CHAPTER 7

Monitoring Eastern White Pine Decline and Its Causes in New England and New York through Enhanced Survey Methods

Aaron Bergdahl
Isabel A. Munck
Rebecca Lilja
Jessica Cancelliere
Robert Cole
Josh Halman
Nicole Keleher
Kyle Lombard
Jen Weimer
Paul Ricard
John Stanovick

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INTRODUCTION

Eastern white pine (EWP) is a major component of forest types in New England and New York where it is found on 4.1 million acres, supporting its ecological importance as key habitat for many organisms. Representing EWP's regional economic importance, the estimated stumpage value of the resource in the Northeast likely exceeds $4.3 billion (USDA Forest Service, FIA program 2021).[1] In the decade prior to 2018, regionally prevailing cool and moist weather patterns during key infection periods for needle diseases and other fungal pathogens of EWP have led to a noticeable regional increase in EWP decline.

The need for this project came from calls to address regional EWP health issues identified as prominent concerns in the Forest Health Highlights reports from Massachusetts, Maine, New Hampshire, New York, Rhode Island, and Vermont since 2009. It was suspected that many cases of EWP decline were tied to chronic stress from repeated defoliation by the white pine needle damage (WPND) complex. In 2016, the documented acreage of WPND was 24,000 acres in New Hampshire and 30,600 in Vermont. However, it is understood that these numbers only partially represented the impacted acreage due to limited aerial surveys that were not always conducted at a time of peak WPND symptoms and the difficulty of viewing symptomology from top-down vantage points. Of further concern was that existing regeneration is often severely affected by WPND in the understory environment. This was viewed as a threat to sustaining EWP, as most of the region's EWP resource is mature with very little acreage in the seedling/sapling stand size class (Ken Laustsen, personal communication[2]).

To address this, a collaborative effort involving personnel from Massachusetts, Maine, New Hampshire, New York, Rhode Island, and Vermont led to the creation of a white pine decline survey and identification of the resources needed to accomplish it. The effort was made possible by funding from the U.S. Department of Agriculture Forest Service, Forest Health Monitoring program. The resources to complete both in-field plot work and surveys were in place by 2018, and field work was completed in that year. The project had diagnostic support from the Forest Service State and Private Forestry field office in Durham, NH, Cornell University, University of Massachusetts Amherst, and University of Rhode Island. For further analysis, long-term climate data were used from regional weather stations.

The objectives of this project were to (1) identify EWP stands with high- and low-intensity

[1] *Estimate comes from sawlog and merchantable volume estimates using U.S. Department of Agriculture Forest Service, Forest Inventory and Analysis (FIA) data and reported stumpage values (Maine Forest Service 2021; Vermont Department of Forest, Parks, and Recreation 2019–2021; New Hampshire Department of Revenue Administration 2021; New York Department of Environmental Conservation 2021; University of Massachusetts Amherst 2021). The FIA estimate is 31 million mbf (thousand board feet) sawlog volume across the States in question. We used a weighted estimate of $127 per mbf across all seven States. At $3 per green ton and less, the remaining merchantable volume in the tree (considered pulp here) adds relatively little to the overall stumpage value.*

[2] *Personal communication. 2021. Ken Laustsen, Biometrician, Maine Forest Service (retired), 17 Perennial Way, Oakland, ME 04963-5240.*

white pine needle damage (WPND) using a variety of data sources, survey methods, and tools such as aerial survey, on-the-ground survey, and existing remote sensing products; (2) assess site factors associated with disease severity levels adversely affecting overall EWP forest health leading to increasing mortality; (3) determine the disease complexes, in addition to WPND, associated with general EWP decline and reduced regeneration; and (4) develop management practices to lessen future mortality.

METHODS

Sites were selected prior to plot work based on species composition of at least 50-percent EWP by basal area. States used various survey methods to identify suitable sites that were selected based on a known history of WPND (unhealthy), or rarely, perceived absence of disease (healthy). Selected stands needed to be large enough to accommodate at least three of the four total inventory plots (prism plots, ≥5 acres). Prism plots (20-factor) were established based on Forest Service Forest Inventory and Analysis (FIA) methods. Plot IDs were labelled, and each plot center was marked with a pin, where latitude/longitude, slope, and aspect were recorded. A monument tree was then selected and marked.

All measurable trees were tallied and the following measurements were taken for living EWP trees: diameter at breast height (d.b.h.); crown position (dominant, co-dominant, intermediate, suppressed, or dead); live crown ratio estimated as 10-percent intervals; crown density estimated as 10-percent intervals; and crown transparency estimated as 10-percent intervals, all based on FIA methods. A WPND severity rating was assigned to each tree, generalizing the location of symptoms in the crown in thirds as bottom, middle, and top. This information was reinforced with estimates of WPND crown symptoms using the following ratings: 0 = no WPND symptoms; 1 = <1/3 crown affected; 2 = ≥1/3–2/3 crown affected; 3 = >2/3 crown affected. Other symptoms observed in the crown such as necrosis, flagging, insect defoliation, symptoms and signs of Caliciopsis canker (*Caliciopsis pinea*), and fungal fruiting bodies (such as decay fungi) were also recorded in the comments. Lastly, the species of the five closest seedlings (consistent with FIA definitions) and their distance to plot center were recorded for future estimation of per-acre seedling density as done in previous studies (Munck and others 2016). Presence/absence of disease on EWP seedlings was evaluated, paying special attention to the presence of WPND symptomatic needles and *Caliciopsis* fruiting structures. On some plots, this presented the best opportunity to collect WPND needle samples. Collected needle samples included branches with symptomatic needles, including current growth and up to 3-year-old needles if present, from several locations on the tree and at different plot locations. Collected samples were placed in separate 1-quart plastic bags and kept on ice in coolers in the field and refrigerated before being sent to cooperating diagnostic labs for fungal identification.

In most cases, data were recorded electronically using a data form created in the Survey123 application (app) by the Forest Service Durham, NH, field office. When survey crews were within cell range and able to access the internet, data were automatically uploaded to a remote server, securing data in real time and reducing the time needed for data entry. The Survey123 app also had a built-in function for recording images at the sites, so crews were encouraged to take pictures of the site and symptomatic trees.

RESULTS

A total of 122 stands (4 subplots each) were identified, and 4,419 trees were surveyed across the 6 participating States. Naturally established stands comprised 64 percent (78) of the plots, and 36 percent (44) were plantations. Highlighting the extent of particular and significant stressors impacting the region's EWP resource, WPND symptoms were recorded on 95 percent of stands, and Caliciopsis canker symptoms were recorded on 71 percent of stands (see fig. 7.1 for WPND and Caliciopsis canker symptoms).

The data presented in tables 7.1 and 7.2 show significant relationships between basal area and crown density and represent the main findings of this project. White pine needle damage severity was shown to increase with increasing stand basal area. Also, increased WPND severity was related to lower crown density in overstory trees. Further, and as expected, presence of causal agents of WPND was correlated with a decrease in crown density. The results suggest WPND symptoms increase within overstocked stands and WPND causal agents are associated with thinner crowns. The majority of samples submitted to diagnostic clinics were positive for the brown spot needle blight pathogen, *Lecanosticta acicola*. The second most frequently recovered pathogen was *Septorioides strobi*, with needle cast pathogens *Lophophacidium dooksii* and *Bifusella linearis* also recovered from symptomatic needles (see fig. 7.2).

DISCUSSION

Defoliation of EWP caused by the complex of WPND foliar fungi has been reported throughout the Northeast for over 10 years. Repeated defoliation has impacted the vigor and growth of EWP (McIntire and others 2018b). In combination with diseases such as Caliciopsis canker and unfavorable environmental factors, thousands of acres have been negatively impacted. The 122 EWP stands included in this work throughout New England and New York were identified using a variety of techniques including on-the-ground and enhanced aerial survey and the National Insect and Disease Risk Map (NIDRM) EWP host layer. This combination of techniques proved to be satisfactory for plot selection given the differing resources available to the participating States.

The results of this survey, the characteristics of EWP as a timber species, and long-term climatic conditions of wet spring seasons suggest the positive potential of low-density management for EWP. Eastern white pine is a species of intermediate shade tolerance that competes well with other vegetation, especially on sites with deep, sandy soils. Once established, EWP exhibits excellent height and diameter growth (Livingston and others 2019). Low-density management would reduce competition for water and light, enhancing establishment and making trees more resilient to

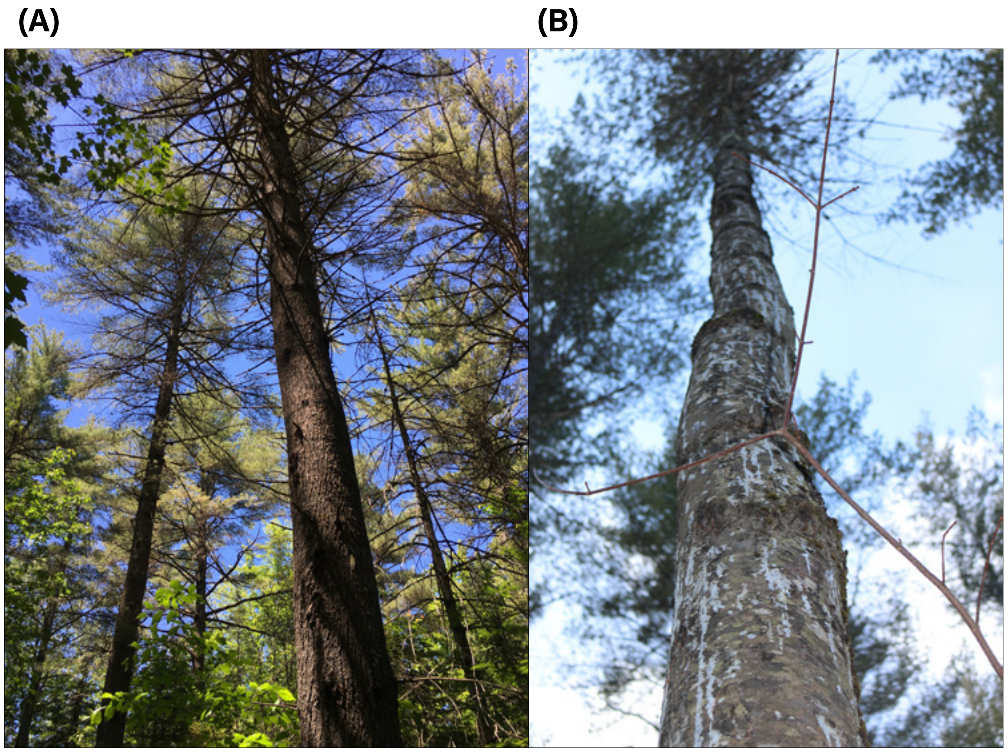

Figure 7.1—(A) White pine trees impacted by white pine needle damage with small, thin crowns and lower branch dieback. (B) Internodal sap streaking, a symptom of Caliciopsis canker. (Courtesy photo by A. Bergdahl, Maine Forest Service)

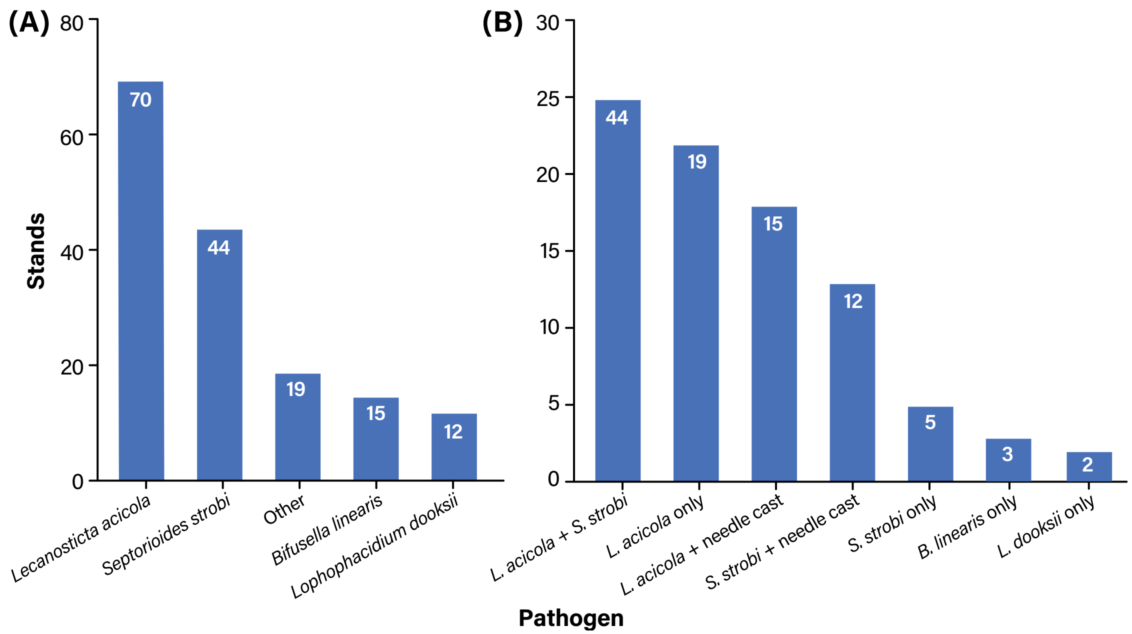

Figure 7.2—Pathogenic fungi recovered from eastern white pine samples collected from 92 stands of 112 in New England and New York. (A) Total number of plots where each pathogen was present. (B) Number of plots with different pathogen combinations. Bifusella linearis *and* Lophophacidium dooksii *are needle cast pathogens (from Munck and others, in preparation [see footnote 3]).*

Table 7.1—Descriptive statistics associated with collected variables (from Munck and others, in preparation [see footnote 3])

Variable	Mean	Standard deviation	Minimum	Maximum
White pine needle damage (WPND) severity rating (0–3) of trees	1.7	0.8	0	3
Proportion of trees with Caliciopsis canker symptoms	0.1	0.2	0	0.9
Live crown ratio	31.3	12.7	11.1	67.1
Crown density	45.7	8.5	27.6	66.8
Total basal area (square feet per acre)	272.2	136.5	33.1	767.5
Eastern white pine basal area (square feet per acre)	247.8	130.8	23.3	584
Proportion of basal area in white pine	88.8	12.4	34	100
White pine seedlings per acre	1,446	3,575	0	21,424
Proportion of white pine seedlings per acre with Caliciopsis canker	0.1	0.2	0	1
Proportion of white pine seedlings per acre with WPND	0.4	0.4	0	1
Longitude	-72	1.8	-76.6	-68.6
Latitude	43.5	0.8	41.5	45
Elevation (m)	224.9	149.2	20	645
Diameter at breast height (inches)	17.7	4.2	5.8	36.8

Table 7.2—Pearson Correlation Coefficients and Prob > |r| under H0: Rho = 0, between stand variables and disease variables, with significant relationships shown in bold (from Bergdahl and others 2020)

Variables	WPND severity for trees	Proportion of trees with Caliciopsis canker symptoms (percent)	Live crown ratio	Crown density	Total basal area (square feet per acre)	White pine basal area (square feet per acre)	Basal area in white pine (percent)	White pine seedlings per acre	White pine seedlings with Caliciopsis canker symptoms (percent)	White pine seedlings with WPND (percent)	Longitude	Latitude	Elevation (m)
Proportion of trees with Caliciopsis canker symptoms (percent)	-0.01188	1											
	0.8967												
Live crown ratio	0.01606	0.13297	1										
	0.8606	0.1443											
Crown density	**-0.33355**	-0.0825	0.09819	1									
	0.0002	0.3724	0.2881										
Total basal area (square feet per acre)	**0.20295**	-0.07971	-0.0427	-0.1496	1								
	0.0256	0.3848	0.642	0.1058									
White pine basal area (square feet per acre)	**0.23578**	-0.0656	-0.0255	-0.1488	0.98116	1							
	0.0089	0.4729	0.7804	0.1062	<.0001								
Basal area in white pine (percent)	0.12957	-0.0377	-0.0263	0.03626	**0.18573**	**0.32443**	1						
	0.1549	0.6801	0.7741	0.6954	**0.0414**	**0.0003**							
White pine seedlings per acre	**-0.20659**	-0.00882	-0.0205	-0.0148	**-0.2299**	**-0.2415**	-0.1314	1					
	0.0224	0.9232	0.8223	0.873	**0.0112**	**0.0074**	0.149						
White pine seedlings with Caliciopsis canker symptoms (percent)	**-0.18904**	0.03263	**0.22841**	-0.0222	**-0.2758**	**-0.279**	-0.1458	0.10076	1				
	0.037	0.7212	**0.0114**	0.811	**0.0022**	**0.0019**	0.109	0.2694					
White pine seedlings with WPND (percent)	0.10487	-0.16084	**0.25387**	0.08893	**-0.2481**	**-0.2395**	-0.0495	0.04954	**0.47433**	1			
	0.2503	0.0768	**0.0048**	0.3362	**0.0061**	**0.0079**	0.5885	0.5879	**<.0001**				
Longitude	0.16952	-0.15541	**0.55729**	-0.0259	-0.0805	-0.0698	-0.0614	-0.0014	**0.22035**	**0.5939**	1		
	0.0619	0.0874	**<.0001**	0.7802	0.3801	0.445	0.5021	0.9876	**0.0147**	**<.0001**			
Latitude	**0.23432**	0.14839	**0.50305**	0.0835	-0.0044	0.04887	0.14675	-0.1529	-0.07614	**0.16692**	**0.41854**	1	
	0.0094	0.1028	**<.0001**	0.3666	0.9615	0.5929	0.1068	0.0927	0.4045	**0.0661**	**<.0001**		
Elevation (m)	**-0.17461**	0.11577	**-0.2793**	0.08881	0.05778	0.06901	0.14756	-0.0407	**-0.19285**	**-0.5124**	**-0.7652**	**-0.1773**	1
	0.0544	0.2042	**0.0018**	0.3368	0.529	0.45	0.1048	0.6565	**0.0333**	**<.0001**	**<.0001**	**0.0508**	
Diameter at breast height (inches)	0.15475	-0.12722	**0.22937**	0.08311	**0.76916**	**0.75558**	**0.21177**	-0.1685	**-0.25065**	-0.06813	0.13658	0.14317	-0.08091
	0.0888	0.1626	**0.011**	0.3689	**<.0001**	**<.0001**	**0.0192**	0.0636	**0.0054**	0.4559	0.1336	0.1157	0.3757

WPND = white pine needle damage.

drought conditions. Reduced disease pressure from the causal agents of WPND associated with lower density stands described in this work would favor higher live crown ratios, increased growth (Livingston and others 2019), and resilience to other agents of decline. For example, stress reduction via lower density stands is thought to reduce incidence and severity of Caliciopsis canker. Reduced impacts of needle loss from WPND are also favored by low-density management, as this study showed that stand basal area was negatively correlated with WPND severity, and presence of WPND causal agents was correlated with decreased crown density. This further suggests that managing stand density would increase resilience to foliar diseases and decrease their incidence. This stands to reason, as increased spacing reduces dispersal of inoculum to adjacent trees (Wyka and others 2018) and enhances drying of foliage, therefore reducing colonization by WPND causal agents and preservation of higher live crown ratios, a strong indicator of tree vigor (McIntire and others 2018a). Further, due to the positive contributions to tree vigor mentioned here, faster growth leads to reduced rotation times, subsequently reducing exposure, impacts, and losses due to decay (Livingston and others 2019).

Stand basal area was found to be negatively correlated with number of seedlings, indicating the positive effect of this style of management on regeneration, and thus, future sustainability of the EWP resource (Munck and others, in preparation[3]).

CONCLUSIONS

The findings of this study support the idea that, under current climatic conditions which dictate disease conditions via increased prolonged periods of moisture during the infection period of WPND, low stand density leads to improved growing conditions, improved stand health, improved tree vigor, and improved regeneration. Thus, managing for lower stand density would not only increase resilience to foliar diseases but have additional positive impacts on the overall sustainability of the regional EWP resource. Although low-density management of EWP does not apply to all growing situations, it should be considered in areas with conditions conducive to disease, on drought-prone sites/soils, and on sites where agents of decline like pine bast scale (*Matsucoccus macrocicatrices*) and Caliciopsis canker are issues of concern. As a final conclusion, aerial survey, interstate coordination, and data collection with the Survey123 app was an efficient way to collect data from a wide geographic range, leading to the interesting results of this study.

For more information, contact:
Isabel A. Munck, Isabel.munck@usda.gov
Aaron Bergdahl, aaron.bergdahl@maine.gov

[3] *Munck, I.A.; Bergdahl, A.; Cancelliere, J. [and others]. Site factors associated with foliar diseases and Caliciopsis canker causing declining health of eastern white pine in Northeastern USA. Manuscript in preparation. Author can be reached at U.S. Department of Agriculture Forest Service, State and Private Forestry, 271 Mast Rd., Durham, NH 03824.*

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