Aaliyah Jason

MELNHE Crew

Project Proposal: Monitoring Beech Bark Disease progression in correlation with soil P availability in Bartlett & Jeffers Brook experimental forests, NH.

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Background

 Beech bark disease (BBD) is a pathogenic complex that causes high mortality and morbidity of American Beech trees (*Fagus grandifolia*) in northern hardwood ecosystems. (Mason M. E. et al, 2013). The start of this disease in northeastern hardwood ecosystems is believed to have been caused by the introduction of *C. fagisuga* (*Bartlett Experimental Forest*, no date).

*C. fagisuga* feeds on beech by using its stylet (feeding tube) to penetrate the thin outer layers of the bark (cork and cork cambrium) to access the sugars that are being transported through the phloem of the tree (Wisconsin Department of Natural Resources,2008). Unlike more common insects, scale insects will become immobile adults after they have stayed on a tree for the deration of one winter. Once this has occurred, *C. fagisuga* and *X. betulae* will live out the rest of their lives feeding on the same tree (Wisconsin Department of Natural Resources,2008). The fungi create lesions (dead tissue) on the tree which then turn into cankers as the tissue around the lesions continue to grow (Mason M. E. et al, 2013). The fungus eventually wraps all the way around the beech and girdles it, causing secondary effects to the tree such as dehydration, transportation disruption, and lowering the tree’s overall ability to fight off infection and invaders (Cale J. A., et al, 2014). We are currently unaware as to why *Neonectria* has only become a problem with the introduction of *C. fagisuga*.

Recent studies have found that there are multiple biotic and abiotic predisposing factors that impact the susceptibility of *F. grandifolia* to *Neonectria*. These susceptibility factors include bark chemistry characteristics such as low levels of phosphorus and calcium, excessive or deficient amounts of nitrogen, and predisposal to scale insect colonization (Cale J. A., et al, 2014). On their own, *C. fagisuga* and *X. betulae* are not deadly to beech, but they create opportunities for *Neonectria* to invade tree bark (Wisconsin Department of Natural Resources,2008). BBD is very deadly. The initial killing front caused by infection has a 50% mortality rate and less than 1% of all American beech has shown resistance (Mason M. E. et al, 2013). Almost all beech in the North Eastern United States are infected.

*Fagus grandifolia* are the only trees immediately affected by the disease, but there are intermediate effects on overall forest health. When American beech trees are under stress, they send out root sprouts in response, creating large homogenous monoculture patches of beech sprouts (Personal communication, Johnston, M., 2015). The sprouts then compete for the nutrients and resources that other species (sugar maple, red maple, etc.) would utilize for growth and survival. This can eventually lower the overall biomass and presence of key species such as maples in northeastern forests.

Introduction

Disease causing scale insects are highly dispersible. Immature motile stage scale insects are transported by wind, birds, wildlife and by humans who transport infected firewood (Wisconsin Department of Natural Resources,2008). The White Mountains have been infected since 1940 and all of the current trees have succeeded trees from the initial wave or survived from the first killing front, meaning that all of the forests there are aftermath forests. There has been a lack of research done previously in this area. It would be beneficial to look at how BBD progresses in aftermath forests to see if there is a different interaction between all five species post killing front.

The MELNHE project area contains multiple stands within Bartlett Experimental Forest. These along with two stands in Jeffers Brook, owned by the Forest Service, will be my area of study. These stands are classified by age (mature, mid-aged, and young). There are four plots in each stand, each with a different treatment (nitrogen, phosphorus, nitrogen & phosphorus, calcium, and a control). Within C1, C6, C8 and soon HBO & HBM, an additional 5th plot has been established and treated with calcium silicate. All plots are treated once annually. The calcium silicate plots were only treated once at the time of their creation because calcium silicate washes away much more slowly than nitrogen and phosphorus. There are buffer zones between each treatment plot to prevent crossing over of nutrients between plots. Prior to a study done in 2013, American beech above 10 cm DBH (diameter at breast height) were tagged. Out of all of the *F. grandifolia* in each stand, 281 of the previously tagged trees were then rated using the 2013 rating system (created by Adam Wilde & Jon Cale) and photographed. These photos were taken in seven stands in Bartlett (C2, C3, C4, C5, C7, C8, & C9). Ratings have been given separately to every tagged beech tree within the Jeffers Brook, Hubbard Brook, and Bartlett stands in 2011 using a rating system created by Matt Vadeboncoeur. This rating system observed the overall health of each beech tree. These rating systems can be seen in the methods section.

Objectives

 I will be surveying BBD affected trees in stands C2, C3, C4, JB Old and JB Young. These stands were chosen for their varying levels of soil phosphorus. My objective is to see if higher levels of soil phosphorus are ideal for limiting BBD progression in aftermath forests in New Hampshire by using the MELNHE plots as a template. The MELNHE plots are ideal for this study because of their independent yearly treatments (N, P, N&P) along with calcium, which may have some other unknown effect. However, I will not base my study entirely upon plot treatment because the stands have not been treated for a significant amount of time. If possible, I will compare individual elements of the pathogen (*C. fagisuga*, *X. betulae*, and both *Neonectria* as one) across the different stands.

 For future use, I will keep a photographic inventory of a section of each tree I survey.

Methods

 I will be using multiple surveying methods for this study. For consistency with past data, I will be using the visual rating method used in 2011 for each tree (Vadeboncoeur et al, 2011). This method looks at the overall health of the tree (foliage health, bark health, canker cover, cracks). It is a 1-5 scoring system, 1 being healthy, 5 being dead. This will allow for a quick and easy comparison of changes over the past four years.

 I will also use the 2013 scoring system (Wild et al, 2013) in three 14.9 cm by 5.0 cm metal frames. These frames are hung from each tree’s nailed in tag (at 155 cm or 20 cm above breast height) so that the tops of each frame fall at 0.5 m, 1.0 m, and 1.5 m. The frames are attached in a line by electrical tape, which checked weekly to assure accuracy.

 For beech bark disease assessment I am using both systems created by Adam Wild & Jon Cale, and Matt Vadeboncoeur along with additions from Dr. Mariann Johnston and myself.

* Matt V. (2011) BBD General rating of entire tree
	1. undamaged, very little or no sign of either causal agent (Crypto/Neonectria); may have low levels of scale (could easily be missed if not closely examined) and may have branch scars or other marks NOT related to the disease (Healthy)
	2. Light damage, Cryptococcus present, bark beginning to crack, tree still shows vigor. Canopy (if visible) 75% intact
	3. Moderate damage, bark heavily cracked, significant Neonectria cankering, some crown damage or limb loss. Canopy 25-75% intact
	4. Heavy damage, bark severely cracked, large girdling cankers, significant crown loss, canopy >25% intact
	5. Dead. Looks like a four but is (ideally) dead from the disease. If dead and looks like a (1-3), rate it that and note dead (from other cause)
	6. Foliage rating listed independently
* Frame Methods (samples of tree surface)
	1. Use three frames with windows that are 14.9cm by 5cm with a nail slit at the top and bottom of the each window. Sides of frame are roughly 4.5cm on top and bottom edges, 5cm on left and right side edges. Frames made from aluminum sheets and have black electrical tape on each outside edge to protect the user. Each frame is attached in a line to go down the tree. The top frame hangs from the nail and the other frames are connected to the first and second frame with vertical lines of electrical tape (material will be changed later). The bottom of the first frame to the top of the second frame is 50cm. This is the same for the bottom of the second to top of third. The first frame is the only one used for photographic inventory
	2. Set up on the tree. On each tree there should by a nail (tag) 20cm above DBH (1.35m). Hang the top frame from the tree tag. Let the two other frames hang loosely down. On top frame, tie the two binder clips together around the tree. Should be tight enough to keep the top frame flatly on the tree’s bark.
	3. Make sure that the tag is on top of the frame so that the number on it is easily visible.
	4. Have cm ruler attached to one side of frame with binder clip. Do not let it overlap into the frame’s window.
* Photography
	+ Use top frame only.
	+ Hold a stick or pole that is (TBDm) away from the tree. Line the camera up at about this distance
	+ (camera TBD) The camera being used in 2015 is the Olympus Stylus 300/400 (unless we get a new one). Set the camera to max zoom, making sure that all edges are within the photo. Take the photo. Do not use a flash because it will glare the image. When there is not enough space between the tree being studied and other trees that are in the way, take a photo on any zoom and any distance so long that the top and bottom are still within the shot (should be at the edges of the camera screen). Leave a note of this in the Photo section of data sheet. If first photo is not clear, take multiple.
* Count the number of scale wax masses in each of three frames. If over 100 masses are present, list (>100). Document them independently, then take an average of the three for each tree (when not in the field). Used to quantify Cryptococcus
* Count each excretory tube within the frames. Keep numbers for each independent, but also average them together. Used to quantify Xylococcus.
* Adam Wild and Mariann Johnston Scoring independently for scale and fungus
	+ Scale:
* 0 - no colonies present
* 1 – Trace from one colony to light very scattered individual colonies. One or two larger colonies only
* 2 – Light, scattered colonies. Some larger colonies may be present
* 3 – Moderate infestation, many colonies visible. Substantial number of larger colonies may be present
* 4 – Heavy infestation. Many large colonies present. Some colonies coalescing.
* 5 – Very heavy infestation, most of bark conspicuously white.
	+ Fungal score:
	+ 0 – Absent.
	+ 1 – Sparse sunken legions. Sparse localized perithecia (perithecia not always present) or few scattered circular infections.
	+ 2 – Few sunken legions covering part of the tree.
	+ 3 – Sunken legions covering most of tree.
	+ 4 – Sunken Legions covering the entire trunk.
	+ Tree condition:
	+ 1 – Good. Foliage green, <10% dead crown branches
	+ 2 – Fair. Foliage green to yellow green, 10-50% dead crown branches
	+ 3 – Poor. Foliage green to yellow green, >50% dead crown branches

There are about eight hundred tagged beech tree in the MELNHE stands (Egan-Anderson, E. et al, 2014). I will focus on stands C2, C3, C4, and JBO & JBY because they have both high and low phosphorus soil composition (Fisk 2011). All materials for this study have been borrowed or been previously owned with the exception of two SD memory cards.

Hypothesis

Beech trees with higher levels of pre-treatment soil phosphorus will show a lower severity of beech bark disease.

Citations

Wild, A., Johnston, M., Cale, J. A (2013). *Scoring beech bark disease.*

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Melany Fisk, Pre-treatment soil P data for MELNHE stands