Beech Leaf Disease & Experimental Management Options

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Quick Facts

- Beech leaf disease (BLD) is a new disease to the United States; scientists have been working quickly to understand its pathogenesis and test treatment options to mitigate or control damage.
- BLD affects beech (*Fagus* spp.) tree species and has not been shown to infect any other genera. This disease poses no direct harm to humans.
- BLD causes rapid decline and mortality of American beech (*Fagus grandifolia*) and European beech (*F. sylvatica*); mortality can occur between 2 to 10 years depending on size. BLD has also been reported to impact Oriental beech (*F. orientalis*) and Chinese beech (*F. engleriana*).
- BLD is caused by an invasive nematode *Litylenchus crenatae* subsp. *mccannii* (*Lcm*; Figure 1). A nematode is a microscopic roundworm that cannot be seen with the naked eye.
- BLD is recognized best by opaque banding of diseased leaf tissue (Figure 2).
- Infection occurs in the leaf buds. *Lcm* does not infect woody tissue.
- Primary damage to leaf tissue occurs in the bud stage.
- Highly infected and damaged leaves become thickened, distorted, prematurely shed, and branch dieback ensues. Decline and mortality follow.
- Current treatment options are very new and considered experimental; adverse impacts are not yet known. Treatment options may change and improve in coming years.
- When treatment is not an option, mitigation steps are key to reducing negative environmental impacts from beech losses.

Figure 1. The beech leaf disease causing nematode *Litylenchus crenatae* subsp. *mccannii*, a foliar feeding microscopic roundworm. Photo Credit: Sabrina Tirpak, Rutgers Plant Diagnostics Laboratory.

Figure 2. Symptomatic beech leaves afflicted with beech leaf disease. These photos are taken against the light sky to show the opaque banding of diseased leaf tissue, an indicative symptom of BLD. Photo Credit: Jean Epiphan, Rutgers Cooperative Extension.

Pathology

Causal Agent

Beech leaf disease (BLD) is caused by an invasive nematode *Litylenchus crenatae* subsp. *mccannii* (*Lcm*; Figure 1). Nematodes are microscopic roundworms. Most nematodes are free-living, but some are parasites of animals and plants. Most plant parasitic nematodes live in soil moisture films and feed on plant roots. The nematode that causes BLD is unique in that it is found in the foliage of a tree rather than in the roots. This *Lcm* nematode is closely related to *Litylenchus crenatae* subsp. *crenatae* from Japan that causes galls in leaves of Japanese beech (*Fagus crenata*). The BLD-causing *Lcm* subspecies differs from *Lcc* in morphology, DNA, and host range. We assume that the BLD nematode is not native to North America. However, a Connecticut Agricultural Experiment Station researcher has partnered with USDA-ARS, USDA Forest Service, and researchers from Japan to determine the exact origin of the beech leaf disease nematode, *Litylenchus crenatae mccannii.*

Disease Distribution

In the United States, BLD was first discovered in 2012, in Cleveland Ohio. Since that time, the disease has spread from Michigan to Canada, Maine and south to Virginia (range as of Dec. 2023; Figure 3).

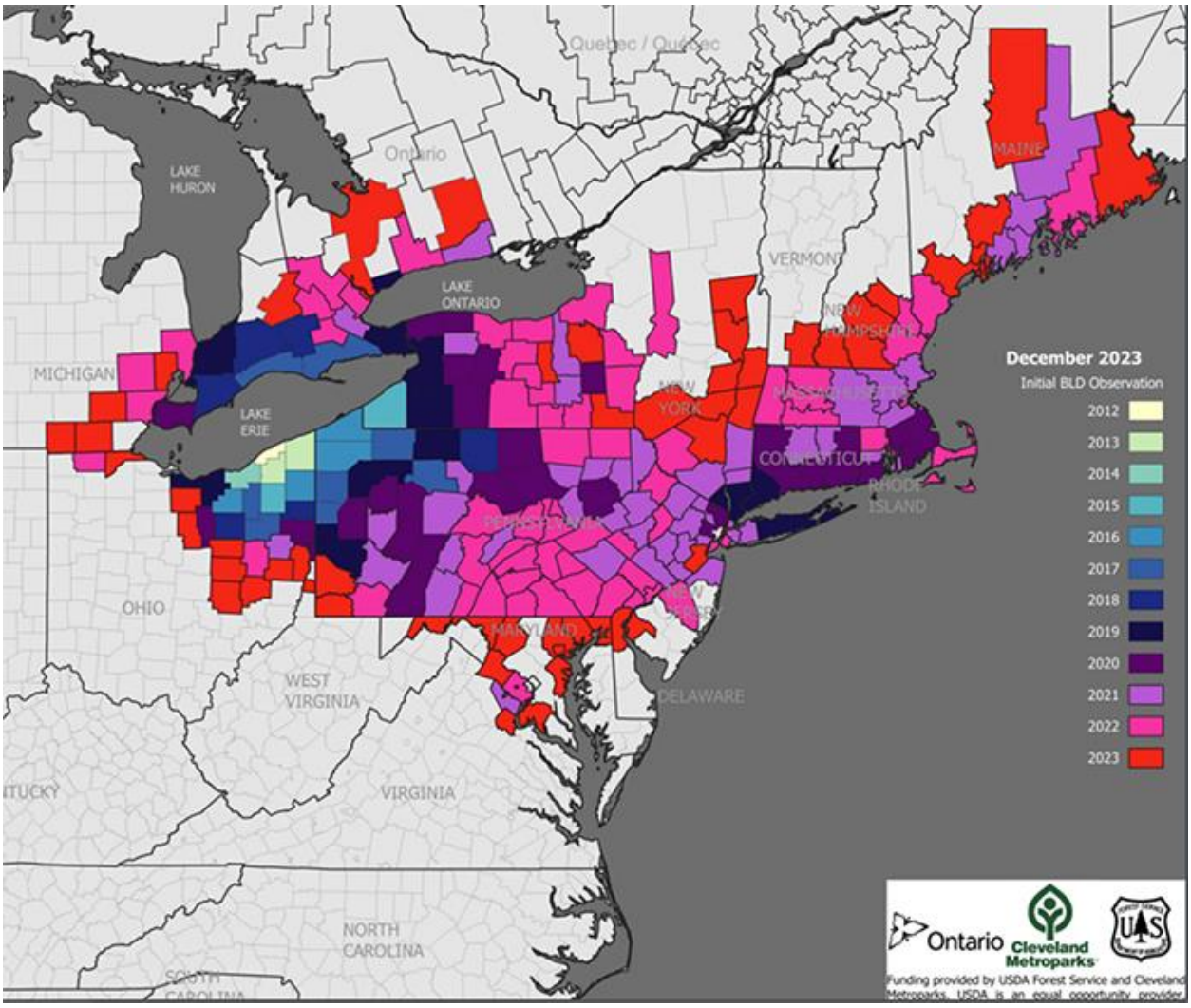

Figure 3. Beech Leaf Disease Range in North America as of December 2023. Credits: USDA Forest Service and Cleveland Metroparks.

Infection and Life Cycle

The *Lcm* nematode only infects beech species (*Fagus* spp.) and is limited to the leaf and leaf bud tissue. To date, the nematode has not been found in beech tree roots, trunks, or other woody tissue. The nematode overwinters in infected buds. In late-winter or early-spring, eggs are laid in the infested tissues and are moved within the leaves as they expand in the spring. Eggs have been shown to persist in aborted buds. Juvenile nematodes are found in symptomatic tissues by mid-summer and adult populations build within the mesophyll cells into the fall. As the season progresses, adult nematodes exit the leaf tissue and migrate to next year's leaf buds. So far, the most active movement of nematodes and infection are thought to occur from mid-summer to early fall. This is also the time that abiotic and biotic vectors may facilitate infection and spread.

Vectors

Recent research out of Penn State University has proven some transmission pathways during the second half of the growing season, when adult nematodes migrate. Wind, humidity, and precipitation have been shown to spread the *Lcm* nematode at least 38 feet from infected beech trees. Rain can flush high numbers of Lcm nematodes down to lower canopy levels. The native beech blight aphid (*Brylloprociphilus imbricator*) has been shown to carry live *Lcm* nematodes and disperse them. Furthermore, live *Lcm* nematodes can survive being passed through the digestive tracts of the white-marked tussock moth (*Orgyia leucostigma*) caterpillars found on American beech. Therefore, the excrement can disperse the nematodes. In addition, live *Lcm* nematodes have been recovered from spider webs in the lower canopy. As numerous species of wildlife utilize beech for habitat resources, the BLD vector pool has the potential to be very large.

USDA Forest Service pathologists found that several species of birds that eat beech buds can carry the *Lcm* nematode DNA in their plumage. These birds have the potential to carry the *Lcm* nematode long distances. Additionally, the movement of plant material by humans, particularly in asymptomatic nursery stock is also suspect. It is feared that BLD will spread throughout the full range of American beech and European beech in the United States and Canada.

Symptoms and Damage

BLD infection in leaves is recognized by banding of leaf tissue (Figure 2). When held up against a light source like the sky, the infected "bands" between the parallel veins appear opaque against the translucent unaffected tissue. The opaque leaf symptom of BLD helps to differentiate it from other beech leaf damaging agents. The infected banding can become thickened, hardened, and sometimes discolored or yellowed. The progression of leaf symptoms can be rapid from one year to the next (Figure 4). Highly infected leaves become malformed, thickened, shriveled, and shed. Defoliation generally occurs from the lower canopy and moves upwards (Figures 4 and 5). As the infection continues to progress, subsequent leaf buds can appear smaller, stunted, diminished, or may be aborted. Ultimately, crowns thin and branches begin to die back, leading to a rapid decline of the tree. Mortality can occur within 1 to 2 years in small saplings and in 6 to 10 years in larger mature trees.

Yale researchers found that thickened infected leaves have increased mass while they have decreased photosynthetic ability, stomatal conductance, and stomatal density. Therefore, infected leaves require more resources to sustain their mass, but have decreased function to photosynthesize and produce those resources. This dysfunction contributes to the mechanisms that cause rapid tree decline and demonstrates how affected beech essentially become starved of photosynthetic resources.

Figure 4. Visual difference between beech leaf disease infection from 2021 with <1% infected leaves (top), to 2022 with >50% infected leaves in the lower canopy (bottom), within the same American beech forest of Morristown National Historical Park, NJ. Photo Credit: Jean Epiphan, Rutgers Cooperative Extension.

Figure 5. Advanced beech leaf disease progression exhibited as defoliation of beech leaves, which usually occurs from the lower canopy upwards. Photo Credit: Colin Milde, Ramapo Tree & Shrub Care LLC.

Foliar Microbiome

USDA Forest Service, Penn State, and Holden Arboretum researchers found microbial differences between BLD affected leaves and unaffected leaves. Mites have been found intertwined with the *Lcm* nematodes in leaf tissue. Fungal communities and bacterial taxa differ between affected and unaffected leaves. One of the isolated bacterial genera found in affected leaves, *Wolbachia* sp., is a known nematode endosymbiont. Microbial co-factors may be contributing to BLD virulence by facilitating *Lcm* nematode feeding, reproduction, survival, or fitness.

Impacts

Ecological and Environmental

American beech is a common tree that is native to several forest types throughout its range from northern Florida up the East Coast to Southern Quebec and inland to the Mississippi River Valley. It is found in uplands and lowlands, in private yards, parks, conserved forest land, riparian forests, and inland seeps. American beech help maintain forest health, ecosystem functioning, habitat provision, and wildlife resources. The loss of these trees throughout its range will facilitate decline of forest quality, ecological function, populations of flora and fauna, and overall biodiversity.

American beech provides abundant resources for wildlife such as larval hosting for hundreds of species of beneficial insects that are essential parts of the forest food web. Beech nuts, a wildlife superfood, are sought-after by numerous forest mammals and birds. Beech provide vital nesting sites and shelter. Furthermore, an obligate epiphytic plant of beech, beech drops (*Epifagus virginiana*), provides floral resources to forest bees and ants. Without American beech as a resource, several wildlife and plant populations will be stressed, decline, or become extirpated.

As American beech leaves fall year after year on the forest floor, they create habitat for overwintering animals and insects, but that is not all. Beech leaves are high in lignan, which slows their decomposition and allows them to accumulate. This process also sustains soil quality and health for forest plants. This thick, tough leaf litter protects soil from erosion and drought. It helps inhibit the germination and infiltration of weeds and invasive plants into beech forests. Invasive worms that destroy forest soil quality, like the jumping worm (*Amynthas agrestis*), are suppressed by beech leaf litter. Without beech in our forests, soil and ecosystem health is at greater risk of degradation and mesophication.

Mature beech often develop abundant root sprouts that grow into stands of saplings (Figure 6). This dense, clonal growth habit provides many ecological services. The deep shade created helps cool our climate, the many leaves intercept rainwater which reduces stormwater runoff, and the shallow, dense root systems hold soil in place to prevent erosion, all of which helps protect our local water quality. These services are especially important where beech live along Category 1 streams and cold-water fisheries as they help conserve water quality. However, the predicted loss of beech will facilitate decline of these invaluable ecosystem services that protect terrestrial and aquatic habitat.

American beech is a long-lived (300–400 years), late successional species of climax forest types. It grows in the shade of mid-succession trees, provides deep shade at maturity, and inhibits growth of earlier succession flora as well as invasive plants. In New Jersey, beech occurs as late succession species in two major forest types, oak-hickory and northern hardwoods. For decades beech served as the last stronghold to maintain climax forest conditions as Eastern hemlock (*Tsuga canadensis*) populations declined due to invasive insects, while the range of sugar maple *(Acer saccharum*) and yellow birch (*Betula allenghaniensis*) transitions northward with climate change. The projected loss of beech due to BLD will shorten forest succession timelines by hundreds of years and enable an

increased rate of disturbance cycles. The beech-dominated and associated climax forest condition will become diminished along with forest quality and ecosystem balance.

Figure 6. An unaffected mature beech among a dense stand of clonal saplings. Photo Credit: Jean Epiphan, Rutgers Cooperative Extension.

Socioeconomic

European beech in North America has often been planted in ornamental and formal gardens in developed landscapes. Cultivation of European beech began in the early 19th century and today there are numerous varieties including copper beech, fern-leaf, weeping, tricolor, golden, and the fastigiate form, Dawyck beech. Oriental beech is commercially available but much less common in trade and landscapes in the United States. American beech has more recently become part of the native horticulture trade and is also planted for forest restoration. The loss of beech nursery stock has and will continue to negatively impact the green industry and agroforestry operations. The decline of beech will affect visual and aesthetic quality of ornamental landscapes which can impact property values. In ornamental settings, beech loss will decrease shade and cooling ecosystem services which facilitates the urban heat island effect.

Management

To date, there are no known quarantines in place for beech nursery stock or beech plant debris in the United States. However, it is best to refrain from transporting beech nursery stock or debris to reduce spread or transmission risk.

Several researchers are currently testing pruning methods and pesticide products to treat BLD. Some products have been shown to improve health and vigor of infected beech while other trialed products have known nematocidal activity for prevention and control of the *Lcm* and BLD. Efficacy data is limited at this time; several products have shown promise, but all are still considered experimental. In the race to save beech, many contractors have been using some of the treatment options listed below even though they are still considered experimental. There may be unknown risks that could cause harm to beech, the environment, or the treatments may prove to be ineffective long term. Be sure to read and follow the label; the label is the law.

Cultural Control

To date, cultural control options have not yet been shown to prevent disease. Pruning of initially infected leaves and small branches may slightly slow infection progression, but pruned trees can be re-infected. Pruning large branches of older beech may facilitate trunk decay and is not recommended. Pruning as part of a treatment plan is currently being researched, but there are no results to date. The nematode is not thought to survive in leaf litter, so raking and removing leaves from landscapes is not considered to be an effective control strategy.

Arboricultural Treatment

Polyphosphite-30® (Plant Food Company, Inc.)

Phosphite materials are thought to work by stimulating the natural defense response in treated trees. The application of phosphite fertilizers has shown promise for control. Cleveland Metroparks and Davey Tree Expert Company performed targeted soil drenches in the drip lines of infected American beech saplings 2"–4" DBH (diameter at breast height) have been shown to improve health and reduce BLD symptoms after 5 years. Newer trials with larger beech trees are ongoing and no results have yet been reported.

University of Rhode Island researchers suggest using 2 fl.oz. of PolyPhosphite-30® + 14 oz. water / 1" DBH. Adjustments are experimentally suggested for trees larger than 4" DBH; for every doubling of DBH greater than 4" increase the amount of phosphite by 1.5. However, high dosage can cause injury to treated trees and these higher rates have not been fully trialed. To properly apply the mixture to the soil, move leaf litter from the drip line area, moisten soil if it is dry, apply to soil area within the drip line avoiding roots, and then replace the leaf litter. Two applications are recommended between May and September at least one month apart, for example, May and July. The uptake of the materials can be enhanced by irrigating the trees after application, but do not overwater to create runoff. Lastly, the application of phosphite fertilizers do not require a pesticide applicator license, but materials labeled as fungicides do. The label is the law.

No trials of phosphite fungicides to treat BLD have been completed and there are no official results on efficacy, benefit, or harm to beech.

Fluopyram

Fluopyram is a group [7] succinate dehydrogenase inhibiting (SDHI) fungicide that acts as a nematicide. The Connecticut Agricultural Experiment Station and Bartlett Tree Experts performed several tests over the last 2 years. Fluopyram has been shown to significantly reduce nematode numbers in leaves and buds as well as improve canopy density. Fluopyram is one of the active ingredients in Broadform® (Envu Environmental Science US), which also includes the group [11], quinone outside inhibitor (QoI) fungicide, trifloxystrobin. Unlike fluopyram, trifloxystrobin has not

proven to have nematicide efficacy in any plant system. Broadform® is labelled for ornamental use only and has a 2ee exemption for use on beech and BLD in many states including New Jersey. Luna Experience® (Bayer Crop Science United States), another product containing fluopyram, is labelled strictly for agricultural beechnut use. Fluopyram cannot be applied near or over water.

Coverage is especially important with foliar-applied materials such as fluopyram, so high pressure sprayers may be needed for larger trees. Good candidate sites for fluopyram include beech with minimal dieback, beech hedges, specimens shorter than 30 feet, and mixed, young stands that are not dense beech plantings. Be aware that efficacy differs among differing site conditions. Research suggests that applications begin in late July with 4 applications at 21-day reapplication intervals. According to the label on Broadform®, if multiple applications are applied, a different product and active ingredient must be rotated in to minimize the potential for pesticide resistance. Reliant® is an option for this rotation.

Another consideration regarding efficacy is if there are nearby untreated hosts. Fluopyram treatments may fail or give less than desirable management if untreated beech are nearby.

Thiabendazole

Thiabendazole is a group [1] methyl bendimidazole fungicide that also has shown nematocidal properties on BLD. This material has been tested in American beech from 10–22" DBH. Preliminary trials suggest that it prevents dieback, reduces leaf symptoms, and reduces *Lcm* numbers in dormant buds, however trials are ongoing. Thiabendazole is the active ingredient of Arbotect 20-S® (Syngenta), which has historically been used to treat Dutch elm disease and sycamore anthracnose. Once properly diluted, Thiabendazole is injected directly into the vascular system of trees and the injection sites must be low on the root flare. Improper placement of injection sites increases the likelihood of decay and less than desirable uptake speed and effectiveness. Optimal treatment timing for macro-injections is after full leaf expansion. While most of the data is on Arbotect applied in August, it is expected that treatments earlier in the year would also be effective. Arbotect 20-S® currently has a 24c exemption for use on BLD in New Jersey, as well as New York, Massachusetts, Ohio and Pennsylvania with additional registrations pending. Application is limited to once every other year. This treatment option is best used for beech larger than 10 inches diameter with less than 50% dieback or defoliation.

Chitosan

Chitosan products are currently being trialed. At this time, it is unknown if they are effective, beneficial, or harmful to beech. No official results have been published.

Mitigation

If treatment is not an option, anticipate decline of beech. Tree decline could be slowed by reducing plant stress in ways mentioned below:

- Provide beech with ample water during times of drought.
- Remove invasive plants from the area that inhibit the success of beech.
- Do not mow or allow traffic under beech within the drip line to reduce soil compaction.
- Allow beech leaf litter to remain under the beech, within the drip line.
- If mulching, apply less than 2 inches of mulch and choose a naturally derived product; do not over-mulch or volcano mulch.

The most important method to mitigate the loss of beech in forests, rural, and suburban environments (not street trees) is to proactively underplant (and deer fence) with native cohort trees as the beech are declining. The tree species in the below list are the most vital to plant in New Jersey to mitigate beech losses. They cohesively provide stable wildlife resources including high protein food sources, slower decomposition rates of leaf litter that help maintain soil quality and habitat, and specifically black gum (*Nyssa sylvatica*) can grow in clonal groves that are structurally comparable to beech sapling groves.

- white oak (*Quercus alba*)
- chestnut oak (*Quercus montana*)
- swamp white oak (*Quercus bicolor*)
- shagbark hickory (*Carya ovata*)
- pignut hickory (*Carya glabra*)
- mockernut hickory (*Carya tomentosa*)
- bitternut hickory (*Carya cordiformis*)
- American holly (*Ilex opaca*)
- white pine (*Pinus strobus*)
- black gum (*Nyssa sylvatica*)

Make sure new tree plantings have the following attributes so they survive transplant shock, grow faster, live healthier, and aptly mitigate the loss of beech and their clonal groves of beech saplings.

- Local ecotypes sourced from your state or ecoregion.
- Smaller-sized stock grown in containers (tubeling or 1–7 gallon size).
- Protected from deer damage with physical barriers like 6ft wire mesh.
- Planted in dense stands of many trees (10–30) to replace one mature beech, 4–8ft spacing.

Controlling invasive plants in and around declining beech is also critical as they can rapidly invade in response to added light from beech canopy loss. The mitigation planting strategy listed above also helps to prevent invasive plant infiltration.

Additional Resources and Links

- Beech Leaf Disease Treatment Update. (Faubert, H.) Univ. Of Rhode Island.
- Frontiers in Forest Health: Beech Leaf Disease. (Kantor & Goraya) Penn State.
- U.S. Forest Service factsheet: Pest Alert – Beech Leaf Disease (PDF).
- USDA Forest Service: Beech leaf disease: An emerging forest threat in Eastern U.S.
- Rutgers Plant and Pest Advisory: Beech Leaf Disease in New Jersey.
- U.S.D.A. – Tellus: What's Killing Beech Trees?
- Bartlett Tree Experts – Research Laboratory Technical Report: Beech Leaf Disease (PDF).
- Rutgers Earth Day Everyday Newsletter: Beech Leaf Disease: Is Saving Beech Out of Reach?
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