.</td></tr>
<tr><td colspan="3">Retain some large trees for wildlife food and habitat.</td></tr>
<tr><td colspan="3">Do not transport firewood or logs during the scale's crawler stage (midsummer to late fall).</td></tr>
</table>

Many questions remain about how best to manage BBD-affected stands in Ontario. For example:

- What are the effects of BBD on stand and ecosystem traits, such as stand species composition and structure, vertebrates and non-vertebrates associated with coarse woody debris, and cavity nesters, in stands where beech is a primary species?
- Will beech thickets develop from dense root sprouting around BBD-killed trees, as observed in other areas? And, if they occur, how will they affect regeneration of other shade tolerant tree species as well as stand management objectives?
- How can survival and growth of disease resistant regeneration be promoted given that it may be competing for resources with dense root sprouts arising from BBD-killed trees?
- How will BBD influence biodiversity objectives in forest management plans?
- Will BBD management require more frequent stand monitoring or harvest entries?

It may be up to a century before the long-term effects of BBD on Ontario's hardwood forests are realized. If, as is suggested in climate projection scenarios, environmental conditions that favour the scale insect and the disease and stress the host tree become more prevalent, recurring waves of the disease might occur. Continued monitoring of the disease and ecosystem change is needed to effectively tailor management actions for beech bark disease at the stand- and landscape-level.

Instructions for Tree Markers

In diseased stands, mark smooth-barked trees with little or no scale with a **B** in blue paint.

Report the UTM location along with a brief geographical description of the site to:

- Dan Rowlinson (OMNR field operations coordinator, Sault Ste. Marie) Office (705)946-7445 or email dan.rowlinson@ontario.ca
- John McLaughlin (OMNR forest research pathologist, Ontario Forest Research Institute, Sault Ste. Marie) john.mclaughlin@ontario.ca

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Résumé

Cette note donne un aperçu de la maladie corticale du hêtre en Ontario, son histoire, sa biologie, ses effets sur les hêtres ainsi que les peuplements et émet des recommandations concernant la gestion des peuplements de hêtre infectés. Le hêtre est un arbre important pour la faune et son bois entre dans la fabrication de nombreux produits. La maladie corticale du hêtre est relativement nouvelle en Ontario. Elle a été officiellement reconnue en 1999, mais s'est répandue dans l'ensemble de la zone d'occupation du hêtre dans la province, causant la détérioration ou la mort des arbres. Un faible pourcentage de la population résiste à la maladie. On recommande d'enlever les arbres atteints, de minimiser la régénération des arbres non résistants et de maximiser celle des arbres résistants.

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