Status of Hemlock in the Eastern United States

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This science update provides an overview of the status and extent of the hemlock resource in the Eastern United States. The overview is based on inventories conducted by the Forest Inventory and Analysis (FIA) Programs at the Northern and Southern Research Stations, research conducted by scientists at the Northern Research Station, and pest surveys conducted by the State & Private Forestry Program of the U.S. Department of Agriculture Forest Service.

Distribution of Hemlock

Two native species of hemlock are found in Eastern North America. Eastern hemlock (*Tsuga canadensis*) is a minor component of the forest resource in much of the Eastern United States, but forests with the highest densities of eastern hemlock are located in New England and the mountainous portions of the Southeast and Mid-Atlantic (fig. 1). The second species, Carolina hemlock (*T. caroliniana*) is similar in appearance to eastern hemlock but is found only on rocky mountain slopes in a limited region covering portions of southwest Virginia, western North Carolina, extreme northeast Georgia, northwest South Carolina, and eastern Tennessee. The highest volumes of hemlock are found in the forests of New York, Maine, and Pennsylvania, but significant numbers of hemlock trees are present in many States (table 1).

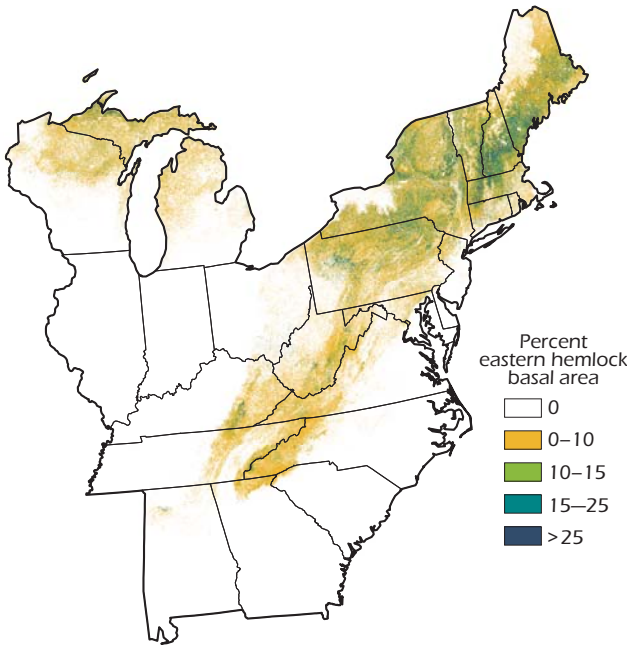

Figure 1—Distribution of relative eastern hemlock basal area, 2006.

Table 1—Eastern and Carolina hemlock statistics in the eastern United States, 2009

State	Net volume in live trees ≥5 inch diameter	Sampling error	Live trees ≥1 inch diameter	Sampling error	State	Net volume in live trees ≥5 inch diameter	Sampling error	Live trees ≥1 inch diameter	Sampling error
	thousand cubic feet	*%*	*million trees*	*%*		*thousand cubic feet*	*%*	*million trees*	*%*
New York	3,006,900	4.9	542.2	5.9	Connecticut	207,912	17.9	49.2	25.3
Maine	1,938,079	5.1	624.1	6.0	Kentucky	205,574	14.8	76.6	15.0
Pennsylvania	1,777,317	5.9	284.9	6.8	Virginia	181,427	17.2	44.7	16.4
Vermont	1,098,034	8.7	167.1	9.4	Georgia	53,063	26.3	22.4	28.8
New Hampshire	1,083,606	7.3	296.4	8.0	Ohio	36,509	40.1	3.7	50.2
Michigan	923,159	5.6	144.7	7.0	South Carolina	35,032	46.1	8.5	40.3
Massachusetts	798,546	10.6	174.6	10.5	Alabama	33,528	49.0	5.2	48.3
Wisconsin	485,304	7.8	77.2	9.9	New Jersey	25,300	38.5	4.0	41.0
Tennessee	433,298	13.3	90.9	10.9	Maryland	18,258	46.9	2.0	58.2
West Virginia	395,372	11.0	116.7	13.0	Rhode Island	10,789	54.6	2.1	58.9
North Carolina	351,660	13.3	93.0	9.6					

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Hemlock woolly adelgid on eastern hemlock foliage. (photo by USDA Forest Service, Bugwood.org)

U.S. Department of Agriculture
Forest Service
Southern Research Station
e-Science Update SRS–038
August 2011

Value of Hemlock

Due to its widespread distribution, long lifespan, and shade tolerance, hemlock plays a distinctive role in forest ecosystems. Its unique ecological, recreational, and aesthetic qualities make it a highly valued component of reserves and parks in the Eastern United States. Of particular importance, the niche it fills in riparian areas makes it essential for the regulation of microclimates including soil conditions and stream temperature. Additionally, dense stands of this slow-growing, long-lived species provide habitat to many species of wildlife.

Hemlock Woolly Adelgid

The hemlock woolly adelgid (HWA) (*Adelges tsugae Annand*) is a destructive, introduced pest that feeds at the base of the needles of hemlock trees. HWA is native to East Asia and Western North America, and was first noticed in the Eastern United States in the 1950s. Since then, it has been expanding its range at between 4.7 and 12.7 miles per year and is currently distributed in 18 States (fig. 2). In areas where populations have established, adelgids frequently reach high densities due to a lack of predators and parasites, and little resistance to infestation by the native hemlocks. These infestations can lead to widespread defoliation and mortality of hemlock trees. HWA currently infests about 45 percent of the range of hemlock in the United States including about 41 percent of the total hemlock basal area. These percentages are up from 26 percent and 25 percent, respectively, since 2004.

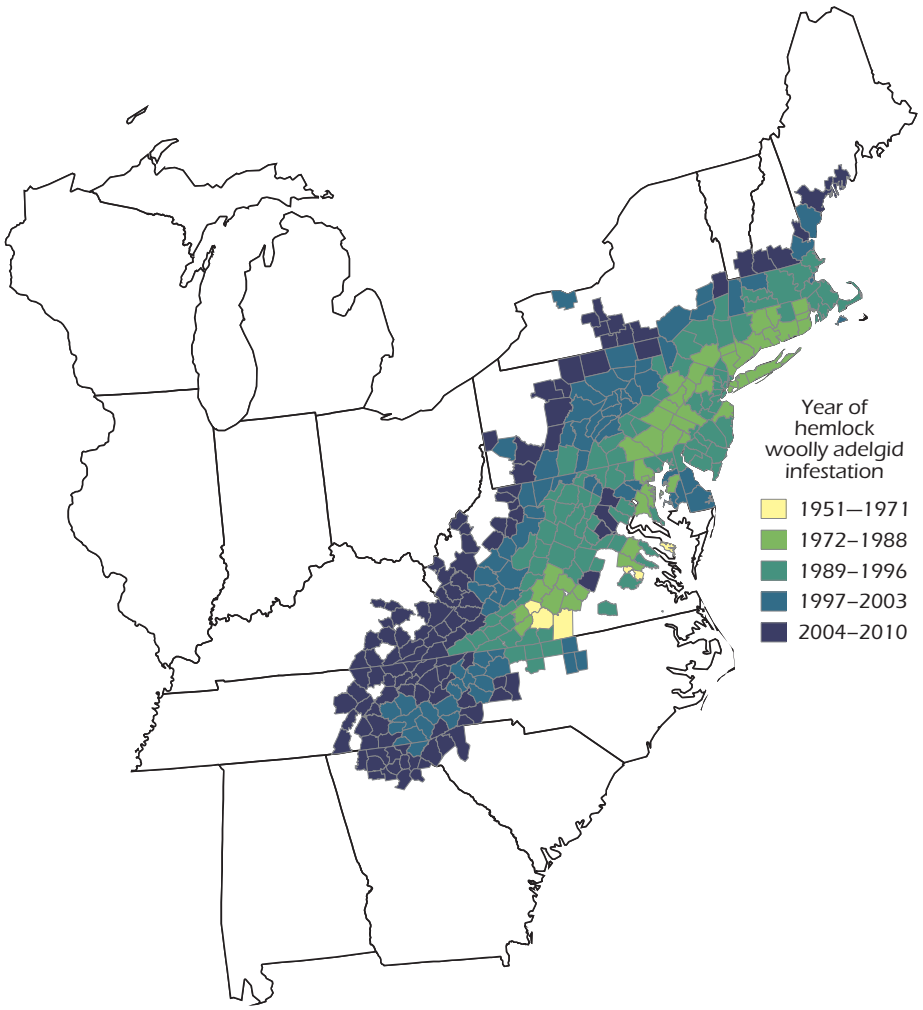

Figure 2—Distribution of hemlock adelgid in United States counties, by year of infestation.

Changes in Regional Abundance of Eastern Hemlock

A recent analysis of FIA data over a 20-year time period across 433 eastern counties containing hemlock showed an overall increase in live-tree hemlock basal area in both infested and uninfested counties. Additionally, results of the analysis showed that the general regional trend in the Eastern United States over the past 50 years has been one of increasing hemlock volume, even with infestation by HWA. Thus, while HWA can have substantial negative impacts on hemlock populations at small (i.e., stand-level) scales, analysis of FIA data suggests that infestation by HWA has not yet reduced the overall abundance or volume of hemlock even in most States where HWA has been active for decades (fig. 3). Despite increasing hemlock volume over the last four decades across most of the Eastern United States however, regions with long-established HWA populations are also the regions with the slowest accumulation of hemlock, indicating the impacts of HWA on net growth and mortality rates may begin to reverse this trend.

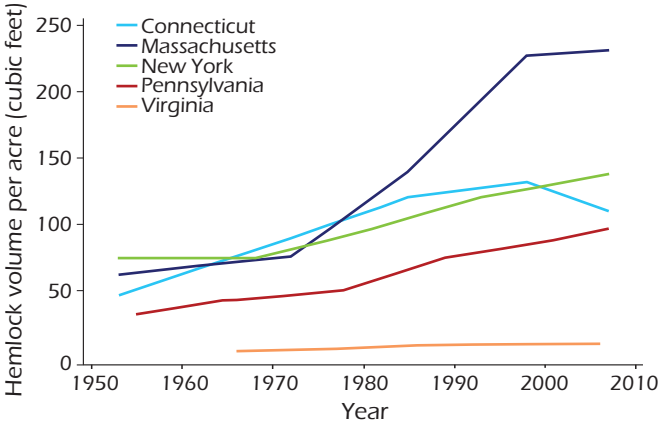

Figure 3—State-level records of hemlock volume from historical inventories.

Growth and Mortality of Eastern Hemlock

Although several studies have documented the impacts of HWA on growth and mortality of eastern hemlock at specific sites, these impacts have not been quantified across the range of the insect in the United States. Annual net growth of eastern hemlock averages about 2.1 percent and annual mortality averages about 0.5 percent across its range. The year of HWA infestation was assigned to each county in order to associate growth and mortality rates with duration of HWA infestation. Net growth rates decrease as years of HWA increase and mortality rates increase as years of HWA increase. Mortality equals net growth in areas where HWA has been present for 10 to 20 years, and mortality exceeds net growth in areas where HWA has been present for >20 years (fig. 4).

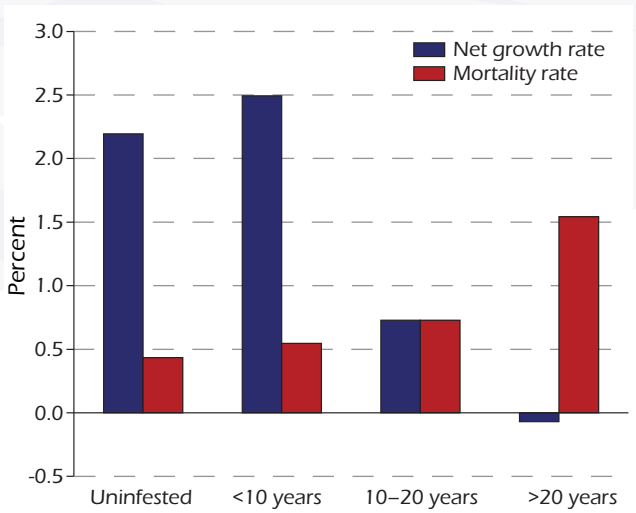

Figure 4—Net growth and mortality rates for eastern hemlock by duration of HWA infestation (FIA data from 2007 and 2008; HWA duration based on 2006 distribution).

Hemlock woolly adelgid on eastern hemlock foilage. (photo by USDA Forest Service, Bugwood.org)

Ecological Impacts

Although the hemlock represents only one of many tree species in eastern forests, it hosts a diversity of birds, animals, and insects that play important roles. For example, recent work on the arthropods (insects and spiders) found in the canopies of hemlocks indicates these trees may support >1,000 species, as such, these trees are a key asset in the maintenance of biodiversity in eastern forests.

Biological Control

Efforts to control the HWA include chemical, silvicultural, and biological control programs. Chemical control has been shown to be highly effective in high value recreation areas and urban settings, however, it is expensive, and because the insecticides impact many other species found on hemlocks, application over entire forests is not ecologically or economically reasonable. Six beetle species (*Sasajiscymnus tsugae, Laricobius nigrinus, L. osakensis, Scymnus camptodromus, S. sinuanodulus,* and *S. ningshanensis*), in addition to fungal pathogens are being evaluated and applied for the biological control of HWA. These have the potential to provide long-term, low-cost control of HWA abundances.

Hybrids

Although eastern and Carolina hemlocks express little resistance to the HWA, hemlock species from the adelgids native environments express varying degrees of resistance and/or tolerance to infestation. Current research with the National Arboretum has produced the first generation of hybrid hemlocks using both Asian species and Carolina hemlocks. It is hoped that these crosses may ultimately lead to a hemlock which is resistant to the adelgid, while retaining some of the characteristics of native hemlocks.

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How to Cite This Publication

Morin, R.S.; Oswalt, S.N.; Trotter, R.T., III; Liebhold, A.W. 2011. Status of hemlock in the Eastern United States forest inventory and analysis factsheet. e-Science Update SRS–038. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 4 p.

Riparian hemlocks provide shade necessary to keep steams cool.
(photo by Randall Morin, U.S. Forest Service)

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