Management Options for Tolerant Hardwood Forests Impacted by Beech Bark Disease

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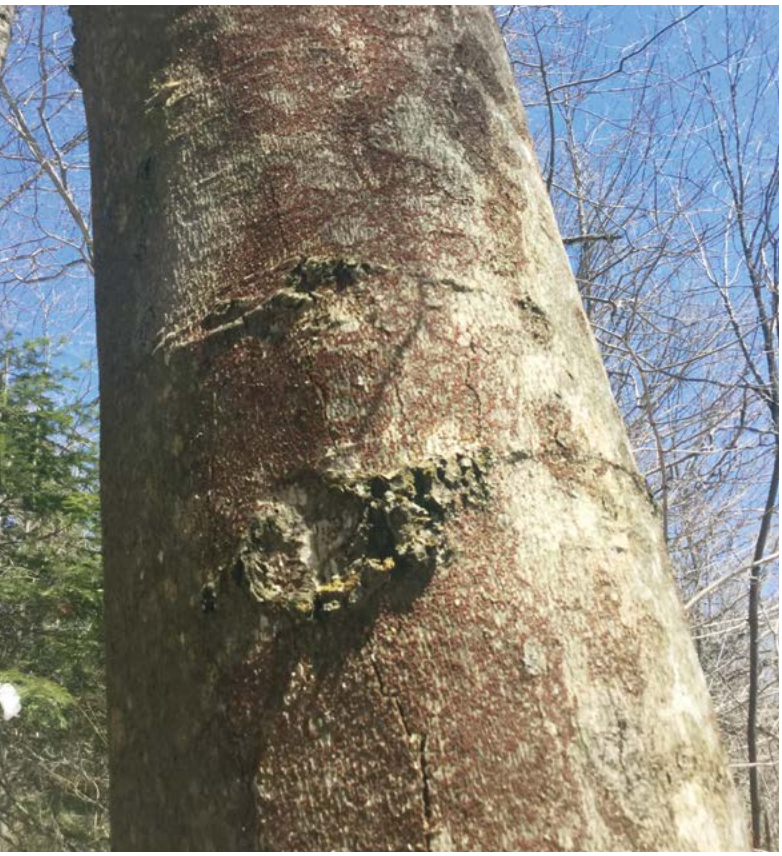
Below: Beech scale insects, a precursor to successful infection by the pathogen that causes beech bark disease, are identified by the white waxy covering visible on the smooth beech bark. Beech leaves in photo for identification.



Above: When successfully infected, beech bark disease that kills the inner bark of the tree give rise to red fruiting bodies, often in pear shaped groups but can be so plentiful they cover large portions of the stem of the tree as in the photo.

Overview of Beech Bark Disease and its Pathways

American Beech is commonly found in the Great Lakes-St. Lawrence Region in forests dominated by sugar maple and other shade-tolerant hardwood species. It is easily identified by its smooth gray bark. Beech is highly valued for its contribution to wildlife habitat, in particular providing mast (hard fruit i.e., beechnuts) as an important fall food for many species, having more nutritional content for wildlife than even red oak acorns. Black bears leave claw marks in the thin smooth bark of the tree when they climb into the crowns to forage for beechnuts on the branches. Beech directly and indirectly contributes to biodiversity. It is not considered a particularly high-value tree for wood products, though it makes for excellent firewood.

Beech bark disease (BBD) has been present for a century in eastern Canada although entry into Ontario has been much more recent. It was first confirmed in the Muskoka area in 2010. Two different organisms lead to BBD, which only affects American beech: a beech scale insect and a *Neonectria* pathogen (normally *Neonecria faginata*). The scale insect feeds by inserting feeding tubes into the outer bark cells allowing the pathogen to enter and become established. The infection can go as deep as the cambium layer. The pathogen causes death to the cells and as more cells are killed, branches and finally whole sections of the tree weaken and die. The lag time between scale infestation and appearance of fungal infection varies from 2 to 5 years, however, local observations suggest the shorter time periods are more common.

Individual scale insects are difficult to see, however, they cover themselves with a white waxy coating which is easily spotted, especially when populations increase. It is not uncommon to see large sections of beech tree trunks covered in white. The scale spreads when the tiny crawler stage travels via wind currents or attached to wildlife. Spread can be assisted by the movement of firewood, especially during the crawler stage, in mid-summer to late fall. In the fall, the pathogen produces small, bright red fruiting bodies called perithecia, which erupt through the bark. Initially, these occur in lemon-shaped clusters, but as the infection progresses, they coalesce into large, sunken areas on main branches and the bole of the tree.

Beech trees can be killed directly by BBD. However, mortality is more often caused by secondary pathogens successfully attacking the trees already weakened by BBD.

There is some evidence to suggest that a very small portion of beech trees might be resistant to the scale insect (1-4%), and therefore not affected by the *Neonectria* canker fungus (McLaughlin and Greifenghagen, 2012). It is believed that some trees may be susceptible to the scale insect, but resistant to the fungal *Neonectria* pathogen. The extent of which is unknown but observational evidence suggests that any resistance or tolerance is minimal.

Left: Beech bark disease causes death of the inner bark of the tree choking off the movement of food up and down the tree causing the dieback of branches and eventual death of the tree in many cases.

Above: Beech thickets form in the understory of dead and dying beech due to increased growth supported by additional light and resources provided by the roots of the mature trees from which a majority of young beech develop. Other trees and plants are shaded out from these beech thickets.

Long-Term Impacts of BBD

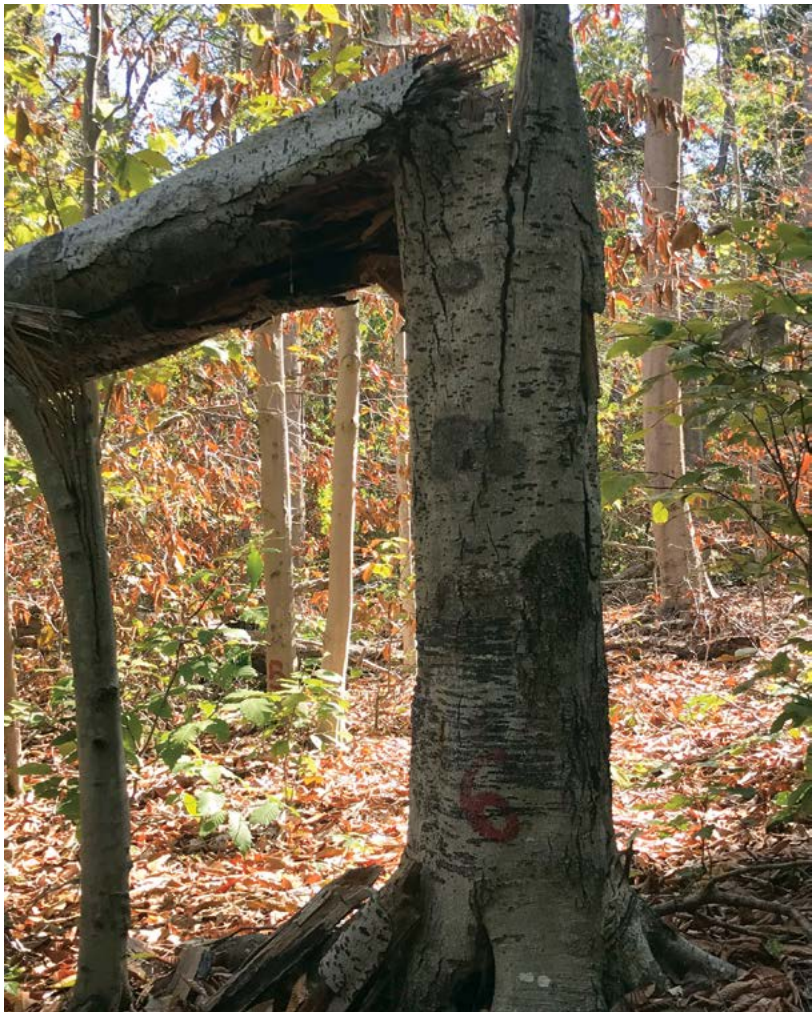
BBD kills a majority of American beech trees across the forest landscape where it is present and is therefore a threat to local forest biodiversity. The loss of a major component of the tree canopy has forest management and wood supply impacts in managed forests. The loss of beechnut production, which has a high caloric content, will have an impact on wildlife. Mature beech trees often provide high-quality cavities for bird nesting and animal denning.

“Beech snap” is a term that describes how large branches or whole mature beech trees break off at the stem – even before it is obvious that they are dying. Beech trees in the forest often grow in clusters, so mass mortality due to BBD results in a large hole in the canopy, affecting cover for wildlife and increasing light levels below.

BBD is unique in that the disease that kills its host also contributes to the successful germination and proliferation of a second generation of the host. Therefore, as mature trees are killed, beech regeneration tends to proliferate in a vigorous manner, sometimes called beech jungles or beech thickets. These young beech seedlings and saplings often originate from root sprouting. The host root provides resources to the beech saplings to take advantage of the additional light from the parent beech trees dying.

Because these saplings have the same genetic makeup as the parent trees from which they sprout, they will not have genetic resistance or tolerance to beech scale or the fungal pathogen. They tend to dominate the understory and eventually the midstory of tolerant hardwood stands where BBD has caused damage to the overstory. They outcompete most other species including sugar maple, yellow birch and other species that should be forming a large part of the future forest canopy. The expectation is then that the young beech trees will not allow other species to mature but will be killed themselves by BBD before they contribute to the mature forest canopy cover that is typical of the Great Lakes St. Lawrence Forest Region shade-tolerant hardwood forests. It is expected that there will be a short period of time in which the second generation of beech trees become sexually mature and produce beechnuts before succumbing to the BBD themselves. In addition to outcompeting other tree species, they also shade out other forest plants, leading to a reduction in species richness.

Left: The death and dieback of mature beech trees represents a loss of mature tree cover, wood supply and beechnut production for wildlife. A second impact of beech bark disease is the beech thickets that shade out other plants and young trees. Because beech leaves fall much later in the season, the dense beech understory shows up well in this winter photo.



Right: Trees affected by beech bark may exhibit “beech snap” a potentially dangerous situation in which large branches or whole stems snapping, even well before the tree is killed.

Top: Brush saw treatment of young beech saplings up to 8–10 cm in diameter by a worker with safety gear.

Second: Young beech felled by brushsaw or chainsaw show immediate results although this can be a slow, labor intensive treatment.

Third: When young beech are controlled by cutting, resprouting often occurs with the new sprouts taking advantage of the established root system. A herbicide application to the cut stump can greatly reduce resprouting.

Bottom: Young beech trees treated the previous year by a stem specific treatment – basal bark treatment – where the leaves flushed in the spring but the young trees died soon after.

Beech Bark Disease Treatment Options

What can be done?

Prevention:

- **Do not transport firewood.**
  Do not transport beech firewood or logs from infested stands to un-infested areas between mid-summer and late fall to prevent beech scale from becoming established in new areas.

- **Minimize root injury.**
  Use harvesting systems or locate recreational trails to minimize injuries to beech root systems. Root injury can cause extensive root sprouting, especially if roots are injured in spring.

- **Remove BBD-impacted overstory.**
  At the forest level, there are no effective treatments against the scale insect nor the *Neonectria* pathogen. Most treatment options are for horticultural and urban trees. In an urban context, through tree hazard assessments, a beech tree may need to be removed. Forest management efforts may be in opposition to long-standing objectives that maintain and even increase beech in stands, by targeting most beech trees for removal. Salvage of BBD-impacted trees is an option to retain some of the value before they become hazardous trees. However, due to the quick decline of the trees, there is little time before the wood has no economic value.

- **Remove beech understory.**
  The more significant, and perhaps not as obvious, approach is to deal with the secondary impact: that of the abundant and vigorous beech understory – ideally in combination with overstory beech removal. If beech trees are left, they will produce root shoots (and beechnuts for seed) before they die. Understory beech removal may be accomplished through a number of possible treatments – although most are not fully successful, and all come with financial costs. Note that any techniques using herbicide will require a pesticide applicator license through the province.

Table 1 Treatment options for BBD

TREATMENT	PROCEDURE	APPROPRIATE STAND CONDITION	PROS	CONS
Brush Saw and/or Chain Saw Not Followed by Herbicide	Using a motorized brush saw with a circular blade, chain saw, or other cutting device, cut the plant off above the ground.	Beech trees >1 m in height. For trees >8 cm diameter, chainsaw will be required as well.	• Immediate results • Clear differentiation between cut vs. uncut stems • Only target trees are affected	• Can be costly • Stems can resprout after a few years requiring re-treatment • Not practical for beech <1 m in height • Workplace hazards such as noise levels and exhaust exposure
Brush Saw and/or Chain Saw Followed by Herbicide	Follow the same procedure as above, then apply an herbicide (glyphosate or triclopyr) to the cut stump to control resprouting.	With herbicide application, beech saplings should be >2 m tall.	• Immediate results • Clear differentiation between treated vs. untreated stems • Only target trees are affected • Herbicide controls resprouting	• Cost is even higher for the two separate treatments • Not practical for beech <2 m • Workplace hazards such as noise levels and exhaust exposure • Herbicide licensing required
Basal Bark Treatment with Triclopyr	Apply Triclopyr, or "Garlon", as ~30% solution in non-petroleum oil (e.g. mineral or vegetable oil). Using a backpack sprayer, apply a small amount of product to individual stems of small trees, spreading around and letting it soak in through the bark, which will choke off the tree. This can be done as a streamlined orone-sided method of spray. In both cases, very little of the product is used, so only target trees are sprayed.	Stems should be >2 m tall so that density is not as high and individual stems are easier to treat.	• Usually cheaper than brush saw treatment • Treated stems do not resprout • No high noise levels and exhaust exposure • Only target trees are affected	• Results can take several months • Target trees may be missed • Aesthetics of dead leaves • Trees >20 cm in diameter not effective or desirable to treat • Herbicide does not translocate (move) into root system, often a pathway of transmission between trees • Herbicide licensing required
Hack N' Squirt	Make one or more slight cuts to the outside of a small beech tree with a hatchet, making a small "cup" with the cut. The number of cuts is determined by the size of the tree. A very small amount of concentrated (50-100%) glyphosate is then sprayed into the cut. The herbicide moves down and into the root system, killing the tree.	Best for beech trees >6 cm in diameter.	• Very little herbicide is used • Clear differentiation between treated vs. untreated stems • More results immediate than basal bark method • Potential to control small beech on same root system • Cost is comparable to basal bark treatment • No special equipment required • No high noise levels and exhaust exposure • Only target trees are affected	• Aesthetics of dying young trees may be a concern • Herbicide licensing required • While it can be effective, not desirable to use for stems >20 cm in diameter • Few stands have the size class of young beech applicable for this treatment
Cut Stump Treatment	During timber harvesting, treat stumps of mature beech trees with a concentrated glyphosate herbicide shortly after the tree is cut. The herbicide will move through the roots of the felled tree and smaller beech stems attached to the root system will subsequently be treated.	Stands with mature beech trees that are to be harvested, with some natural regeneration taking place around the mature stems.	• Highly targeted technique with relatively few trees having to be treated • Cost would generally be low compared to other methods • Only target trees are affected	• Only applies to trees harvested in a logging operation • Treatment having to take place occur shortly after the tree has been felled may pose safety concerns with ongoing logging operations • Most or all mature beech would need to be cut
Broadcast Spray of Herbicide	Apply a concentrated solution of herbicide (most often glyphosate) on foliage of beech trees using either a backpack sprayer or a sprayer mounted to a piece of equipment. Target trees, along with their root systems, are killed. Large equipment is typically used for large areas of continuous beech, whereas targeted backpack spraying would be appropriate for smaller patches.	Beech <2 m in height, <1 m optimal. Areas or patches where there is not a lot of non-target surrounding vegetation would be more appropriate.	• This treatment could be cost-effective depending on equipment, height of beech and distribution of beech in the stand • Results are normally seen within a few weeks	• Must be done on the ground, not from the air (e.g. helicopters) • Non-target trees and plants are affected • Only effective when foliage is green and trees actively growing • Restrictions for using close to water • Workers shouldn't spray above their heads • Requires more volume to carry into the stand, can be expensive • Most controversial treatment for BBD

COMMENTS

- Late spring or early summer ideal to reduce sprouting.
- Winter conditions not practical for this treatment method.

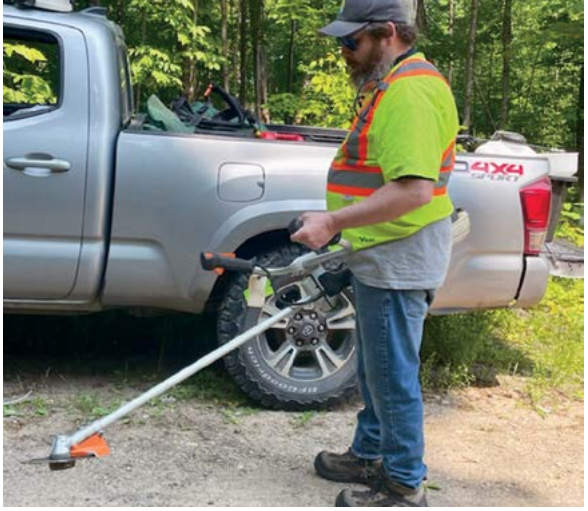
- Both glyphosate and triclopyr can be used.
- Must be snow-free season application.

- Triclopyr is herbicide used. A dye can help applicator identify trees they have treated.
- Can be applied almost year-round. Winter conditions not practical for this treatment method.
- Stems must be dry to be effective so rain, frost and dew must no longer be present.

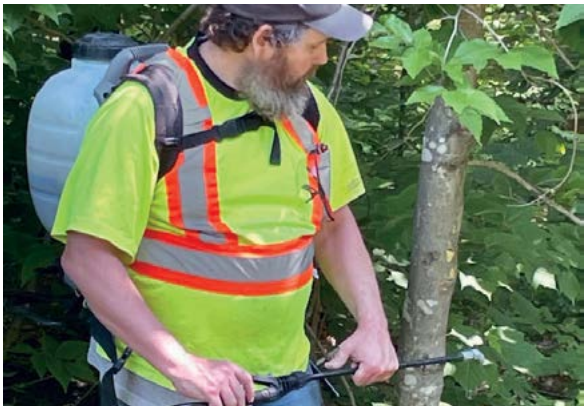
- Recommendations are variable and dependent on applicator licensing.
- Few weather restrictions, but best done in growing season.

- Mainly associated with a logging operation or a tree removal.
- Should carry out during the growing season only.
- Ongoing research for effectiveness on young beech stems attached to the root system located far from the cut stump.

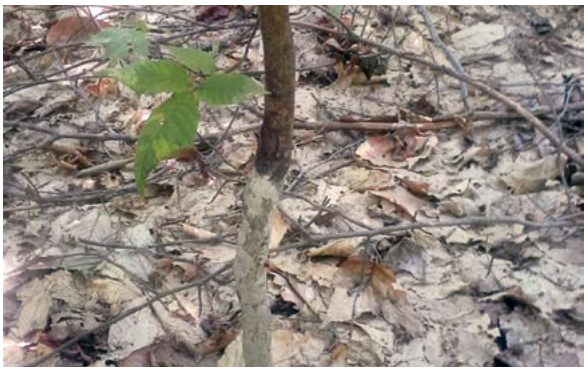
- Some non-target tree species are quite tolerant of the herbicide, in particular sugar maple.



Brush saw used to mechanically cut small beech. Note: safety equipment and operator training highly recommended.



Basal bark treatment applies a small amount of appropriate herbicide to the stem of a beech tree. Safety equipment and pesticide licensing required.



Beech sapling stem shortly after a basal bark treatment.

Hack and squirt involves making small cut(s) around the tree with a hatchet, generally one cut per 5 centimeters of diameter with a small amount of herbicide applied to each cut.

Cut stump treatment in which an appropriate herbicide is applied around the perimeter of a mature stump shortly after the tree is felled, normally in a timber harvesting operation. The blue in the photo is from a dye used to show to workers which stems have been treated. A similar approach can be used after brushsaw treatment to prevent sprouting.

Regeneration and Tree Planting

The overall objective is to reduce the amount of beech in the understory and mid-story so that other species of trees may be in a more competitive position to grow and form part of the mature forest canopy. However, the reduction of beech understory may also result in increased plant diversity of non-woody species such as ferns.

There are two broad conditions encountered in beech regeneration control projects:

1. There may already be healthy young non-beech trees (e.g. maple) growing among the beech. This is the optimal condition so that the beech control acts as a tending treatment, thus releasing the established desired species of tree from the beech competition. This increases the chance of success and decreases the time for these non-beech trees to dominate the stand.
2. There are few healthy, young non-beech trees among the beech that are removed. In this situation, the beech removal acts as a site preparation treatment so that a new crop of young trees must be established. While these new trees are being established, new beech seedlings may also be becoming established, especially when there are larger beech trees still remaining in the stand.

Tolerant hardwood forests are very well-suited to natural regeneration. The number of tree species that can be found is relatively large compared to other forest types in Canada. In addition to beech, sugar maple, yellow birch, red oak, black cherry, basswood, red maple and white ash are hardwood trees typically found in tolerant hardwood stands. Some conifer trees may be found in these stands, with eastern hemlock being the most common. White spruce, white pine and red spruce are often associated species. While these associated species share many attributes in requirements for light conditions and soil conditions, each have different growing conditions for which they are better suited or are better able to be competitively successful.

All trees can be either planted or naturally regenerated depending on the suitability of the site and availability of seed trees. In Canada, most regeneration efforts of tolerant hardwoods are accomplished through natural regeneration, while artificial regeneration is quite common in conifer tree planting efforts.

The pros of artificial regeneration over natural regeneration:

1. If timed correctly, planted trees may have a competitive advantage over new beech seedlings.
2. The need for specific soil exposure conditions that some species require is normally negated (e.g. yellow birch seed).
3. It removes the unpredictable timing of seed crops.

The cons of artificial regeneration over natural regeneration:

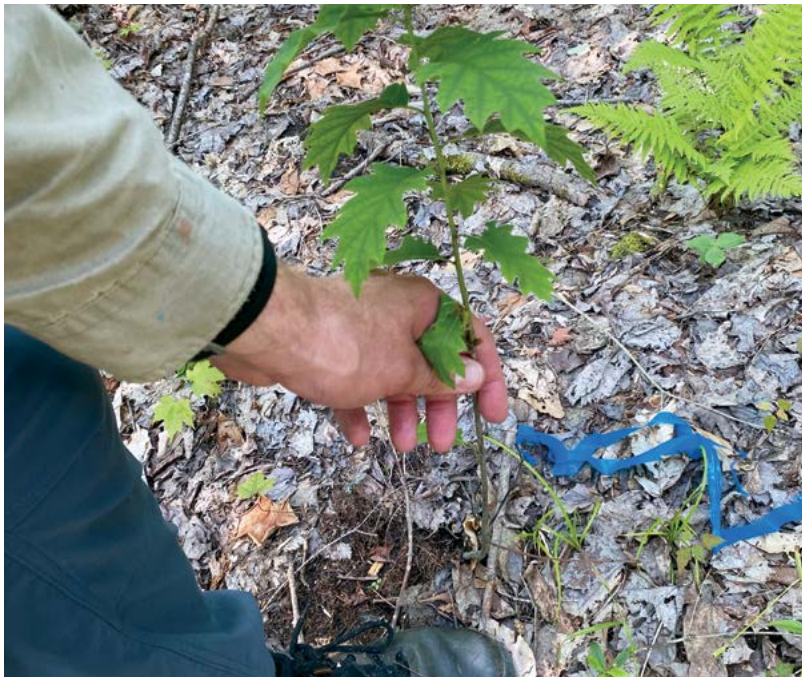
1. Not all species are commonly found at tree nurseries, so seedling availability can be a limiting factor.
2. Planting stock and planting of that stock represents a significant financial investment. If planting hardwood species, these often cost more to produce and have lower probability of survival due to various factors, including browsing by animals such as deer.
3. Hardwood species naturally germinate in the range of thousands of trees per hectare, which significantly increases the probability of enough trees surviving to maturity.

Tree planting can be done to augment natural regeneration. However, natural regeneration may aggressively out-compete planted trees. For example, naturally regenerated sugar maple may shade out a planted oak tree. Refer to Appendix 1 for a list of tree species that can be used for supplemental planting/regeneration efforts.

Monitoring

Tending of the planted or naturally regenerated trees may be required. This may involve control of future beech, less desirable trees over planted trees, or non-woody vegetation including grasses, raspberries, and other herbaceous plants. As with any forestry-related activities, professional foresters and other forestry consultants are good resources to assist in deciding how to proceed. There are potential tending options using manual, mechanical and chemical tending.

Below: A brush saw treated area planted to a variety of suitable species to provide more certainty of successful regeneration of non-beech tree species such as this oak planted in a sunny area.



Above: An area where the control of beech regeneration is being successfully regenerated naturally to sugar maple.

References

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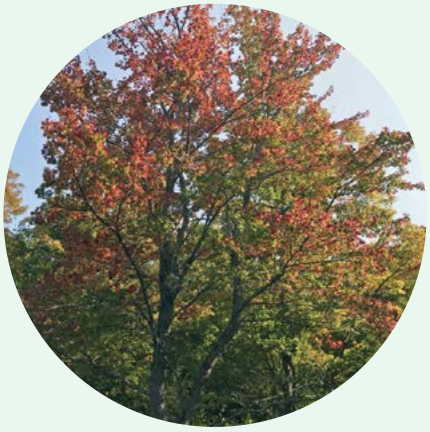
Appendix 1

List of tree species that can be used for supplemental planting and regeneration efforts after beech removal.

Sugar Maple is typically the most common tree in the forest and are well suited to natural regeneration because they: 1) are quite shade tolerant meaning they can establish and survive in relatively low light situations for a fair amount of time and are able to respond to the provision of more light from harvesting or decline/death in the overstory of individuals or small groups of trees. 2) Sugar Maple stands produce abundant amounts of seed every 4 to 7 years, 3) Sugar Maple seed is quite large so when they germinate there is enough energy provided to the root radical to penetrate the leave layer into the soil below.

Yellow Birch needs more light to persist in the understory and its seed is very small so needs some sort of disturbance on the forest floor to have its root radicle be successful in reaching soil. It does have the ability to grow quite quickly, light requirements may be well suited to large gaps created by several dead, dying or salvaged groups of Beech and is a high-quality sawlog producing tree.



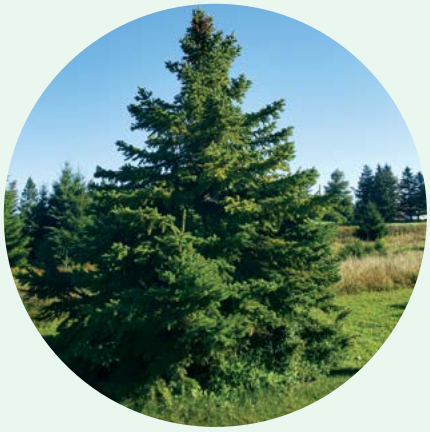
Red Maple is competitive in a variety of light conditions and although it is often regarded as a less economically valuable species. It can also be susceptible to browsing from deer and moose.

Red Oak has even a larger seed than maple but acorns are preyed on heavily by many wildlife species. In addition, Red Oak seedlings are very susceptible to browsing from deer and multiple browsing events can make red oak unsuccessful in getting above 2-3 meters. Red Oak also needs more light than maple and Beech but larger openings created by the removal of groups of Beech may be well suited to oak.

White Ash has light requirements that would be satisfied in canopy gaps created by small and large groups of Beech being removed in the overstory. It can grow quite quickly and regenerates well by vegetative methods. Its seed is larger than that of birch so has some energy to assist its root radicles in reaching the soil through light leaf layers. However, due to the spread of emerald ash borer in Ontario- an effective killer of ash trees, it may be ill advised to put much effort into ash regeneration.

Eastern Hemlock plays a significant ecological role where it is found in tolerant hardwood stands, both for cover for deer in winter and in providing unique habitat for some specific migratory birds such as the blackburnian warbler. Hemlock sites vary from shallow sites with perched water tables to much more moist conditions. Hemlock seed is only successful if established on exposed soil and sometimes on old logs as the seedlings easily get smothered by the following year's leaf fall. Hemlock is also very susceptible to browsing. Hemlock is quite shade tolerant. It may be difficult finding nurseries that sell eastern hemlock.

White Pine is often found in tolerant hardwood stands, but normally only as scattered individuals. The seed requires a disturbed site to establish on soil and requires a moderate amount of light to be successful. Hardwood overstories, midstories and understories usually provide too much shade for the successful regeneration of white pine unless management activities occur to provide the necessary light conditions. White Pine seedlings are commonly available at nurseries.



White Spruce is not commonly found within tolerant hardwood stands but is sometimes found in certain parts of these stands. White Spruce is somewhat more shade tolerant than White Pine and is commonly available from most tree nurseries. Establishing White Spruce in pockets where Beech occurred is most likely more desirable than maintaining Beech.

Red Spruce is not commonly found in Ontario but where it occurs, can be found in association with tolerant hardwoods. While difficult to find as planting stock from nurseries, it is quite shade tolerant and possibly a good choice in replacing Beech.

Front and back cover: Aerial view of a hardwood forest with canopy gaps with efforts to control abundant beech understory so that other species may survive and fill in those gaps.

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