Growth Declines Associated with White Pine Needle Damage Defoliations in the Northeastern US.

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Introduction

White Pine Needle Damage (WPND) is a complex of rain dispersed fungal pathogens that infect and defoliate the needles of eastern white pine (*Pinus strobus L.*). Since the spring of 2009 the northeastern United States has been experiencing an outbreak of WPND that continues to persist and spread throughout the region.

WPND defoliates second and third year needles prior to the current year needle elongation. This effectively thins the crowns and often results in the premature death of the lower branches. WPND represents a significant threat to tree health and has been known to cause mortality in trees of extreme and chronic infection

Study Area

The US Forest Service has established eight permanent study plots for monitoring WPND throughout the NE region spanning four cold hardiness zones. The 2014 field season focused on four sites within the 4a , 4b, 5a, and 5b climate zones.

Durham, NH (**TOM**)

Bethel, ME (**BTH**)

Hillsborough, NH (**FOX**)

Lyman, ME (**MEF**)

Research Hypotheses

1 White pine pathogen induced defoliations initiate in a large pulse in the summer and have contrasting degrees of severity across a geographic gradient.

2 Reduction in leaf area during the growing season will result in stem wood growth declines that can be observed through annual tree rings since the 2009 outbreak in New England.

Methodology

Litter Fall Sampling: In 2014 litterfall was measured using 0.18m^2 traps (n=5) replicated over 3 plots at each of the study sites. Litter was collected at the end of each month May – October, then dried and sorted for *P. strobus* needles. Stem counts at each plot were used to normalize litter fall (g m^{-2}) based on basal area (m^2) of white pine.

Dendrochronology: Tree ring analysis was conducted using increment cores sampled from FOX (n=54), MEF (n=32), and BTH (n=31). Ring widths measured to 0.001 mm precision were used to create a master chronology for each site and were differentiated based on USFS crown defoliation ratings as high and low severity of WPND infection. Ring widths were standardized by converting to units of basal area increment (BAI, cm^2). Growth reductions were analyzed in respect to the 2009 initial outbreak and compared between tree health classes.

Regional Defoliations

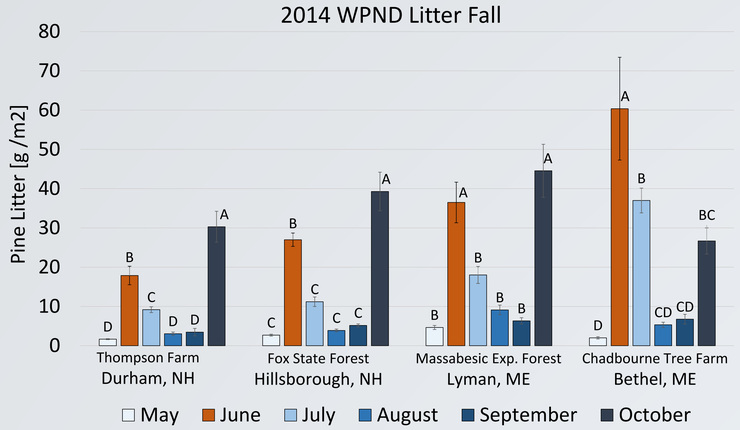

Figure 1. Monthly litter fall totals (May-August) across the four study sites. Error bars show the standard error for each month. Letters signify significant difference between months for each site using a t-test. Summer defoliation accounted for 48.5%, 50.2 %, 57.3%, and 75.8% of the total growing season litter fall at TOM, FOX, MEF, and BTH respectively.

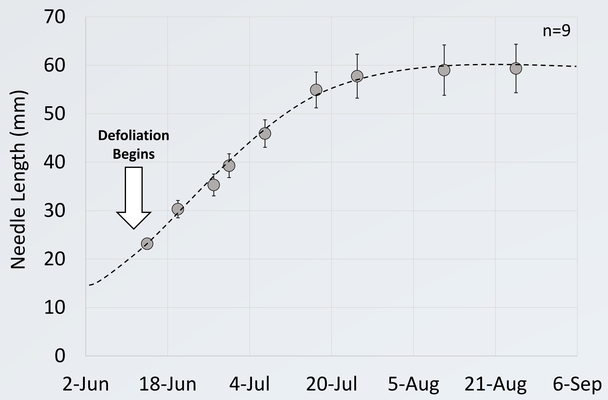

Figure 2. Elongation of the current year needle growth (mm) measured at the Thompson Farm in Durham, NH. The arrow shows the approximate onset of pathogen induced defoliations.

Annual Needle Retention

Figure 3. Healthy eastern white pine can retain 3-4 years of needles, while trees defoliated by WPND often shed all but the current year of needle growth. Defoliation begins in June when current year needles are <50% elongated and stomata are only partially functional. Photo: Stephen Wyka 2014.

Wood Production

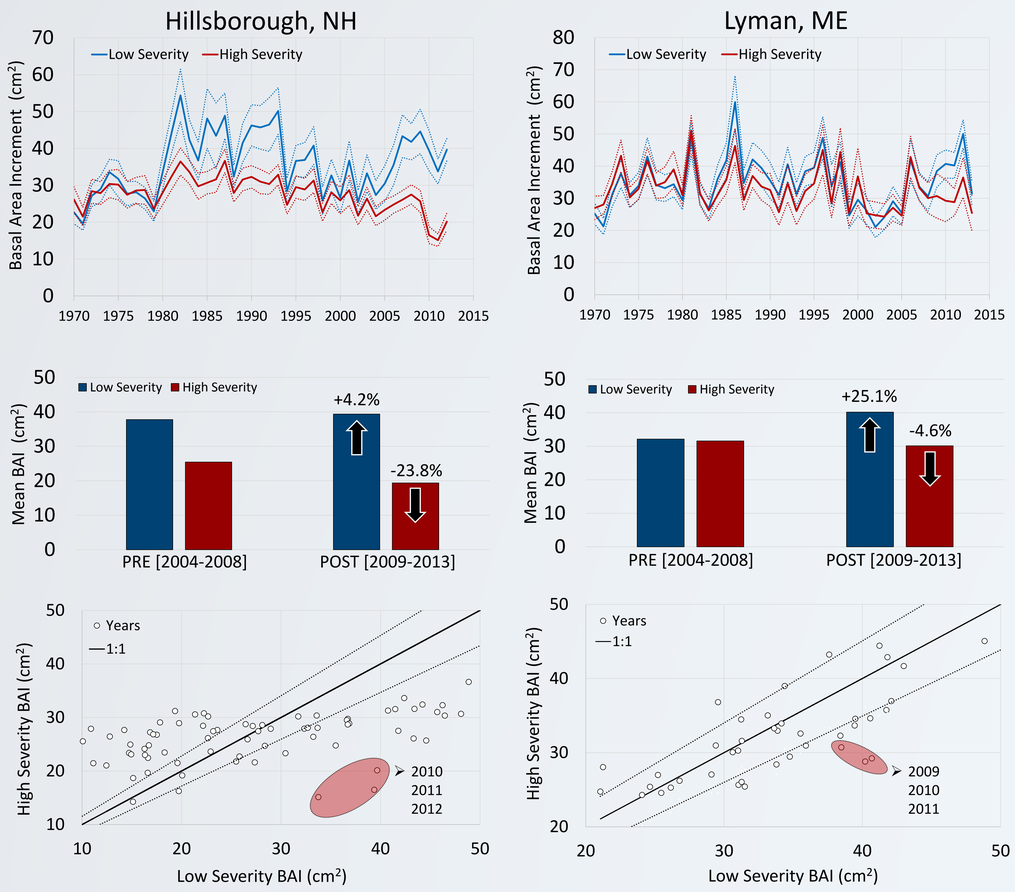

Figure 4. Tree ring chronologies generated for sites Hillsborough, NH and Lyman, ME. Blue and red represent the compiled low and high severity tree health class respectively with associated dashed lines showing standard error. Both sites show a divergence in the chronologies beginning in 2009.

Figure 5. Growth analysis of the five year pre and post-outbreak BAI for each chronology. At each site the low severity trees experienced increased growth while trees of high severity infection had a reduction in wood productivity.

Figure 6. A comparison of the low and high severity chronologies for each site. Each white dot represents a year of growth and the black line shows the 1:1 relationship for the low severity chronology, dashed lines are the standard error. Outlier years are identified (red ovals) showing historically significant divergence in the chronologies due to WPND outbreaks.

Conclusions

- All sites exhibit significant defoliation in the month of June. TOM and BTH also show a marked needle cast continuing into July. Defoliation severity appears to increase from south to north.
- At the onset of WPND defoliation current year needles are only partially elongated and stomata are not yet fully functional. This represents a loss of photosynthetic potential and decrease in tree hydraulic conductance for much of the growing season.
- Dendrochronology analysis revealed that trees of high severity WPND infection were sensitive to the initial outbreak in 2009. Sensitive trees were typically of a smaller diameter class and experienced a decrease in mean BAI since the initial outbreak. A net difference in BAI pre and post-infection of 28.0% and 29.7% was measured at FOX and MEF respectively.
- Trends in wood growth and litter fall suggest that WPND has spread and will continue to persist in New England.

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