HEMLOCK WOOLLY ADELGID: CLIMATE CHANGE AND RANGE EXPANSION

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Introduction

The Hemlock Woolly Adelgid (*Adelges tsugae*, HWA) is an invasive forest pest that was introduced to the Eastern U.S. in 1951. The HWA feeds on Eastern Hemlock (*Tsuga canadensis*) trees, which are an important component of the climax forest in Maine (Northern Research Station 2010, Carey 1993). These slow growing, shade tolerant trees will often die within 6 years of a HWA infestation. While much of the East Coast has seen devastating HWA outbreaks, Maine has largely been spared due to the HWA's inability to survive in a colder climate (Paradis et al. 2007).

However, with warming winter temperatures due to climate change, it is possible that this protection could disappear in the future (NOAA). In this study, I use GIS techniques to quantify the amount of forest vulnerable to HWA invasion in the coming years.

Background

New England has already seen its fair share of damage due to invasive pests. Between the chestnut blight and Dutch Elm disease, this region has already seen dramatic shifts in species composition. It is therefore that much more important to detect, and preferably prevent, future large-scale disturbances.

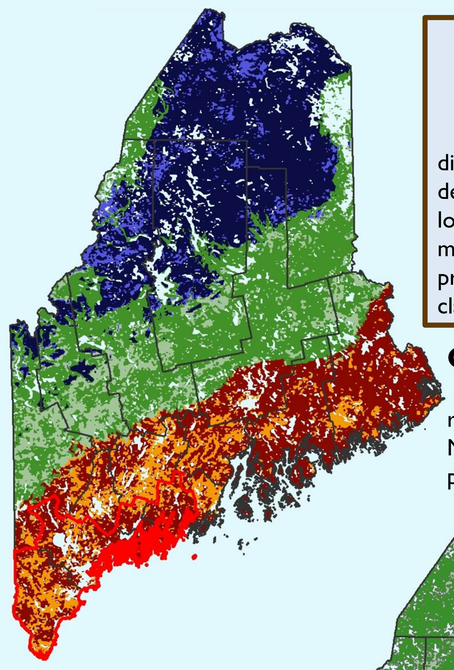
Methods

I obtained county-level HWA invasion data from the North Eastern Forest Service, with the most recent infestation occurring in 2010 (2013). Land cover data was obtained from the USGS 1992 National Land Cover Dataset. Current climate data was obtained from a model based off Hijmans et al. (2005). This data consisted of January minimum temperatures, averaged over the last 50 years. Predicted climate change data was obtained from the Intergovernmental Panel on Climate Change (IPCC) for the years 2020 and 2050. I used SRES B1, the most conservative model, which predicts a 1.1 to 2.9˚C increase by 2050. All spatial analysis was done in ArcGIS 10.0.

I reclassified the land cover to represent habitat suitability for HWA, where coniferous and mixed forest types were highly suitable (high impact zones), deciduous forest types were somewhat suitable (low impact zones), and everything else was not suitable. I reclassified all three temperature layers into warm, medium, and cold regions based on whether they never reached temperatures below -15 ˚C , reached temperatures between -15 ˚C and -18 ˚C , or reached temperatures below -18 ˚C , respectively. These temperature ranges are more conservative than what is given in the literature (typically -25 - -35 ˚C) as necessary to kill HWA.

In Maine, HWA are expected to be able to increase their range at about 8km per year (Evans and Gregoire 2006). For each map, I created a buffer out from the infected counties to depict the range for the region susceptible to infestation.

Finally, I intersected the temperature, land cover, and HWA range layers for each time period. I determined the amount of land that was susceptible to HWA infestation, its degree of protection, the level of impact. For each combination of criteria (e.g., Warm, High Impact) I found the percentage change in infested hectares between the current model and each of the future time periods, holding the HWA range constant. This metric explains the percentage increase in HWA range attributable to climate change.



Woolly Adelgid Range Expansion in Maine

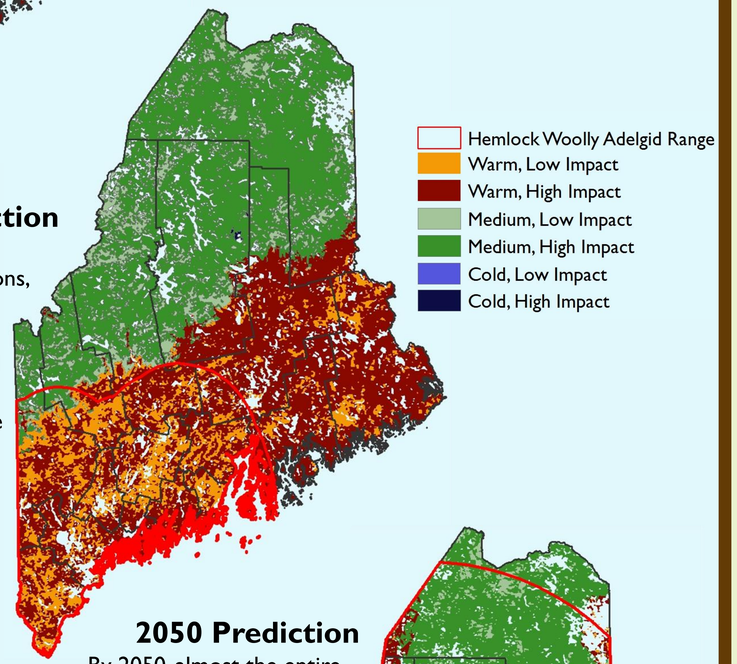
For each time period, the state of Maine is divided into three Climatic Zones. The Blue zone denotes regions that are very protected due to very low winter temperatures. The Green zone is moderately protected, and the Red zone is not protected at all. Within each zone, forest types are classified as either High Impact or Low Impact.

Current Estimation

As of 2010, HWA infestations have only been reported in the four southernmost counties of Maine. Much of the state is completely or partially protected from infestation.

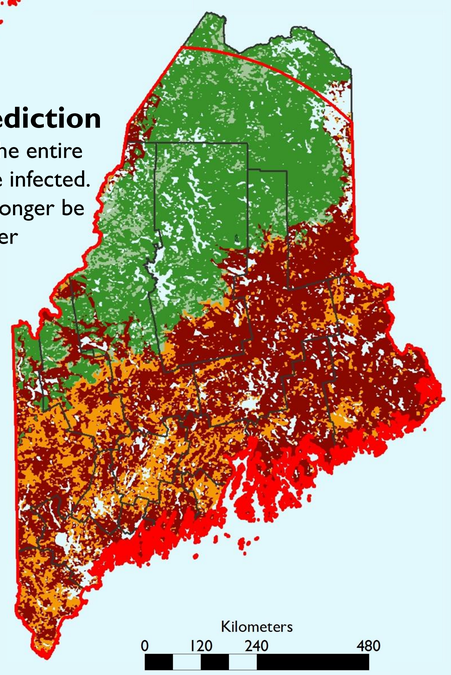
2020 Prediction

By 2020, even under the most conservative predictions, virtually no forest in Maine will be completely protected. The adelgid will be able to spread from the initial four counties into the High Impact coniferous forests in the north.



2050 Prediction

By 2050, almost the entire state of Maine could be infected. Most of Maine will no longer be protected by cold winter temperatures at all.



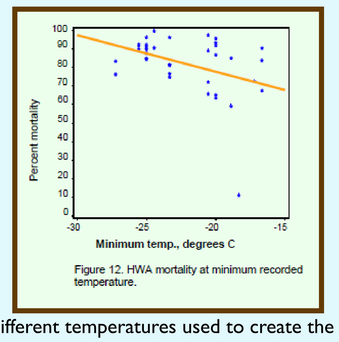


Figure 12. HWA mortality at minimum recorded temperature.

The different temperatures used to create the climatic zones correspond to different levels of mortality in HWA. Figure taken from Shields and Cheah (2003)

Results

Table 1: For each climate zone (partial or no protection) and forest type (high or low impact), percent change in hectares of infected forest between current climate conditions and climate change predictions for each time zone is displayed. Furthermore, percent of total Maine forests is calculated and displayed in the final column.

Time Period	Non-Protected (Percent change)		Partial-Protection (Percent change)		Percent of Maine at Risk
	High impact	Low impact	High impact	Low impact	
Current (2010)	--	--	--	--	7.5
2020	45	35	-90	-84	27.8
2050	82	97	-38	13	96.8

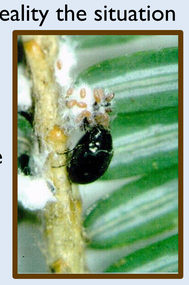
In 2020, climate change results in a dramatic shift in amount of protected forest. 45 percent more high impact forest will be infected without any climatic protection than if the climate did not change until 2020. Furthermore, 90 percent less high impact forest will have even partial protection under the climate change scenario.

By 2050, over 80 percent more infected high impact forest will be unprotected under the climate change scenario. 38 percent less high impact forest will have partial-protection if winter temperatures warm.

The total amount of infected forest in Maine increased from the current level 7.5 percent to over 25% by 2020 to over 95% by 2050.

Conclusions and Implications

By 2050, virtually the entire state of Maine could be at risk of HWA invasion. This can largely be attributed to climate change. After 40 years far more forest will be susceptible if the winter climate warms than if it remains constant. Furthermore, my model was conservative with regards to every variable, meaning that in reality the situation could be substantially worse.



The results of this study clearly implicate that serious thought needs to be given towards how to control the spread of this pest. Already, certain towns in Maine have issued a quarantine on Hemlock to control the dispersal of HWA. Predacious beetles have also been released, with the hopes that they will keep HWA numbers down. I recommend that future studies take into account the effect of climate change on these biological control mechanisms as well.

The loss of the hemlock in Maine would be devastating. It is the most shade tolerant tree in Maine, and greatly alters the environment in which it is found in addition to providing important deer wintering areas and forage for many animals (Carey 1993).

Acknowledgements

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