CHAPTER 13.

Searching High and Low: Patterns of White Ash Health across Topographic Gradients in the Allegheny Region (Project NE-EM-09-02)

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INTRODUCTION AND PROJECT OBJECTIVES

White ash (*Fraxinus americana*) is an important species in eastern forests that is currently threatened by an introduced insect pest, the emerald ash borer (EAB) (*Agrilus planipennis*). Understanding the patterns of white ash health across the landscape prior to the arrival of EAB will enable us to better understand factors that affect forest health in general and will provide information on the ecology of a tree species of particular current interest. As EAB is known to be attracted to stressed ash trees, this knowledge may lead to improved risk maps and monitoring and detection strategies.

White ash decline has been a regional concern for many years, and recent decline episodes have increased interest in this problem. It is of particular interest within the Allegheny National Forest (ANF) in northwestern Pennsylvania. At the ANF, white ash is found at moderate abundances (< 5 percent of live basal area) mixed with other tree species, but it experiences the second highest levels of crown dieback (following sugar maple, *Acer saccharum*) of all the major tree species regionally. Drought and pathogens have been identified as factors contributing to and inciting ash decline (Han and others 1991), but nutrient deficiencies may play a role in predisposing ash trees to decline. White ash is a base cation-demanding species and is associated with soils with higher pH and greater base cation availability (Finzi and others 1998). Another base cation-demanding species, sugar maple, exhibits strong relationships between soil nutrition and decline (Horsley and others 2000). Within the unglaciated portion of the ANF, topographic position is related to nutrient deficiencies. Upper slope positions generally exhibit lower availability of base cations calcium (Ca) and magnesium (Mg) compared with levels at lower slope positions, which have good nutrition (Bailey and others 2004). Finally, based on observations of Morin and others (2006) and trends in the Forest Inventory and Analysis (FIA)/Forest Health Monitoring (FHM) data for the ANF, ash decline and mortality appears to be concentrated on ridgetops and upper slopes.

The objectives of this project were to assess white ash health status in the Allegheny Plateau region using an intensified ash health plot network to enhance existing FIA/FHM data. This enhanced sampling will enable us to explore how topographic position, elm spanworm

(*Ennomos subsignarius* [Hubner]) defoliation history, and other site characteristics are related to ash decline and mortality patterns across the landscape. In addition, we will create a formula to convert between FHM canopy health ratings (dieback, crown density, etc.) and a user-friendly health rating system developed for use by managers and based on the typical decline progression of ash trees infested by EAB. Finally, this enhanced ash monitoring plot system will serve as a basis to monitor future ash mortality with the anticipated arrival of EAB within the next 5 to 10 years.

BRIEF METHODS

We established new plots to enhance existing FIA/FHM spatial coverage across the ANF and capture a wide gradient of soil fertility (e.g., topographic gradient and soil parent materials). In cooperation with our collaborators from the ANF, we divided the entire forest ownership into a 1.88-by-1.44 mile grid and identified grid squares containing ash based on inventory data. Within each grid square, we systematically searched the area to locate a pair of plots containing white ash where one plot in the pair was established on a lower slope position and the other an upper slope position. We established a total of 193 plots across the entire ANF ownership. At each plot, we conducted an overstory inventory and an herbaceous species inventory (presence or absence) with an emphasis on indicator species strongly associated with base cation-rich sites. As part of the overstory inventory, we rated ash crown health of 538 white ash trees using two different methods:

1. A simple 1–5 categorical rating system developed for easy use by managers and based on the typical decline progression of EAB-infested ash trees (Smith 2006). In this system, a rating of 1 represents a healthy canopy, 5 is a dead canopy, and 2–4 are specific stages of thinning and dieback.

2. The standard numerical FHM phase 3 crown measurement methodology, including uncompacted live crown ratio, crown density, crown transparency, and crown dieback.[1]

A formula relating the two crown health methods was derived and tested on an independent dataset of ash stands in Ohio that

[1] U.S. Department of Agriculture Forest Service. 2007. Crowns: Measurement and Sampling. Section 12 in Forest Inventory and Analysis national core field guide, volume 2: field data collection procedures for phase 3 plots, version 4.0. U.S. Department of Agriculture Forest Service, Washington Office. Internal report. On file with: U.S. Department of Agriculture Forest Service, Forest Inventory and Analysis, Rosslyn Plaza, 1620 North Kent Street, Arlington, VA 22209.

were in various stages of infestation by EAB. To assess whether health ratings were related to deficiencies in base cations, we collected leaves from the focal ash tree in each plot to assess foliar nutrition. Leaves were dried and analyzed for macronutrients and micronutrients, including Ca and Mg. To assess whether health ratings were related to past infestation by insects, defoliation records from aerial surveys were used to determine the number of times each stand was defoliated by elm spanworm, a species known to defoliate ash.

RESULTS AND CONCLUSIONS

Conversion formula

The FHM measures of ash tree health most closely related to the categorical health rating system were canopy density and canopy dieback. The full details of this analysis and the conversion formulas are published in Royo and others (2012). The relationship between FHM crown density and categorical crown health ($R^2 = 0.65$) gave correct predictions with the independent dataset from Ohio 71 percent of the time when dead trees were excluded (82 percent when dead trees were included). The relationship between FHM crown dieback and categorical crown health ($R^2 = 0.91$) gave correct predictions with the independent dataset 93 percent of the time when dead trees were excluded (97 percent including the dead trees). The latter model gave poor predictions for crown health category 4 trees, however, due to differences in considering only recent dieback of twigs for FHM and all dead branches in the tree for the categorical ratings.

Nutrient differences

Foliar nutrient data showed that Ca and Mg foliar concentrations were greater on lower slope positions than upper slope positions. The incidence of herbaceous plants known to track base cation availability was also greater on lower slope positions and was correlated with the foliar base cation data. This relationship between topographic position and base cation availability is a known phenomenon in unglaciated areas of the ANF, likely caused by leaching of nutrient-rich stratigraphic layers.

Ash health

Ash health was related to topographic position, base cation concentrations, insect defoliation history, and tree diameter at breast height. Crown dieback was greater on upper slope positions than on lower slope positions (fig. 13.1). Greater crown dieback was associated with lower base cation concentrations on the upper slope positions. Categorical crown health ratings also showed poorer crown health on upper slope positions. Upper slope positions with lower base cation concentrations or with a history of defoliation by elm spanworm had the poorest crown health. In addition, crown health was poorer for smaller trees. Standing dead ash trees showed similar relationships to site characteristics. The relative abundance of dead ash trees was greater on sites with upper slope positions, lower base cation concentrations, smaller trees, and a history of elm spanworm defoliation (fig. 13.2). A manuscript including the full details of the ash health, nutrient, and defoliation findings has been published (Royo and Knight 2012).

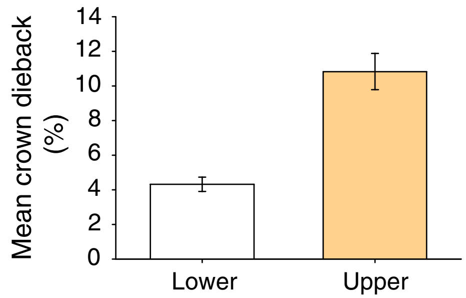

Figure 13.1—Crown dieback of white ash trees was greater on upper slope positions than lower slope positions. (Reproduced from Royo and Knight 2012.)

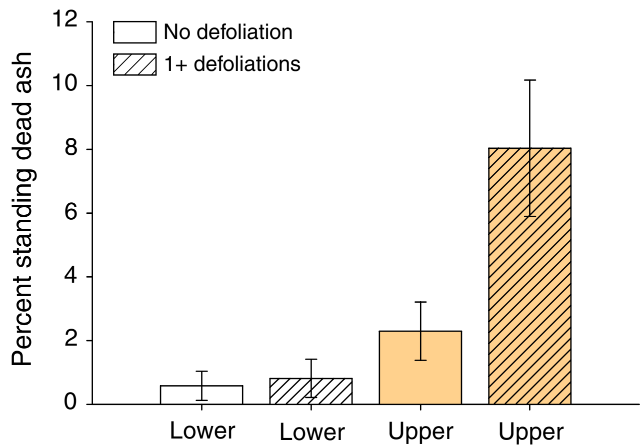

Figure 13.2—Percent standing dead white ash was greater on upper slope positions, especially in areas with a history of defoliation by elm spanworm. (Reproduced from Royo and Knight 2012.)

Our data show that multiple factors may interact to influence ash crown health, dieback, and mortality and that there are particular sites where a "perfect storm" of poor nutrition and defoliation stress may lead to especially poor health and greater ash mortality. Topographic position appears to stress ash trees due to low base cation availability on upper slope conditions. Elm spanworm defoliation further exacerbates the poor health of the already stressed trees.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

This study provided a landscape-level picture of white ash health and its relationship to topographic position, past defoliation events, and nutrient availability. The synergistic interactions among these factors can create conditions that lead to dieback and death of ash trees. Our results suggest that management of upper slope areas with low nutrient availability to favor nonash species that may have better health and survival in these conditions could lead to improvements in forest health.

As future stressors occur in forest landscapes, their distribution and effects on trees will be affected by the underlying patterns of tree stress that already exist. Understanding these patterns can help us predict the effects of and possibly respond to future threats. For example, EAB, an introduced pest that kills ash trees, is known to be attracted to stressed ash trees, and stressed ash trees are known to die more rapidly than healthy trees in EAB-infested areas. The results of our study could assist in management planning and improve EAB detection by targeting high-risk areas.

CONTACT INFORMATION

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