White Pine Needle Damage Report

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In recent years, a complex of foliar fungal pathogens, known collectively as White Pine Needle Damage (WPND), have caused significant defoliations of eastern white pine (*Pinus strobus*) throughout its northeastern range during the summer months. To date, there are at least four pathogens associated with WPND. However, the most ubiquitous fungi found on needle samples throughout New England has been *Lecanosticta acicola* (Broders et al. 2015, Wyka and Broders 2015, Wyka et al. 2016), commonly known as "brown spot needle blight". Symptoms of this disease include the chlorosis (yellowing) of second and third year foliage in late-May and early-June. Following this brief period of yellowing, infected needles are cast in a defoliation process beginning in mid-June and often observed persisting into July. During the summer needle cast, the current year needles are not yet fully elongated, but appear healthy (Fig. 1). However, prior to defoliation, fungal spores are carried from infected second and third year needles via rain splash to the current year foliage, thus defoliation severity in a given year has been found to be linked to precipitation of the previous year, particularly in the month of May (Wyka et al. 2016).

Figure 1. The twig on the left is from a diseased tree, having lost nearly all the second-year needles. The current year needles are partially elongated at the branch tips, but do not fully mature until mid-August. The branch on the right is from a healthy individual, showing a typical amount of second year foliage retained in the summer time. Both branches were collected from the same site on the same day in June, 2014. Photo credit: Stephen Wyka.

Symptoms are most often prevalent on the lower portions of the crown due to the rain-dispersed nature of the pathogens. The premature loss of foliage represents a four-month period of the growing seasoning in which infected pines exhibit substantially thinned crowns. Foliar litter trapping studies were used to quantify the exact timing and magnitude of WPND-induced defoliations in the NE region (Fig. 2). Although there was some variation in defoliation severity from year to year, a significant amount of foliar biomass was consistently observed in the months of June and July since 2014, which can be primarily attributed to WPND. While eastern white pine is an evergreen that retains foliage year-round, it will still cast older needles in the month of October, similar to deciduous trees. Historically, over 90% of total annual litterfall of white pine is observed in the month of October alone (Guiterman et al. 2012). In light of WPND defoliations in recent years, infected stands have cast approximately 57% of their older needles during the summer months on average, while September and October only accounts for 43% of the total annual litterfall. This indicates a significant change in the seasonal distribution of white pine foliar biomass and retention of older needles.

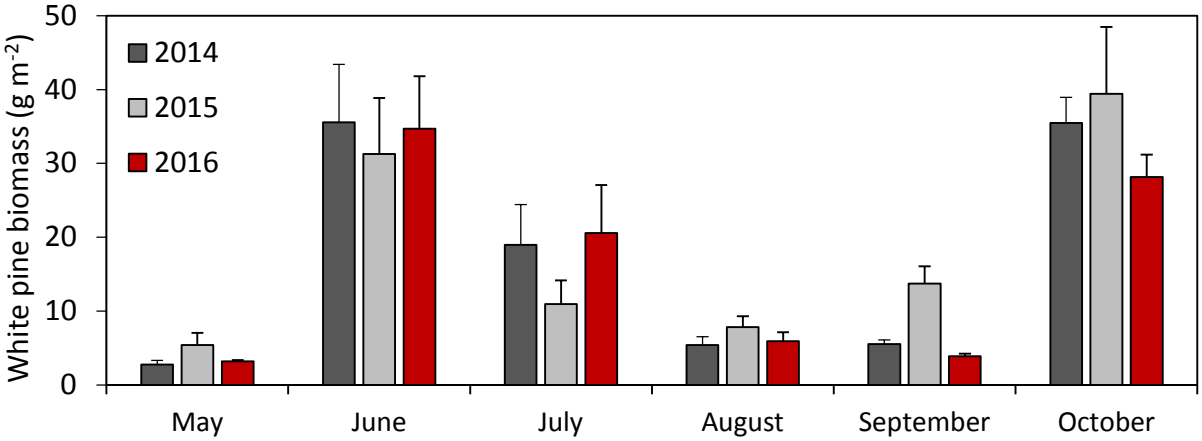

Figure 2. Mean monthly litter fall totals across sites in southern New Hampshire and Maine.

Defoliations during the summer months have also been shown to influence the nitrogen retention of infected trees. Nitrogen is an important component of the photosynthetic enzymes of chlorophyll and is generally indicative of tree health and productivity. Typically, trees will resorb foliar nitrogen into storage tissues in the fall prior to senescence and reallocate nitrogen to new foliage the following year. Nutrient analysis of white pine needles cast in June and July were found to have twice the amount of foliar nitrogen (0.8%) than needles cast during the normal senescence period in October (0.4%), suggesting that WPND-infected trees are not

resorbing nitrogen as efficiently in the summer time. Thus, the tight internal recycling of nitrogen within trees is likely being altered by WPND defoliation, as more nitrogen is distributed to the forest floor which may be made available for uptake by other plants or lost to leaching.

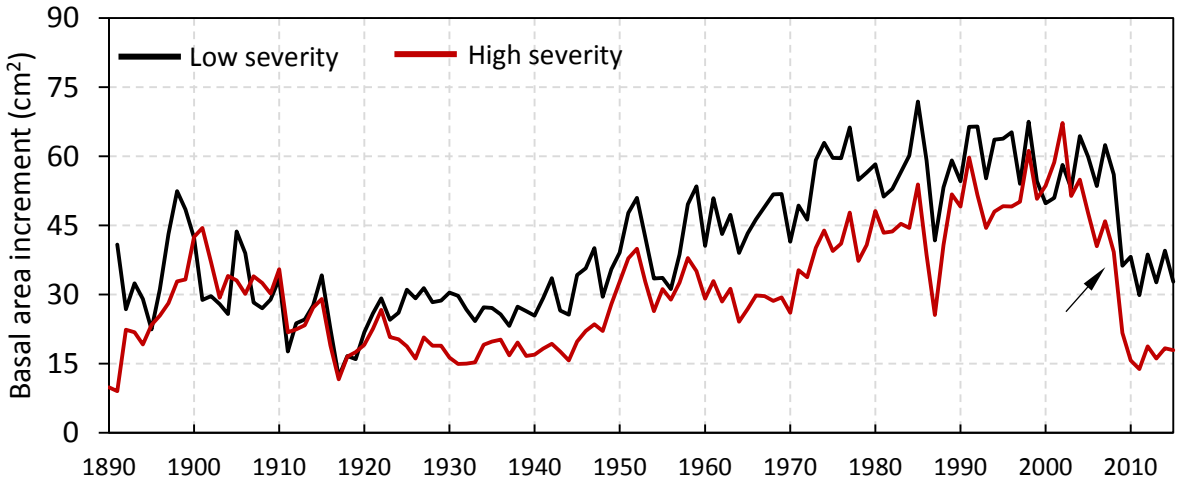

Figure 3. Tree ring chronologies from a white pine stand at the Mohawk Trail State Forest, Charlemont, MA. The vertical axis shows the annual basal area increment; the horizontal axis is years. The black and red lines show low and high severity trees respectively, based on observations of crown chlorosis and defoliation. The arrow points to 2009, the year identified as the most significant onset of WPND-induced decline.

Severe outbreaks of WPND were widely reported in the northeast region ca. 2010, and observations of defoliation in Maine were noted in 2006 (Munck et al. 2012). Tree ring analysis of white pine stands throughout New England has been used to estimate the exact time of disease outbreaks and to quantify woody growth declines associated with WPND. These studies have shown that many stands in the region experienced a significant decline in growth starting in 2009, 2008, and 2007; suggesting that WPND fungi infected stands the region as early as 2006. Across eight stands measured to date, a mean growth decline in basal area increment of 41% has been reported. A highly symptomatic stand at the Mohawk Trail State Park in western Massachusetts has exhibited a 72% decline in basal area increment since 2009 (Fig. 3). This stand is of interest because it is one of the few regarded as old-growth in the state. Based on the tree ring analysis we can see that the magnitude of the current growth decline is unprecedented in the 120+ year lifetime of these trees (Fig. 4).

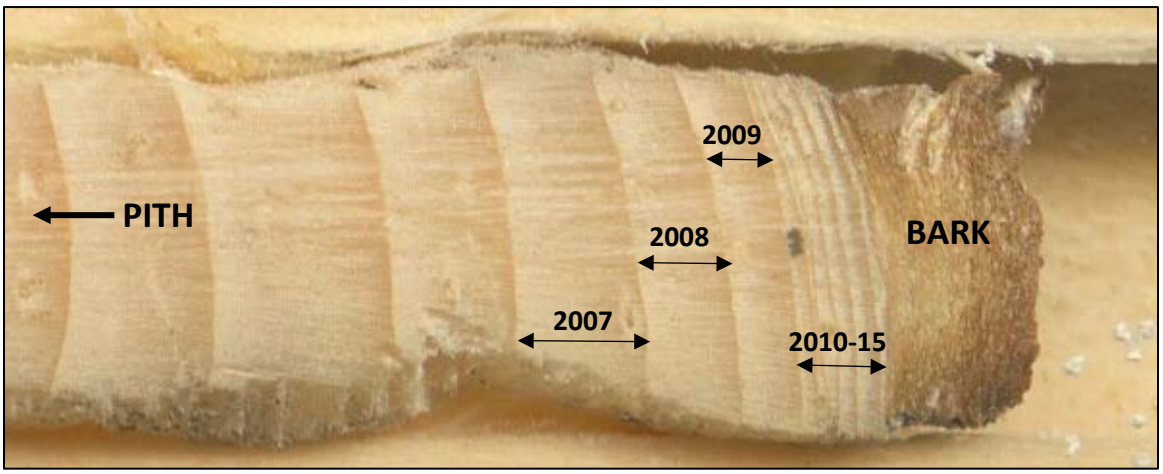

Figure 4. A tree core extracted from the Mohawk Trail State Park, Charlemont, MA. The onset of the outbreak is clearly visible after 2009. The post-outbreak ring widths (2010-15) are significantly reduced over this six-year period following WPND infection.

Despite high levels of decline observed throughout the region, mortality of WPND infected eastern white pine has been very low. Suppressed and overtopped individuals tend to be most sensitive to infection, as rain splashed spores from neighboring trees can readily infect an entire crown. Branch die-back, especially near the bottom portion of the crown, has been observed in chronically diseased trees. As a result, trees with a high severity of infection tend to have relatively low live crown ratios (LCR < 30%) and high levels of crown transparency. Silvicultural thinning is currently being tested as a means to reduce the spread and severity of WPND within infected stands. Removing high risk trees and increasing the distance between crowns may mitigate the asexual dispersal of WPND-associated fungi. Following proper stocking guidelines for eastern white pine is being recommended to reduce both pathogen pressure and stress caused by intraspecies competition for resources (Leak and Lamson 1999).

Considering the drought that occurred throughout Massachusetts and southern New Hampshire during the summer of 2016, in conjunction with WPND defoliations, white pine has been exposed to high levels of both biotic and abiotic stress over the past year. A dry spring may act to mitigate WPND spread and severity. However, taking a close look at last year's drought we see that while April and May were classified and moderately dry in parts of the state, the climax of the drought occurred in mid-September (Fig. 5). Rather than reducing pathogen pressure, the 2016 drought likely further stressed eastern white pine, a species that is known to be somewhat drought tolerant, but also sensitive to dry soils. When white pine is exposed to

prolonged soil moisture deficit it will respond by closing stomata to reduce water use, however, by doing so it will inherently reduce photosynthesis, leading to further growth declines.

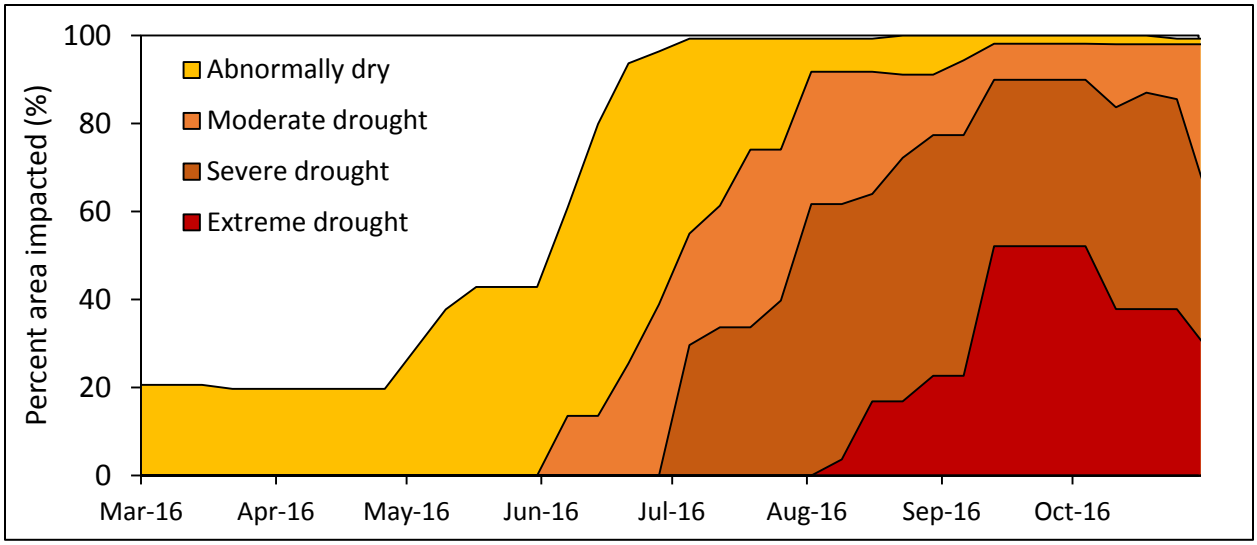

Figure 5. Drought report for the state of Massachusetts between March and October, 2016. Data obtained from the United States Drought Monitor (droughtmonitor.unl.edu): National Drought Mitigation Center (NDMC), the U.S. Department of Agriculture (USDA) and the National Oceanic and Atmospheric Association (NOAA).

<u>In summary:</u>

1. White Pine Needle Damage is a complex of several foliar fungal pathogens that may work independently or together to affect the health of infected trees.

2. Watch for symptoms of needle yellowing of the second and third year foliage in May and early-June. Defoliation typically begins in mid- to late-June and often continue into July.

3. Foliage cast during the summer months has been shown to have relatively high levels of nitrogen; consequently, infected ornamental and urban trees may benefit from nitrogen fertilization.

4. Infected stands of eastern white pine have been experiencing woody growth declines on the order of about a 40% reduction in basal area increment since ca. 2009.

5. At this time, it is recommended to maintain proper stocking levels for eastern white pine to mitigate WPND spread and severity; thinning high risk individuals such as suppressed trees and crowns that appear to have high rates of infection may help mitigate the impacts of WPND on the health of white pine stands.

Literature Cited:

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