HWA Risk Assessment in Deer Wintering Areas of Southern Vermont

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ABSTRACT

Hemlock woolly adelgid (HWA), *Adelges tsugae* Annand, an introduced aphid-like insect from Asia, is threatening to eliminate eastern hemlock, *Tsuga canadensis* (L.) Carr., throughout its range. Among its many ecological functions, eastern hemlock provides winter cover and browse for white-tailed deer, *Odocoileus virginianus* Zimmerman, in areas experiencing harsh winter conditions. In central and southern Vermont, eastern hemlock is the basic component of many white-tailed deer wintering areas (DWA) and is thought to reduce snow depths and moderate temperatures. The first objective of this study is to determine the relative risk of HWA infestation to the eastern hemlock dominated DWAs in southern Vermont. The eastern hemlock component of conifer dominated DWAs will be determined and used in a GIS model predicting the susceptibility and vulnerability of DWAs to HWA infestation. A sub-sample of thirty-two DWAs in southern Vermont were inventoried in summer and fall of 2004 for analysis. The second objective is to quantify the effects of eastern hemlock cover on winter temperature and snow depth conditions. Within six site-paired hemlock and hardwood stands, temperatures were recorded half-hourly and snow depths were recorded biweekly in the winters of '03-'04 and '04-'05. Preliminary results indicate that extreme temperatures are moderated and snow depth is reduced within eastern hemlock stands as compared to site-paired hardwood stands. The elimination of eastern hemlock from the forests of southern Vermont by HWA would greatly alter the local ecology and will dramatically affect species reliant upon hemlock stands for winter habitat.

KEYWORDS

Tsuga canadensis, Odocoileus virginianus, Adelges tsugae, winter, risk assessment.

INTRODUCTION

Eastern hemlock, *Tsuga canadensis* (L.) Carr, represents the most important deer wintering area (DWA) cover type in southern Vermont (Reay et al. 1990), and the removal of this cover by hemlock woolly adelgid, *Adelges tsugae* Annand (HWA), has the potential to negatively affect white-tailed deer, *Odocoileus virginianus* Zimmerman, populations and health. It is believed that, for deer living in areas with severe winters, the two main factors leading to winter hardship are cold temperatures and deep snow pack (Verme 1968). Eastern hemlock is

considered to be one of the most shade-tolerant species in North America (Goerlich and Nyland 1999) and grows in stands with particularly dense foliage, which is thought to reduce radiant heat loss and intercept falling snow. Thus, it is assumed that temperatures beneath hemlock canopies are moderated and snow depth is decreased, but this has not been statistically quantified. Dominant overstory vegetation replacing dying eastern hemlock tends to be exclusively hardwood species (Orwig and Foster 1998, Orwig and Kizlinski 2002), and therefore current winter conditions within hardwood stands approximate those of HWA aftermath forests.

The methods required to accurately remotely sense eastern hemlock are not yet developed. As a result, a large scale eastern hemlock coverage map of Vermont is not available, whereas an extensive GIS data layer of the DWAs of Vermont is available (VCGI 2003). Thus, the conifer component of the DWA GIS layer is currently the best approximation of an eastern hemlock coverage map for southern Vermont.

The primary objective of this study is to determine the relative risk of HWA infestation to the eastern hemlock dominated DWAs in southern Vermont. The second objective is to compare winter environmental conditions in hemlock stands versus hardwood stands to quantify some of the potential effects of HWA induced defoliation on important winter habitat elements.

METHODS

RISK ASSESSMENT OF DEER WINTERING AREAS

A random subsample of 32 DWAs in southern Vermont was selected for field surveying in the summer of 2004 from three elevations and three size classes. One sampling plot was assigned for every 40 acres of conifer and mixed cover within each site. Plot data included: DBH of trees within a 10-factor prism plot, understory stems and percent cover by species, groundcover stems and percent cover by species, and crown transparency. At the stand level, data will be evaluated for elevation and size class trends in the eastern hemlock component of DWAs. At the plot level, a spatial statistical analysis will be performed relating site attributes (slope, aspect, elevation, edaphic characteristics, and distance from streams) and eastern hemlock occurrence in order to create a GIS model predicting eastern hemlock occurrence in the landscape.

Spatial statistical analysis using the HWA risk assessment GIS layers (Machin 2003) and vegetation data will be done in order to classify the DWAs of southern Vermont into low, medium, and high risk categories based upon the estimated eastern hemlock component and vulnerability and susceptibility to HWA infestation.

WINTER HABITAT ASSESSMENT

To compare important white-tailed deer winter habitat conditions in hardwood versus hemlock stands, three sites were chosen for study in winter ’03-’04 and six sites in winter ’04-’05. Sites were selected across a range of aspects and elevations in order to account for the effects of landscape diversity within DWAs. Eastern hemlock and hardwood site-pairs were se-

lected within each site with corresponding slope position, aspect, elevation, and proximity to control for between site-pair environmental variability.

Three temperature data loggers per half site-pair were attached at breast height to the north side of the boles of selected overstory trees serving as plot centers within each site. The degree of snow compaction and the extent of snow crust formation were measured on a bi-weekly basis from January-April '04 and December-April '04-'05 using a snow compaction devise based on the design of Verme (1968). Four measurements of effective and true snow depths were measured along randomly assigned directions stretching from plot centers.

PRELIMINARY RESULTS

Temperature and snow depth data from '03-'04 were analyzed for differences between cover types within site-pairs (Figures 1 and 2 and Tables 1 and 2).

CONCLUSIONS

With HWA populations less than two miles south of the border in Massachusetts, the state of Vermont is on the verge of infestation. It is extremely important for Vermont land and wildlife managers to prepare for the inevitable ecological changes that will accompany the mortality of eastern hemlock. Evaluating the potential risk of HWA introduction and establishment in the DWAs of Vermont is important for two specific reasons: 1) the DWA GIS layer is currently the best approximation of an eastern hemlock coverage map for the state of Vermont and 2) eastern hemlock provides invaluable winter habitat to white-tailed deer in the northern portion of their range. Information gleaned from the GIS analysis will be valuable for land and wildlife managers concerned both with hemlock forests and with the wildlife species that depend upon them. In addition, spatial analysis may provide a widely applicable predictive model for creating a region-wide eastern hemlock coverage map. Results of this study will help prioritize eastern hemlock DWA management activities in preparation for the probable infestation by HWA. The snow depth and temperature study will quantify the buffering capacity of eastern hemlock on winter conditions that has long been assumed. Lastly, this study will hopefully promote further scientific inquiry into the ecological implications of eastern hemlock removal on winter conditions.

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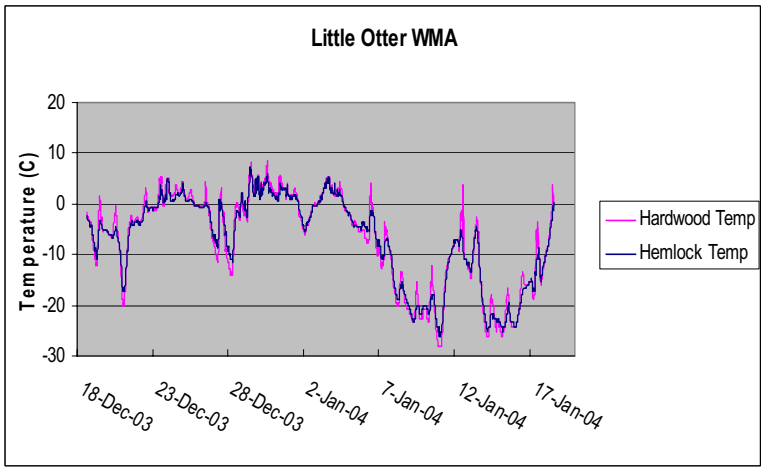

Figure 1. Graph exhibiting the buffering of extreme temperatures under an eastern hemlock canopy in the winter of '03-'04.

Table 1. P-values of a one-way ANOVA testing for temperature differences between hardwood and hemlock stands in winter '03-'04.

	Little Otter WMA	Otter Creek WMA	Gale Meadows WMA
Day maximum temperature	p < 0001	p = .0158	p = .0033
Day mean temperature	p = .005	*	*
Night mean temperature	p = 0.562*	*	*
Night minimum temperature	p = .0314	*	*

* No statistical significance.

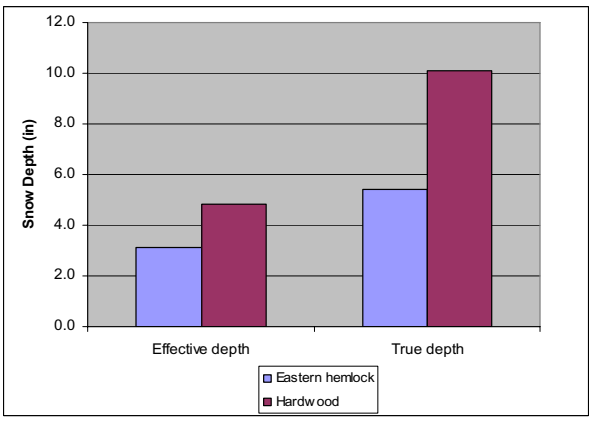

Figure 2. Winter '03-'04 overall average snow depths in eastern hemlock versus hardwood stands.

Table 2. P-values of a t-test assessing the average daily difference between snow depths in site paired hardwood and hemlock stands.

	p-value
Average True	0.002*
Average Effective	0.1025
Between Tree True	0.004*
Under Tree True	0.0025*
Between Tree Effective	0.0841
Under Tree Effective	0.1384

* Significant at $\alpha < .05$

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