Spatial and Temporal Relationships Between Forest Bird Declines and Prevalence of the Hemlock Woolly Adelgid in the Northeastern United States

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Spatial and Temporal Relationships Between Forest Bird Declines and Prevalence of the Hemlock Woolly Adelgid in the Northeastern United States

Abstract
The eastern hemlock (Tsuga canadensis) is a vital foundation tree species throughout the eastern United States, providing essential structural diversity and habitat for more than 120 different animal species. Within the past few decades, T. canadensis has undergone significant declines that are largely associated with the hemlock woolly adelgid (HWA; Adelges tsugae), an exotic, aphid-like insect native to East Asia. From the 1970s to present day, the HWA has spread throughout southern New England, large portions of the Mid-Atlantic region, and parts of Tennessee and the Carolinas. Research has shown that loss of the eastern hemlock is drastically altering forest community structures, potentially impacting a wide variety of forest fauna, including avian populations strongly associated with hemlock forests. Here we present research investigating the correlation between HWA prevalence and recent declines of hemlock-associated forest birds in the Eastern US. We analyzed bird population trends data from the North American Breeding Bird Survey (BBS), US Forest Service HWA data, and land cover data to analyze the population trends of hemlock-associated and forest generalist species in association with the arrival of HWA, taking hemlock density into account. We found a significant correlation between the timing of HWA arrival and declines of conifer forest specialist birds. The Black-throated Green Warbler and the Blue-headed Vireo exhibited significant decline along survey routes after HWA arrival. Populations of some forest generalists (Tufted Titmouse, White-Breasted Nuthatch) were unaffected and continued to increase linearly, while others (Red-Eyed Vireo, Ovenbird) showed minor decrease in population.

Keywords
Eastern Hemlock, bird habitat, bird populations

Disciplines
Environmental Health and Protection | Environmental Monitoring | Environmental Sciences | Poultry or Avian Science

Comments
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The eastern hemlock (Tsuga canadensis) is a vital foundation tree species throughout the eastern United States, providing essential structural diversity and habitat for more than 120 different animal species (Nackollos et al. 2009; Zakewitz et al. 2014). Within the past few decades, T. canadensis has undergone significant declines that are largely associated with the hemlock woolly adelgid (HWA; Adelges tsugae), an exotic, aphid-like insect native to East Asia (Orwig et al. 2008; Ross et al. 2004). From the 1970s to present day, the HWA has spread throughout southern New England, large portions of the Mid-Atlantic region, and parts of Tennessee and the Carolinas (Figure 1; US Forest Service 2013).

### Introduction

The hemlock woolly adelgid is an exotic insect native to East Asia (Orwig et al. 2008; Ross et al. 2004). From the 1970s to present day, the HWA has spread throughout southern New England, large portions of the Mid-Atlantic region, and parts of Tennessee and the Carolinas (Figure 1; US Forest Service 2013).

### Methods

**Our study included 746 Breeding Bird Survey (BBS) routes within the Appalachian and North Atlantic Landscape Conservation Cooperative regions (LCCs; Figure 2). BBS routes are surveyed once during prime bird breeding season (late May to early July) every year. Each BBS route is comprised of 50 point counts where all birds seen or heard within a 400 meter radius are counted. Year of HWA infestation, by county (US Forest Service 2013) was then attributed to each route. For routes where infestation occurred during the period 1966 to 2013 (n=471), we assigned the year of infestation as year=0, then estimated trends during the period 10 years prior to 10 years post infestation. Population trends were estimated using log-linear regression models with Poisson error terms, in program TRIM (Pannekoek & Van Strien 2005).**

### Results

**Table 1: Year of change point in population trends of 13 forest birds, where 0 represents the year of HWA infestation. Significance of change points assessed with Wald tests. Population trends calculated using program TRIM (Pannekoek & Van Strien 2005).**

<table>
<thead>
<tr>
<th>Species</th>
<th>Year of change point</th>
<th>Test Statistic</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black-throated Green Warbler</td>
<td>4</td>
<td>4.53</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Blue-headed Vireo</td>
<td>4</td>
<td>4.53</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hermit Thrush</td>
<td>4</td>
<td>4.53</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Blackburnian Warbler</td>
<td>0</td>
<td>6.19</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Eastern Wood-Pewee</td>
<td>0</td>
<td>6.19</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Red-eyed Vireo</td>
<td>0</td>
<td>6.19</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>White-breasted Nuthatch</td>
<td>0</td>
<td>6.19</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Black-throated Green Warbler</td>
<td>0</td>
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</tr>
</tbody>
</table>

**To rule out the possibility that other large-scale environmental stressors have driven recent forest songbird declines, we assessed changes in forest cover within 400 m buffers of each BBS route. We calculated the percent total forest (coniferous, mixed forest, deciduous forest, woody wetlands) and coniferous and mixed forest cover (coniferous forest, mixed forest) using 2001 and 2011 land cover (USGS National Landcover). We tested for significant changes in forest cover using paired t-tests. We conducted a more thorough examination of changes in forest cover around BBS routes in Pennsylvania (n=104) from 1992 to 2011 using Fragstats (McGarigal et al. 2012).**

### Conclusions

Recent population declines of two hemlock-associated bird species show patterns that are consistent with the hypothesis that declines are associated with HWA. However, to fully eliminate other environmental stressors, spatio-temporal models will be needed to account for spatial autocorrelation in the data. A potential limitation to our analysis is that hemlock-associated birds are not hemlock specialists, but rather, conifer generalists. Hence, in areas where there are alternatives to hemlocks as nesting and foraging habitat, the effects of HWA may be buffered.

### Literature cited


References


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Relationships between forest bird declines and Hemlock Woolly Adelgid prevalence in the eastern United States

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