West Virginia Department of Agriculture
Cooperative Forest Health Protection Program

Hemlock Woolly Adelgid Management Plan

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Table of Contents

Eastern Hemlocks in West Virginia

Eastern hemlocks are an important component of West Virginia's forests. They comprise about 1% of forested land statewide, and up to 9% in individual counties (Figure 1). Hemlocks are relatively large, long-lived, and shade-tolerant trees. They form dense canopies under low light conditions creating distinctive wildlife habitat. In addition to providing shade critical for maintaining the water temperature of many native trout streams, they provide food and shelter for songbirds, turkey, and grouse, and forage and cover for a variety of mammals (Ward et al. 2004). Forty-seven species of mammals and ninety-six species of birds have been documented using the hemlock resource in the northeastern United States (Degraff et al. 1992).

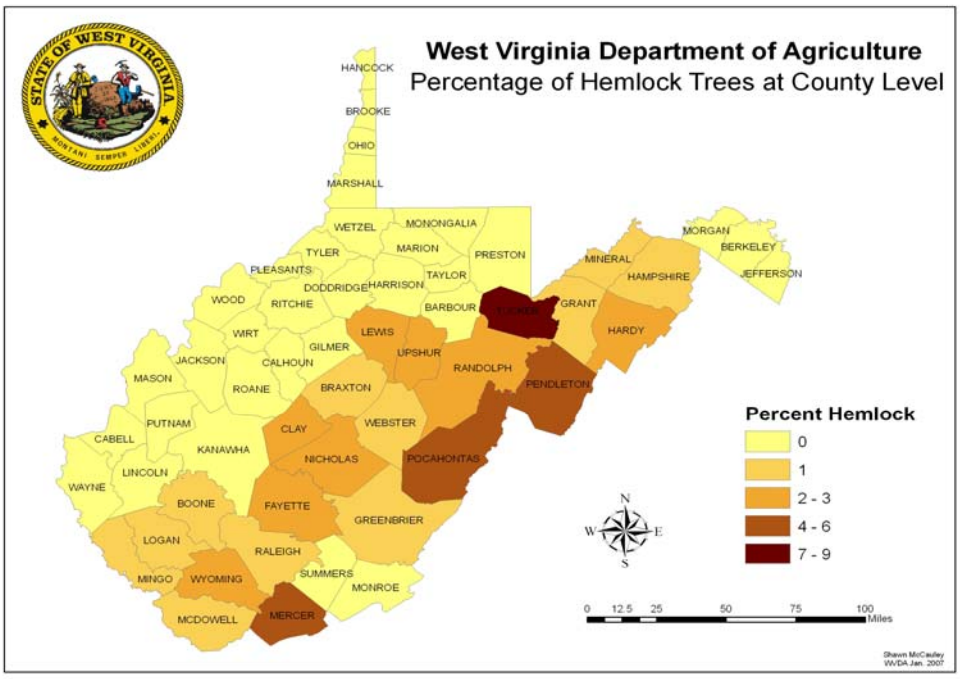

Figure 1. Percentage of hemlock in West Virginia forests by county.

Hemlocks have exceptional aesthetic value and provide a beautiful backdrop to some of West Virginia's most popular recreation and tourism areas. The ancient hemlocks in Cathedral State Park, for example, are the principle attraction to the park. Blackwater Falls, one of the most commonly photographed natural sites in the state, is so named for the dark color of the water caused by tannins from fallen hemlock and spruce needles.

Hemlock is not generally considered an important timber species. In West Virginia, it is primarily used for the production of log homes. It is also used locally for barn and outbuilding projects and general farm use (Cook 2007). Hemlock is also used for pulpwood, lumber and bark mulch (Ward et al. 2004).

Hemlock woolly adelgid (HWA) in West Virginia

In 1992, the West Virginia Department of Agriculture (WVDA) conducted an initial survey for HWA in West Virginia. Infestations were detected in Grant, Pendleton, Hardy and Hampshire Counties. Subsequent surveys found HWA in Mineral, Morgan, and Pocahontas Counties (1993), Berkeley and Jefferson Counties (1997), Greenbrier and Monroe Counties (1998), Mercer and Summers Counties (2000), Randolph, Raleigh and Tucker Counties (2001), Fayette, Nicholas and Preston Counties (2002), Webster County (2003), Monongalia and McDowell Counties (2004) and Upshur and Wyoming Counties (2005). With the addition of Barbour, Boone, Braxton, Clay and Kanawha Counties in 2006, HWA has now been found in 29 West Virginia counties (Figure 2). Thousands of trees in the eastern panhandle have been killed by HWA.

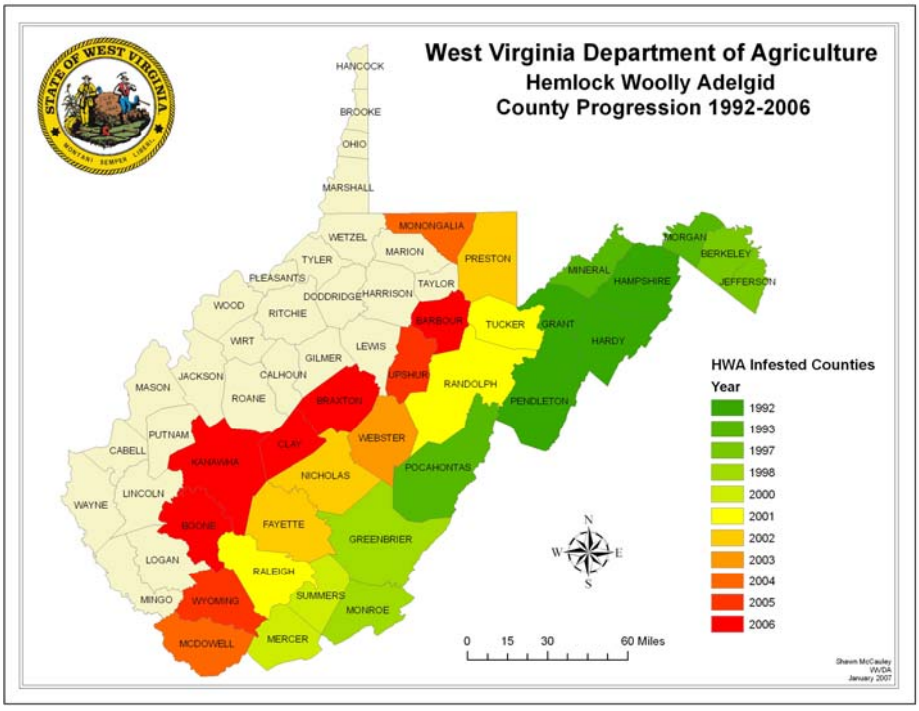

Figure 2. Progression of hemlock woolly adelgid detection in West Virginia.

The West Virginia Department of Agriculture HWA Program

The West Virginia Department of Agriculture (WVDA) conducts an HWA survey and suppression program, funded in part by the USDA-Forest Service, which has five main areas; (1) detection surveys have been conducted each year since 1992 to determine the extent and severity of HWA infestations, (2) WVDA staff have participated in HWA education and outreach since its detection in 1992, (3) permanent plots have been monitored yearly since June of 1993, (4) predatory beetles have been released and

monitored since 1999 (5) imidacloprid treatment of high value and high profile hemlocks on state lands began in the fall of 2004.

Permanent Plot Monitoring

HWA permanent study plots at Greenland Gap in Grant County, Cathedral State Park in Preston County, and Blackwater Falls State Park in Tucker County are visited each year. Crews evaluate individual hemlocks in terms of tree condition and severity of adelgid infestation. Five year surveys evaluate stand density and composition. Results are submitted to the USDA-Forest Service for analysis.

Education and Outreach

The WVDA Pest Identification Laboratory and the Forest Entomologist answer an increasing number of HWA related calls from home and woodlot owners, extension agents and arborists. Literature and written recommendations are generally sent out unless inquiries can be sufficiently dealt with over the telephone. Site visits are sometimes made to confirm the identification of the pest.

HWA information has been presented at many meetings and events through oral presentations, poster displays and literature distribution. HWA has also been a topic in many issues of the yearly Cooperative Forest Health Protection Calendar, of which approximately 5,500 copies are distributed yearly.

Biological Control

In 1999, the WVDA began releasing the predatory beetle *Sasajiscymnus tsugae* in order to study its effect against HWA as part of a USDA-FS multi-state predator impact study. From 1999 to 2005, over 90,000 *S. tsugae* were released at 17 HWA infested sites in West Virginia.

Two other species of predatory beetles, *Laricobius nigrinus* and *Scymnus sinuanodulus* have been released in WV. Two releases of 300 *L. nigrinus* adults each were made at Watoga State Park and Seneca State Forest in November of 2003. A supplemental release of 300 adults was made in March 2004 at Seneca State Forest.

In 2005, approximately 450 *S. sinuanodulus* adults were released in an HWA-infested hemlock stand in Calvin Price State Forest. A supplemental release of 450 adults was made at the same site in 2006.

Beetle release sites are visited once a month for 4 consecutive months each season. Visual detection surveys are conducted for a minimum of 2 man hours at each site. Limited numbers of *S. tsugae* have been recovered at several sites including the initial 1999 release site. No *S. sinuanodulus* have been recovered.

Chemical Suppression

In the fall of 2004, the WVDA initiated a suppression program to treat high value and high visibility infested hemlocks with the systemic insecticide imidacloprid. A combination of soil and stem injection methods were used depending on soil conditions

and proximity to water sources. Merit 75WSP was injected into the soil around infested trees with a Kioritz soil injector. IMA-jet was injected into the trunks using the Arborjet Tree IV system. The WVDA has treated almost 1400 trees with imidacloprid.

The WVDA Hemlock Stand Priority Survey

In March of 2006, a hemlock priority survey was mailed to 165 individuals and agencies that were thought to have an interest in hemlock woolly adelgid and its management. The mailing list included state park and state forest superintendents, county extension agents, conservation districts, and personnel associated with USDA APHIS, USDA-FS, USDA-NRCS, USFWS, USDI-NPS, WVUDOF, WVU Division of Plant and Soil Sciences, WV Division of Forestry, WVDOT, the Natural Heritage Program, WV Division of Culture and History, and the WVDNR. Forty-three surveys were completed and returned.

The majority of respondents agreed or strongly agreed to the following statements:

1. Hemlocks are an important resource in WV. (88%)
2. Hemlock woolly adelgid is a problem in WV. (93%)
3. Chemical insecticides should be used to protect hemlocks in WV. (75%)
4. Biological control, including the release of predatory beetles, should be used to protect hemlocks in WV. (77%)
5. Resistant species of hemlocks should be planted in WV to replace hemlocks that are killed by hemlock woolly adelgid. (68%)

Participants ranked the 5 most important functions of hemlock stands from a provided list. Responses were relatively evenly split between recreation, wildlife habitat, historical importance, biological diversity and aesthetics. Write-in responses included "lumber", "post and rail timber", and "watershed protection".

Respondents also ranked the most important qualities of high priority candidates for HWA control. Answers were divided between large trees, very old trees, trees of historic significance, trees of ecological importance and trees that shade streams as shown in Figure 3. Write-in responses included "trees that represent isolated populations" and "trees that are ready to be harvested within 10-15 years".

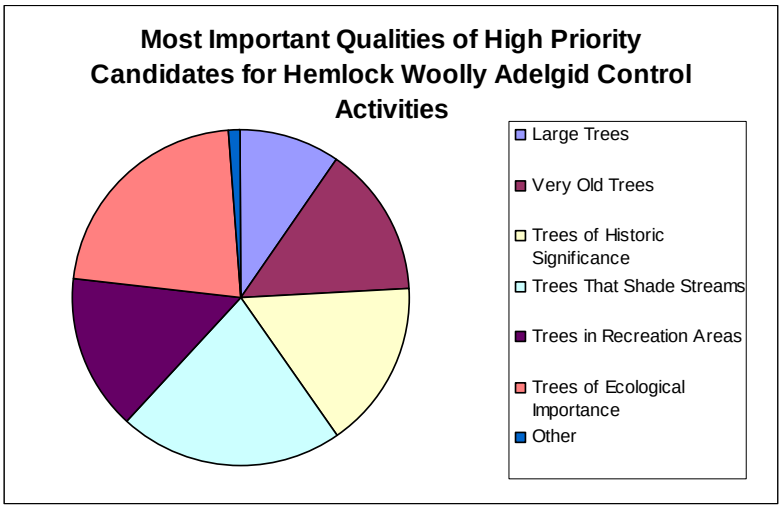

Figure 3. WVDA Hemlock Stand Priority Survey results of most important qualities of HWA control candidate trees.

Survey participants ranked the 10 most important state parks, state forests and wildlife management areas in relation to hemlock health. The results were as follows (Figure 4):

1. Cathedral State Park
2. Blackwater Falls State Park
3. Canaan Valley Resort State Park
4. Cooper's Rock State Forest
5. Holly River State Park
6. Beartown State Park
7. Droop Mountain Battlefield State Park
8. Audra State Park
9. Babcock State Park
10. Kumbrabow State Forest

When asked to justify their selection of specific state lands, respondents most commonly named aesthetics, recreation, biodiversity and watershed protection (Figure 5).

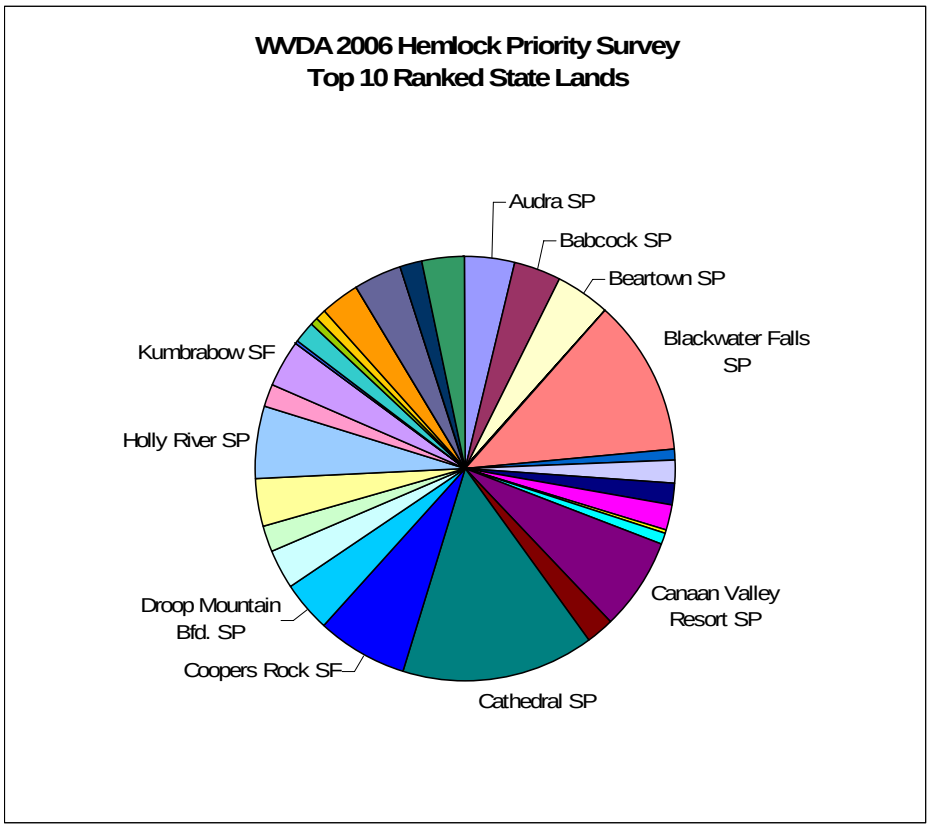

Figure 4. The WVDA Hemlock Stand Priority Survey top ranked state lands.

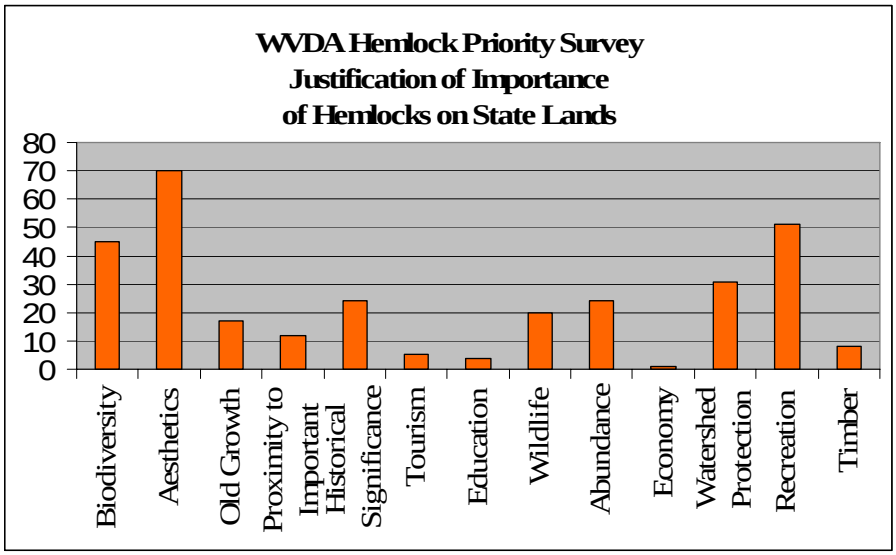

Figure 5. WVDA hemlock priority survey justification for state lands ranking.

Hrabovsky, Hicks Survey

Ellen E. Hrabovsky and Dr. Ray R. Hicks completed "West Virginia State Parks/Forests and the Hemlock Woolly Adelgid: A Survey" in August of 2005. The results were based on surveys submitted mainly by superintendents of state parks, state forests, and wildlife management areas.

Most state owned areas that have hemlocks reported that the hemlock stands are frequented by the public (83%) and that the loss of those hemlocks would have a negative impact on the facility (87%). The principle function of eastern hemlocks on state lands, as rated by park superintendents, was aesthetics (53%) followed by ecological diversity (23%). According to the survey respondents, the most important attributes of eastern hemlocks on state lands were ecological value and presence in high use areas.

Potential Impacts of HWA

Ecological Impacts

DeGraaf et al (1992) and Yamasaki et al (2000) found hemlocks to be a critical part of the habitat requirement for many species of birds and mammals in the northeast. They suggested that HWA induced hemlock decline could have considerable effects on the occurrence and distribution of a number of avian and mammalian species. In a study of the Delaware Water Gap National Recreation Area (DEWA), Snyder et al. (1998) found nearly 3 times as many brook trout and an average of 37% more invertebrate taxa in streams draining hemlock forests than those draining hardwood stands. Research has also shown the effects of hemlock decline on carbon-nitrogen cycling, microorganism abundance (Stadler et al. 2006), and habitat structure and composition (Foster 1999).

In studies conducted in the Harvard Forest in Massachusetts, Orwig and Foster (1998) found no apparent resistance to HWA, and all age and size classes of eastern hemlock were affected. In heavily declining stands, seedlings were scarce, suggesting that hemlock regeneration is unlikely and hemlock stands will more likely be replaced by hardwoods.

Economic Impacts

The loss of eastern hemlock would cause dramatic changes in some of the State's most popular tourist destinations. The loss of millions of dollars in tourism revenue is a potential result. Additionally, it would be difficult to estimate the cost of the removal of hazard trees in tourist areas, in the urban forest, and in other high traffic areas in West Virginia.

Although not generally considered an important commercial species, hemlock wood products are of significant value locally, especially to rural communities (Ward et al 2004).

HWA Management Options

Option 1: No Action

HWA, in combination with secondary wood boring insects and abiotic stressors, will continue to cause widespread decline and mortality. Eastern hemlock stands may be virtually eliminated from the state and replaced with mainly deciduous species. Critical wildlife habitat may be lost in terrestrial and riparian ecosystems. Declining hemlocks may pose safety hazards. Removal of hazard trees may need to be addressed.

Option 2: Chemical Control

There are a variety of products available for the control of hemlock woolly adelgid. Insecticidal soaps, horticultural oils and other foliar sprays can be effective against HWA on ornamentals or small hemlock trees and shrubs. These products are often unsuitable for use on very large hemlocks because complete coverage is needed for adequate control.

Imidacloprid is a systemic insecticide that has had considerable impact on adelgid populations. It is a relatively new insecticide in the family of chemicals called neonicotinoids where the mode of action is similar to that of nicotine, causing disorder within the insect nervous system. Because it selectively targets the insect nervous system, it poses low hazard to mammals and most other non-insect species. Imidacloprid is a suitable treatment for very large trees because it is transported by the tree's vascular system,

Imidacloprid is not practical for use in large scale forested settings because its application is limited to individual trees. However, treatment of a selected number of infested hemlocks may enable some trees to recover from current infestations. This may protect high value specimen trees, highly visible trees and/or trees of area value until biological

control agents have a chance to build up to impact levels, or until other HWA control measures become available.

Option 3: Biological Control
Experts believe that introduction of a complex of HWA natural enemies, once established, may suppress HWA populations to a level that will not harm trees (Ward et al. 2004). Beetle predator research has yielded promising results under experimental conditions, but effects on wild HWA populations are much more difficult to assess.

The WVDA, with the support of the USDA-Forest Service, has released over 100,000 predatory beetles (see page 4). Monitoring efforts have recovered a limited number of beetles.

Recommended Action

The WVDA recommends continuation of all five areas of the current HWA program; 1) survey and detection, 2) education and outreach, 3) permanent plot monitoring, 4) biological control and 5) chemical suppression. New biological control agents and other technologies will be evaluated as they become available. Tree selection for chemical suppression will be directed, in part, by the results of the WVDA Hemlock Stand Priority Survey and the Hrabovsky, Hicks Survey.

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