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

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

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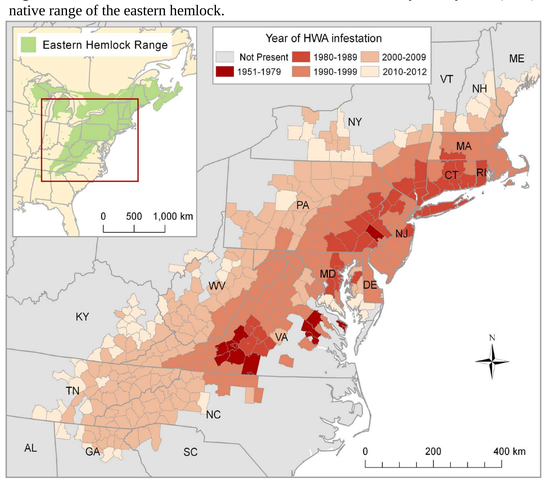
Introduction

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 (Nuckolls et al. 2009; Zukswert 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).

Figure 1. Year of initial HWA infestation in the United States by county, and (inset) native range of the eastern hemlock.



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 (Nuckolls et al. 2009; Ross et al. 2004; Tingley et al. 2002). Some forest bird populations have exhibited considerable decline in the past few years, after long periods of recovery (Figure 2; Sauer et al. 2014). Forest bird declines could be due to the spread of HWA, but this has yet to be confirmed.

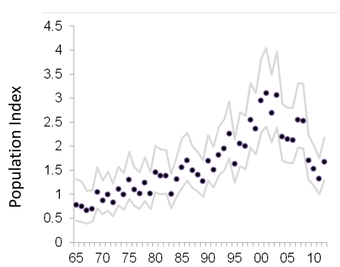


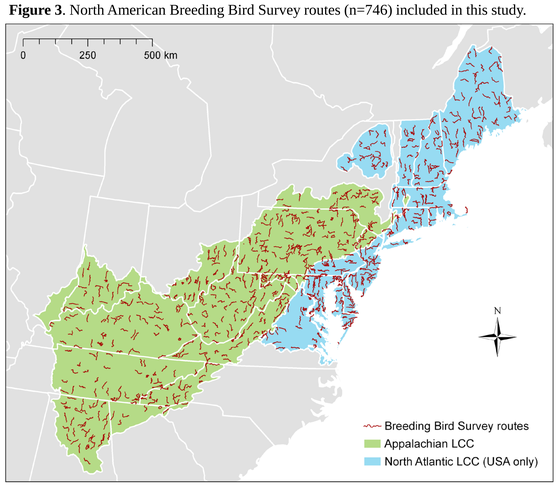
Figure 2. Population index (with 95% confidence intervals) of the Black-throated Green Warbler *Dendroica virens* in Pennsylvania 1966-2013. Data retrieved from The North American Breeding Bird Survey (Sauer et al. 2014)

Here we present research investigating the spatial and temporal correlation between areas of HWA infestation and the decline of hemlock-associated forest birds, across most of the eastern hemlock's range.

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 joined to BBS routes in ArcMap 10. Infestation in the county in which the majority (or plurality) of each BBS route is found 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). We estimated significant change points in the years following infestation could indicate a significant effect of HWA on forest bird populations. We conducted the analysis on 13 forest bird species, including some species strongly associated with hemlocks, and forest generalists that are unlikely to be affected by HWA.

Figure 3. North American Breeding Bird Survey routes (n=746) included in this study.



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 forest, 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).

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).

Species	Year of change point	Wald Test	p
Eastern Wood-Pewee		0.83	n.s.
Blue-headed Vireo	9	4.32	<0.05
Red-eyed Vireo		3.36	n.s.
Tufted Titmouse		1.81	n.s.
White-breasted Nuthatch	4	4.53	<0.05
Hermit Thrush		2.24	n.s.
Wood Thrush		0.82	n.s.
Magnolia Warbler		2.97	n.s.
Black-throated Green Warbler	3	19.25	<0.001
Blackburnian Warbler	0	6.19	<0.05
Ovenbird		1.35	n.s.
Hooded Warbler		2.55	n.s.
Scarlet Tanager		3.31	n.s.

Figure 4. Population trends of four bird species from 10 years prior to 10 years post HWA infestation. Vertical blue line indicates year of infestation. Linear trends with change points fitted in program TRIM (Pannekoek & Van Strien 2005).

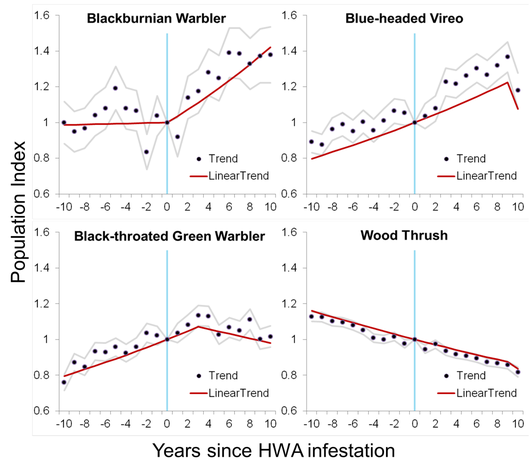


Table 2. Paired two-sample t-test for means, analyzing the significance of changes in percent forest cover in HWA infested and non-HWA infested regions between 2001 and 2011.

Forest cover type	2001	2011	Change	p
% forest	56.80	56.23	-0.569	<.001
% coniferous forest	14.76	14.60	-0.164	<.001
% forest, HWA regions	55.92	55.37	-0.544	<.001
% coniferous Forest, HWA	13.83	13.68	-0.148	<.001

Table 3. Paired two-sample t-test for means, analyzing the significance of changes in Pennsylvania forest metrics between 1992 and 2011. Class metrics calculated using Fragstats.

Forest metrics in Pennsylvania	Mean 1992	Mean 2011	Change	p
Total area (sq. m)	1,674	1,690	16	n.s.
Largest Patch Index (%)	23.2	22.8	-0.4	n.s.
Edge density (m/ha.)	68.5	64.1	-4.4	<.001
Core area percent of landscape	23.7	24.5	0.8	<.001
Number of disjunct core areas	52.7	53.0	0.3	n.s.

Results (continued)

The Blue-headed Vireo and the Black-throated Green Warbler populations showed significant downward changes in population trajectories after HWA infestation (Table 1, Figure 4). The Blackburnian Warbler and White-breasted Nuthatch show significant upward change in population trajectories during and after the year of HWA infestation (Table 1, Figure 4). The remaining species showed no significant change in population trend.

Total forest cover and evergreen forest cover showed small but statistically significant decline between 2001 and 2011 (Table 2). Forest edge density declined significantly in Pennsylvania, and core area percent of landscape significantly increased (Table 3).

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

McGarigal, K., SA Cushman, and E Ene. 2012. FRAGSTATS v4: Spatial Pattern Analysis Program for Categorical and Continuous Maps. Computer software program produced by the authors at the University of Massachusetts, Amherst.

Nuckolls, A. E. et al. 2009. Hemlock declines rapidly with hemlock woolly adelgid infestation: Impacts on the carbon cycle of southern Appalachian forests. *Ecosystems*, 12: 179-190.

Orwig, D. A. et al. 2008. Multi-year ecosystem response to hemlock woolly adelgid infestation in southern New England forests. Canadian Journal of Forest Research, 38: 834-843.

Pannekoek J., & Van Strien A. 2005. *TRIM 3 Manual*. Trends and indices for monitoring data. Research paper 0102. Voorburg, The Netherlands: Statitics Netherlands, CBS.

Ross, M. R. et al. 2004. Mesohabitat use of threatened hemlock forests by breeding birds of the Delaware River Basin in northeastern United States. *Natural Areas Journal*, 24(4): 307-315.

Sauer, J. R., et al. 2014. The North American Breeding Bird Survey, Results and Analysis 1966–2012: Version 02.19.2014. USGS Patuxent Wildlife Research Center, Laurel, MD.

Tingley, M. W., et al. 2002. Avian response to removal of a forest dominant: Consequences of hemlock woolly adelgid infestations. *Journal of Biogeography*, 29: 1505-1516.

US Forest Service. 2013. Forest Health Protection – Hemlock Woolly Adelgid: Distribution Maps. http://na.fs.fed.us/fhp/hwa/maps/distribution.shtm.

Zukswert, J. M. 2014. Forest community structure differs, but not ecosystem processes, 25 years after eastern hemlock removal in an accidental experiment. *Southeastern Naturalist*, 13(Special Issue 6): 61-87.

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