



## Beech Leaf Disease Long-Term Monitoring Plot Protocol

### Authors

Danielle Martin, USDA Forest Service; Constance Hausman, Cleveland Metroparks; Dan Volk, Cleveland Metroparks; Sharon Reed, Ontario Ministry of Natural Resources and Forestry; Tom Macy, Ohio DNR Division of Forestry; John Pogacnik, Lake Metroparks; Cameron McIntire, USDA Forest Service

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### Purpose

To allow for a thorough study of the establishment, progression, and severity of beech leaf disease (BLD) throughout the eastern United States and Canada.

### Plot Placement

A minimum of eight plots should be placed per state, but cooperators are encouraged to establish as many plots as they are capable of monitoring on an annual or bi-annual basis. Alternatively, a plot within each county may be appropriate depending the size of the state. Plots should be distributed throughout the variety of forest types or ecoregions that occur in each state where beech grows. Consideration should be given to placing plots within varying distances to water sources (rivers, streams, lakes) because nematode spread may be associated with moisture levels. Establish plots in locations with no management planned. Each plot should have a minimum of three beech trees (sapling or overstory) per plot.

In states with known BLD occurrences, plots should be placed within a range of BLD symptoms (i.e. distance from leading edge – high, medium, and low severity) and in areas with and without beech bark disease (BBD), if possible. Plots should be representative of BLD and BBD conditions in the stand. Consideration should be given to placing a plot in locations where a positive nematode diagnosis has occurred, either asymptomatic or symptomatic. Cooperators are encouraged to place a Hobo®, ibutton®, or other humidity data logging device in their plots to capture humidity and temperature trends. Place the device near the center of the plot, in a netted bag, 12 inches off the ground, hanging by a pole, preferably covered. If this option is not feasible at a site, sensors may be fixed to a tree nearest to plot center below DBH. Leave the device to collect data throughout the field season on a 1-hour interval. Leaf samples are to be collected from each plot and submitted to the National Plant Diagnostic Network or state clinics for diagnoses and nematode detection.

**Site selection:** Plots are not intended to be random locations. Assess the stand to find a high concentration of beech trees, and if possible, with a diversity of size/age classes. Take into consideration existing BLD monitoring plots in your state and try to establish new plots in areas that have unique features (ex: different tree species composition, stand density, elevation, distance to bodies of water, and/or the urban interface). If a plot is to be established on private property, get a firm commitment from the landowner that no management will be conducted, and that site access will not be compromised in the foreseeable future. Be sure to obtain permits when necessary.

**Monumenting:** Use a semi-permanent monument to mark the plot center and the four seedling subplots. The monument should follow any guidelines set out by the land manager. A 1" diameter PVC ground stake of 1-2 ft length is ideal, but pin flags are also acceptable. If possible, use a different color at plot center from the seedling subplots. Once the 0.1 ac mature plot outline is established, mark all trees >5" (12.7 cm) DBH with aluminum tags near ground level and facing plot center, include all tree species and dead trees.

## Assessment Timing

When re-assessing plots, it is important to make sure plots are reassessed at a similar time of the year due to changes in canopy conditions throughout the year. While individual leaf symptoms do not change during the growing season, total canopy symptoms will change through the year. In other words, a leaf that emerges with three stripes will not gain additional stripes throughout the year. However, shrunken/curled leaves can detach from branches throughout the season, as early as June.

## Supplies

- DBH tape
- 10-m tape or logger's tape
- Handheld GPS
- Clinometer
- Binoculars
- Aluminum tags
- Nails
- Hammer
- 1-meter stick or string
- Data sheet
- Clipboard
- 10-factor prism
- Compass
- Densiometer or Canopy app
- Humidity data logging device (if available)
- Flagging or PVC stakes

## Sheet 1: Meta Data

### General Information

- **Plot ID:** Two-letter state code, two-letter county code, two-digit sequential numbering within the county (ex: the first plot in York County Maine will be "MEYO-01").
- **Project Name:** Beech Leaf Disease Monitoring
- **Date:** (mm/dd/yyyy)
- **Surveyor Names:** First and last names
- **Plot Coordinates:** Latitude and longitude at plot center using a GPS device
- **Elevation above sea level (m)**
- **Site remarks:** Include information for parking and directions to access the plot. Provide site descriptions and general vegetation characteristics. Add notes about distance to nearby bodies of water (streams, creeks, lakes, etc.), even if they run intermittently.

### Location

- **State & County**
- **Local Place Names** to describe the location (park, reservation, or special name)
- **Landowner:** (public or private)

### Site Attributes (taken from plot center):

- **Basal Area:** Use a 10-factor prism from plot center to assess # of live trees, then multiply the total by 10 to calculate basal area, ( $\text{ft}^2 \text{ac}^{-1}$ ). For borderline trees, multiply the tree DBH (in inches) by the PRF (2.75 for a BAF-10 prism) to obtain the limiting distance (ft); if the limiting distance is greater than the measured distance (ft) to the center of the tree, tree is "in" the plot.
- **Slope %:** Use a clinometer to estimate % slope, assess overall landscape from plot center.
- **Aspect:** Downhill reading will be averaged with uphill rating (+ 180°)
- **Slope Shape:** Convex, concave, or flat.
- **Slope Position:** Bottom, lower, mid, upper, or summit.

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## Sheet 2: Mature Tree Data

The mature tree plot is a circular 0.1-acre plot, 37.2-ft (11.3 m) radius. Measure all trees  $\geq 5''$  DBH.

### Species

Use the first two letters of genus and species will be used to identify species. (Ex: American beech, *Fagus grandifolia* = FAGR). If a snag is present, simply write "SNAG" in the crown class, and identify species if possible. If the species is unknown, write UNKN.

### Tag Number

All trees  $\geq 5''$  (12.7 cm) at DBH are marked with aluminum tags and nails. Tags will be placed 1 foot from the base of the tree, facing plot center. The sequence of the tags does not matter and can share numbers with other plots, but for ease of measurement, consider placing tags clockwise starting from the north.

### DBH

Diameter at breast height will be measured for all trees  $\geq 5''$  (12.7 cm). Make note on the data sheet if this was measured in **inches** or **centimeters**.

### Crown Class

Crown class measurements will be taken for all trees  $\geq 5''$  DBH.

- Dominant (D): Trees with crowns extending above the general level of the forest canopy and receiving full light from above and partly from the side.
- Codominant (C): Trees with crowns forming the general level of the forest canopy and receiving full light from above but comparatively little from the sides, usually with medium-sized crowns more or less crowded on the sides.
- Intermediate (I): Trees are shorter, have smaller canopies, and are more crowded than those in the preceding classes but crowns extending into the forest canopy formed by codominant and dominant trees, receiving some direct light from above but none from the sides.
- Suppressed (S): Trees with crowns entirely below the general level of the forest canopy, receiving no direct light, either from above or the sides.
- Dead (Snag): If tree the is completely dead.

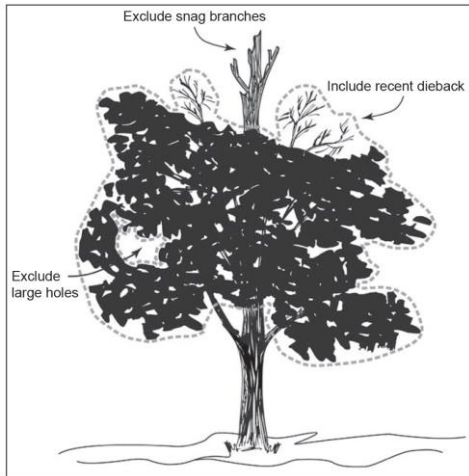
### Crown Dieback and Density

Overall crown dieback and density measurements will be taken for all trees  $\geq 5''$  DBH.

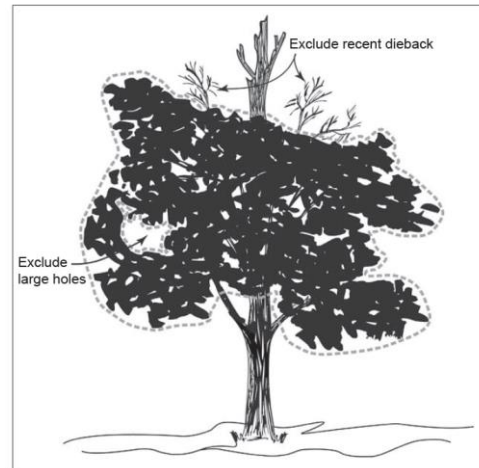
Percent of crown density (**Figure 1**) and crown dieback (**Figure 2**) are separately determined and put into one of eight categories (**Table 1**)\*

It is ideal to have two trained technicians assess each tree simultaneously from opposite sides. If an assessment is borderline on a category, the technicians need to come to an agreement on the final category (e.g. a rating of 50% needs to fall into either category 4 or 5).

\*Note that crown density and dieback measurements use the same categorical scale, but only crown dieback uses category 7 and 8 to denote dead trees. If a tree is dead and without foliage, the crown density rating will be 1 (indicating 0% leaf cover).



**Figure 1.** Dieback assessment is measure for mature trees and saplings. The dotted line represents the crown silhouette used to rate crown dieback.



**Figure 2.** Crown density assessment is measured for mature trees only. The dotted foliage density outline excludes dieback, snag branches, and areas where foliage is not expected to occur.

| Crown dieback, density, & BLD symptom assessment |                                    |
|--|------------------------------------|
| Rating   | Observed %                         |
| 1  | 0                                  |
| 2  | 1-10                               |
| 3  | 10-25                              |
| 4  | 25-50                              |
| 5  | 50-75                              |
| 6  | 75 - 99                            |
| 7  | Recently dead (fine twigs present) |
| 8  | Dead long time                     |

**Table 1.** Categorical ratings for assigning crown assessments of crown density, dieback, and BLD symptoms.

| Canopy Position |          |
|-----------------|----------|
| Rating          | Position |
| 1               | Lower    |
| 2               | Upper    |
| 3               | Both     |

**Table 2.** Categorical ratings used to assign crown position for measurements of main/fine branch dieback and BLD symptoms in the canopy.






**RECORD THE FOLLOWING FOR BEECH TREES ONLY**

**Dead Main and Fine Branches**

Percentage of both main and fine dead branches and their position within the canopy are to be recorded using cover classes 1-6 for beech only. The canopy position is to be divided into two equal parts, lower and upper with respect to the mid-point of the crown (**Table 2**). Affected areas will be recorded as follows: 1 (lower section affected), 2 (upper section affected), 3 (both sections affected). In general, fine branches will be defined as those which support leaves and buds, while main branches are all other structural branches typically >1" in diameter.

**BLD Symptom Assessment**

Record the percentage of normal (asymptomatic leaves of typical size, color, and shape), striped (leaves with interveinal dark striping or bubbling) and shrunken/curled leaves (leaves are smaller than typical, often thickened with curled edges) and their canopy position. Use the same 1-6 cover class categories as for other canopy assessments.

| BLD   |   | Not BLD   |  |   |
|---|---|---|--|---|
|  |  |  |  |  |
| Banding symptom   | Shrunken/curled symptom   | Leaf curling aphid  | Beech erineum mite   | Nutrient deficiencies   |













**Table 3.** Examples of symptoms observed with BLD, as well as other common leaf pests of beech.

**Beech Scale and Neonectria Canker Assessment**





Presence and severity of beech scale and *Neonectria* cankers are visually evaluated for each mature and sapling beech tree (**Table 4**). A clipboard (roughly 9x14 inches) is held against the trunk on the north and south sides of each beech tree at breast height. The area within the clipboard is assessed for both the north and south side of the stem. An overall rating for scale and *Neonectria* cankers outside the monitoring frame (above and below) is recorded as well. The columns on the data sheet with the heading “Scale (N, S, O)” and “*Neonectria* cankers (N, S, O)” are for North/South/Overall positions.

| Severity of Scale and <i>Neonectria</i> Cankers |   |
|---|---|
| Rating  | Observed Severity   |
| 0   | <b>No infestation</b>   |
| 1   | <b>Trace:</b> 1-10 single-scale colonies.<br><i>Neonectria</i> fruiting or cankers are present but are sparse across <10% of the bole   |
| 2   | <b>Light:</b> numerous (>10) single-scale colonies.<br><i>Neonectria</i> /cankers scattered over 10-30% of the bole   |
| 3   | <b>Moderate:</b> accumulation of scale colonies producing a clumping appearance<br><i>Neonectria</i> /cankers present on 30-50% of the bole   |
| 4   | <b>Moderate-Heavy:</b> scale colonies building to appear in lines streaming down the bole<br><i>Neonectria</i> /cankers consume >50% of the bole, creating fissures and a craggy appearance |
| 5   | <b>Heavy:</b> scale increased to the point where portions of the bole appear white-washed<br><i>Neonectria</i> /cankers cover the entirety of the bole, with many sunken lesions            |

**Table 4.** Categorical ratings for scale colonies and *Neonectria* cankers associated with beech bark disease.

| Beech Bark Disease Assessment |   |  |
|-------------------------------|---|--|
| Rating                        | Scale example   | Canker example   |
| <b>0</b><br>No infestation    |    |    |
| <b>1</b><br>Trace             |    |    |
| <b>2</b><br>Light             |   |   |
| <b>3</b><br>Moderate          |  |  |
| <b>4</b><br>Moderate-heavy    |  |  |
| <b>5</b><br>Heavy             |  |  |

**Table 5.** Visual examples for assigning categorical ratings for the severity of scale and cankering associated with Beech Bark Disease. Presentation of symptoms are highly variable in the field.

| BBD   | Other bark diseases   |  |   |
|---|---|--|---|
|  |  |  |  |
| <p><i>Neonectria</i> spp.</p>   | <p><i>Phellinus igniarius</i></p>   | <p><i>Phytophthora cactorum</i></p>  | <p><i>Nematogonium ferrugineum</i></p>  |

**Table 6.** Visual example of the fruiting stage of *Neonectria* associated with beech bark disease, as well as other bark diseases found on American beech.

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### Sheet 3: Saplings Data

The regeneration plot is an 11.8' (3.6 m) radius plot, in the center of the main plot. To identify saplings within the subplot, use a measuring tape or a string that is cut to length to measure stem distance relative to the plot center.

Measure and record all saplings <5" (12.7 cm) DBH, and taller than breast height (4.5', 1.3 m). Measure DBH to the nearest 0.1", otherwise denote as <1" for small trees.

Canopy assessments are not broken into crown position for the sapling assessment.

#### **Sapling assessments:**

- Estimate the overall dieback for each sapling (crown density not measured).
- Note if BLD is present anywhere in the crown (Yes / No).
- If BLD is present, estimate the proportion of the symptoms in the crown (beech only).
- Rate the severity of scale and cankering on each beech sapling.

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### Sheet 4: Seedlings Data

The seedling plot is a 1-m radius plot taken at each cardinal direction, 37.2 feet from the main plot center. A seedling is anything <5 inches DBH, and lower than any woody species below breast height.

#### **Seedling assessments:**

- Record subplot location (N, S, E, W), as it pertains to main plot center.
- Record the subplot cover class using the 1-6 scale used for estimating crown density. Assess the entire subplot (1 m<sup>2</sup>) for woody species only.
- Record total number of seedlings within the seedling plot for each species.
- For beech seedlings, note if BLD symptoms are present (Y/N).

**Densiometer:** Optional, not required. Take four readings at each subplot (N, S, E, W). Estimate using a handheld densiometer or use the free CanopyApp smartphone application.



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## Other Pests/Remarks (Damage Codes)

Only record if pest/disease is affecting health of the tree, for example affecting >10% of foliage, crown, stem, or root collar. For other pests, describe the type, location of damage, and percent of the tree affected using the codes below and a similar code to the dieback code. A general code is depicted by a numeral identifier. If the surveyor is familiar with the specific cause of the ailment, he or she may identify it further. For example, Eriophyid mite would be identified as 3E.

### 1. Abiotic (general)

- a. Ice/snow
- b. Frost
- c. Drought
- d. Flooding
- e. Fire damage
- f. Nutrient deficiency

### 2. Mechanical Injury/Human

- a. Pruned
- b. Blowdown
- c. Animal (general-rubbing gnawing, girdling, birdpecking, grazing)
- d. Sapsucker
- e. Porcupine
- f. Beech Snap
- g. Wound closed, scar
- h. Dry seam, frost crack
- i. Wet seam, bleeding crack
- j. Wound open, scar hole
- k. Overmaturity (only largest tree affected, hollow bole)
- l. Lightning
- m. Topped tree

### 3. Insect activity (general or unknown)

- a. Defoliators (general)

- b. Aphids (general)

- c. Leaf rolling aphid

- d. Mite (general)

- e. Eriophyid mite

- f. Ambrosia beetle

- g. Bark beetles

- h. Borer, other

- i. Ants

- j. Defoliators (spring)

- k. Defoliators (fall)

- l. Gypsy moth

- m. Forest tent caterpillar

- n. Hickory Tussock Moth

### 4. Canker (unidentified/general)

- a. Eutypella

- b. Hypoxylon canker

- c. **Aftermath BBD canker**

### 5. Leaf Chlorosis/scorch

### 6. Root Decay or rot (general)

- a. Armillaria

- b. Laetiporus root rot

- c. Phytophthora root rot

### 7. Other diseases (general or unknown)

- a. Powdery mildew

- b. Tarry Spot

- c. *Nematogonum ferrugineum*

**Location Codes** (\*if necessary, record in “Other Pests/Remarks”)

- I. Stump/roots (defects visible on the buttress roots or the stump within 30 cm from the ground)
- II. Bole-lower half (above the stump. 30 cm above ground, but in the lower half of the bole)
- III. Bole-upper half (upper half of the bole, but below crown or branch forks)
- IV. Whole bole (defects in both halves or continuous)
- V. Twigs/branches
- VI. Canopy/foilage
- VII. Whole tree (includes bole, stump, and roots)

**Damage Severity** (\*if necessary, record in “Other Pests/Remarks”)

0= No damage, 1= 0-10 percent affected, 2= 11-50 percent affected, and 3= > 50 percent affected.

**Tree Remarks:** List additional comments such as excessive suckering.

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