MARYLAND DEPARTMENT OF AGRICULTURE
Forest Pest Management
Hemlock Woolly Adelgid

Treatment and Suppression Plan

Created 2004 / revised 2010

MARYLAND HEMLOCK WOOLLY ADELGID MANAGEMENT AND SUPPRESSION PLAN

PURPOSE

This plan was developed in an effort to slow or control the damage to Maryland's eastern hemlock forests caused by an invasive insect called the hemlock woolly adelgid (*Adelges tsugae*). It is also the intent of this plan to serve as a request for project review and the pre-approval of a series of treatment options that can slow the spread of the adelgid in Maryland, for the period of 2010 thru 2015. This will allow MDA –Forest Pest Management to react quickly when new infestations are found or new treatment options are appropriate. The plan will also allow us to direct our efforts to timely treatments of sites with damaging levels of HWA.

INTRODUCTION

The hemlock forests of Maryland are part of a unique and often fragile habitat. Eastern hemlock (*Tsuga canadensis*) is the most shade-tolerant of all North American tree species, requiring as little as 5 percent full sunlight (Silvics of North America – Agricultural Handbook #654). The slow growing conifer, which can take 250 to 300 years to reach maturity, can exceed 800 years of age. Because of its shade tolerance and intolerance of fire it is usually found growing in riparian areas or in steep cove forests in the northern and western tier counties of Maryland. It's estimated that more than 42,000 acres of such forests exist in Maryland.

Eastern hemlock is not a particularly valuable timber species. At one time the tree was sought after for its bark which was once important for tannin to supply the leather making industry. Today hemlock is used by the pulp and paper industry and its lumber is used for barn siding and other specialty uses. Although its value as a timber species is minimal, it occupies an important ecological niche, and has significant esthetic and recreational value.

The health of Maryland's hemlocks, and the associated ecosystems, is being threatened by the hemlock woolly adelgid (HWA). This small, exotic insect is native to Asia, and was first found in North America in British Columbia in the1920's. It was reported in Richmond, Virginia in 1951, and spread northward into Maryland by the 1980's.

Heavy infestations of HWA may result in decline of tree health and eventual mortality. The severity of decline and mortality is often hastened by drought, or other pests, such as elongate hemlock scale and hemlock borer.

Tree mortality and decline have been most severe in Virginia, New Jersey and Connecticut. In New Jersey, 55 percent of 26,000 acres of hemlock have been severely impacted. Several stands in Maryland, which have been infested with HWA for more than 10 years, have extensive decline and some mortality. Landscape hemlocks in the Baltimore – Washington area were infested in the late 1980's and natural stands in the area became infested by 1990. The infestation steadily moved westward and native stands of

hemlock in Frederick and Washington Counties became infested in the early to mid-1990's. Infested hemlocks in Allegany County were found in 1999, and the first infested hemlock in Garrett County was found in December, 2001.

While adelgid populations moved into much of Maryland in the 1980's and 1990's, there were very few management tools available to stop its spread. Native stands of hemlock, especially in Harford and Frederick Counties, were heavily infested with adelgids, elongate hemlock scale and several years of drought. By the late 1990's, these areas showed significant decline and mortality. In 2003, a Hunting Creek Hemlock Woolly Adelgid Management Team was assembled to address the dead and dying hemlocks along Hunting Creek in Frederick County, especially in Cunningham Falls State Park. A management plan was developed to remove hazard trees near the high use trails in the Park, and inject hemlocks that were still healthy enough to benefit from treatment. Treatments took place in late 2003, and follow up assessments took place in 2004 and subsequent years.

Although treatment options for HWA are still being developed, there are now more tools available than there were just 10 years ago. These tools along with the movement of HWA into high value hemlock stands in Western Maryland necessitate development and implementation of this statewide HWA management plan.

HEMLOCK WOOLLY ADELGID BIOLOGY

Hemlock woolly adelgids are most easily recognized by the white "woolly" wax they produce on young hemlock twigs. The "wool" is present all year, but is most abundant and conspicuous during the spring and fall when egg masses are present. Most other stages in the life cycle are much harder to see. Fully grown adults are only about the size of a period on a printed page.

There are two generations of hemlock woolly adelgid per year. This cool weather species completes most of its development from October through May.

Overwintering adults lay eggs in April and May under the white woolly mass. Nymphs (crawlers) hatch and within a few days settle on twigs. They will feed and remain attached to the twig through their maturation into 1st generation adults in late May. Wingless adults then lay eggs which hatch by July. The new crawlers settle on the new growth and become dormant until October. They then resume feeding and develop during the winter, maturing by spring. The life cycle of the hemlock woolly adelgid, like most members of the adelgid family, is very complex. There are two forms of the insect, with each form going through six life stages (egg, four nymphal stages and adult). This is a very simplified version of the life cycle.

Adelgids feed by inserting their tube-like mouthparts into the underside of the base of hemlock needles. As feeding progresses, needles desiccate, turn pale green and drop from the tree. Buds may also die, and in heavy infestations, dieback of major limbs and tree mortality may occur.

In eastern North America, eastern hemlock (*Tsuga canadensis*) and Carolina hemlock *(T. caroliniana)* are highly susceptible to damage by adelgid and often succumb within 6-10 years. HWA is rapidly spreading throughout the range of eastern hemlocks. It is estimated that in the past decade it has spread at a rate of 20-30 km per year. Wind, birds, deer and humans are factors in both short and long distance dispersal. Hemlock woolly adelgids (HWA) can now be found in all Maryland counties where hemlocks occur. Throughout much of the State, landscape trees, as well as natural forest stands have become infested.

ASSESSMENT AND RANKING PROCESS

In July 2003, a task force was created to assess and prioritize among vulnerable hemlock forest stands across Maryland. The multidisciplinary task force was made up of members of the Maryland Department of Agriculture, Maryland Department of Natural Resources, USDA Forest Service, USDI Park Service and other partners. Task force disciplines included entomology, forestry, wildlife management, park and recreational management, fisheries management, agricultural inspectors, geographers and ecologists. The group met to agree on process and to begin assessing vulnerability and value of hemlock stands statewide. A list of approximately 75 priority stands were identified and rated, and later further refined to a “top 50” list of priority hemlock stands throughout the state on which this management plan will concentrate its efforts. This list has been finalized to include only public owned sites which are those eligible for treatment under this plan. Additions to this list must be public owned lands and approved by MD DNR and MDA-FPM. See Table 1.

FUNDING

The Maryland Department of Agriculture, Forest Pest Management Section has received special funding from the US Forest Service to develop and implement a statewide hemlock woolly adelgid suppression plan. This funding has helped support HWA control efforts including soil and trunk injections from July, 2004 to the present. The US Forest Service has also supported MDA’s HWA monitoring and evaluation activities. The use of biological control agents (as discussed in the Treatment Options below) has increased and is promising, although still in the research evaluation stage. Predatory beetles that are part of this biocontrol effort are currently supplied by the US Forest Service at no cost to the State, and their availability is dependant upon production facilities under contract with the US Forest Service.

MONITORING

Evaluating the health of hemlocks and the level of HWA infestations is integral to the successful implementation of a management plan. Since the late-1980’s, MDA’s Forest Pest Management Section has been conducting HWA detection and impact surveys across the State. This Management Plan will/has identify(ied) priority stands, and FPM staff will concentrate HWA and hemlock health surveys on the priority stands as discussed above.

Detection and monitoring are critical components of an Integrated Pest Management plan. Treatment decisions begin with knowing the location and density of the pest. Priority hemlock stands identified in the Plan will be annually surveyed to assess HWA populations. These surveys will begin as soon as summer estivation ends, and the white, woolly masses are evident, usually in early October.

Surveys will classify HWA densities into the following four categories:
None: no adelgids observed
Light: less than 25% of the trees are infested and most often individual trees have less than 25% of the branches infested
Moderate: 26-50% of the trees appear to be infested and most often individual trees have less than 50% of the branches infested
Heavy: more than 50% of the trees are infested and most often the majority of the branches on individual trees are infested

An assessment of hemlock health in these stands will be conducted simultaneously with the assessment of HWA densities. Tree health information will be reported on a stand level basis in the following categories:

Healthy: trees appear to be in reasonably good health with less than 10% of the trees showing signs of stress such as: defoliation, needle discoloration, and/or branch tip dieback. Hemlock mortality less than 10% throughout the stand
Light Decline: trees appear minimally stressed with many trees showing 11-25% defoliation, needle discoloration and/or branch tip dieback. Larger branch mortality may be present but not frequent on trees within the stand. Hemlock mortality less than 10% throughout the stand
Moderate Decline: trees generally appear under stress with most trees showing 26-50% defoliation, needle discoloration and/or tip dieback. Larger branch mortality is relatively common throughout the stand. Hemlock mortality 11-25% throughout the stand
Severe Decline: trees appear obviously stressed with most trees showing >50% defoliation, needle discoloration and/or branch tip dieback. Larger branch mortality is common throughout the stand. Hemlock mortality may be more than 25% throughout the stand.

Information from HWA and hemlock health surveys will be entered annually into a stand database. This information will be used to direct additional surveys, public information, and treatment and restoration efforts.

TREATMENT OPTIONS

The selection of treatment options for landscape or forest areas will be based upon HWA population levels, hemlock health, access to the trees/stand and proximity to sensitive riparian areas. The decision to treat a stand and its inclusion in this Plan is based upon management objectives, and the esthetic, wildlife, recreation, fishery, forestry, and natural heritage values of the stand.

There are currently no proven methods available to suppress HWA in a large scale forest setting. However, we have been able to treat significant sized areas or parts of stands over the years by efficiently using methods which are available for individual tree treatment or treatment of groups of trees. Current insecticide treatment options include the use of foliar sprays or systemic insecticides. Foliar sprays involve the application of horticultural oil or insecticidal soap via hydraulic sprayers and are limited to trees where access is possible by truck mounted equipment and areas where insecticide drift would not contaminate streams and lakes. Systemic insecticides can be applied either through soil injections, soil applied tablets, soil drenches, trunk sprays, or stem injections. Although the various types of soil treatments have proven to be the most effective method of systemic applications, stem injections are recommended for hemlocks growing within 50 feet of open waterways. Research is currently underway for the application of aerial fungal pathogens to suppress hemlock woolly adelgid populations. Should this prove effective, aerial fungal spraying may be incorporated into this plan.

Treatment options for hemlocks in the landscape are much different than those available for forest situations. Easier access for application equipment and lack of sensitive riparian areas allow for a wider range of treatments in the landscape environment.

The most widely used systemic insecticide for HWA is imidacloprid. Various formulations of imidacloprid are available depending on the method of application and equipment to be used to deliver the product. Treatments with imidacloprid are normally done in the early spring or late fall when there is adequate soil moisture present. Systemic insecticides are translocated by the tree up to the crown where the pest is feeding and control usually occurs within 2-6 months. Systemic insecticides can be injected into the soil around the base of the tree, injected into the trunk of the infested hemlock, or sprayed on to the trunk of an infested tree. Trunk injections are not recommended on trees less than 4” in diameter. Soil injections and trunk sprays should only be used around trees that are a safe distance from water sources.

HWA population densities often fluctuate normally as a result of two generations per year, declining tree vigor caused by heavy adelgid infestations and/or other variables, such as drought and other insects. Extreme cold winter temperature will also impact adelgid survival. As such, final treatment decisions

Ultimately, treatment decisions will be made considering numerous factors including rank, infestation level, tree health, available treatments options, funding and likelihood of success

LANDSCAPE TREE TREATMENT OPTIONS.

Options for trees or parts of stands that are easily accessible AND do not have environmentally sensitive areas (such as streams) nearby:

- Cover sprays with insecticidal soap, dormant oil or horticultural oil.
- Cover sprays with contact or foliar absorbed insecticides.
- Trunk injection with imidacloprid.
- Soil injection with imidacloprid.
- Soil drench with imidacloprid.

FOREST STAND TREE TREATMENT OPTIONS.

Options for stands that are inaccessible or have environmentally sensitive areas nearby:

- Trunk injection with imidacloprid (when environmentally sensitive areas are an issue).
- Soil injection with imidacloprid.
- Soil drench with imidacloprid.
- Imidacloprid tablets applied in soil
- Trunk sprays with Safari
- Biological control: release of predatory beetles or other natural enemies as they become available.
- Aerial fungal spray (possible future treatment option)

TREATMENT OPTION DETAILS

Cover Sprays

Individual hemlocks or small groups of landscape trees greater than 50' from sensitive areas or streams can be treated with insecticides using ground equipment, such as mist blowers or hydraulic sprayers. The use of this ground equipment limits the selection of this option to areas with good road access adjacent to the trees needing treatment. The insecticide, as well as the equipment, used will be site specific and dependant upon tree size, location and health, HWA population levels and time of year. Dormant oil, horticultural oil, insecticidal soap or foliar absorbed insecticides can be used as cover sprays. The application of any of these insecticides will follow EPA-approved label guidelines.

Dormant Oil. This option will be used on individual trees or small groups of trees <30' in height. Dormant oils suffocate adelgids so must be applied directly to the insect when they are immobile. Dormant oils are applied during the 'dormant' season for most insects, from November to March, although HWA are active during this time, it is still the appropriate time for dormant oil treatment of HWA. An example of a site where dormant oil cover sprays may be used is the parking lot areas of some State Parks, such as Rocky Gap or Deep Creek Lake.

Horticultural Oil and Insecticidal Soap. The selection and application of horticultural oil will follow the same guidelines as dormant oil, with the exception of time of year for application. These oils are used when temperatures are warmer, and will be used from April through June, and September.

Foliar Absorbed Insecticides. The use of foliar absorbed insecticides is restricted by the proximity of the hemlocks to open water. While cover sprays using registered insecticides such as abamectin and imidacloprid are very effective in reducing HWA populations, they will be used only when there is sufficient distance from water, and will closely follow label restrictions. Specific high value sites that have HWA, such as Swallow Falls State Park, and are away from Muddy Creek, may be treated with a foliar absorbed

insecticide (this is very unlikely and treatment with stem injected insecticides is the most likely treatment for these trees). The timing for use of cover sprays with insecticides is during the season when there are immature or unprotected life stages; usually from July through October.

Aerial Fungal Spraying The use of an aerial spray of a fungal pathogen to suppress hemlock woolly adelgid populations is currently being researched, and may be incorporated into this plan in the future if proven to be effective and economical.

Soil Treatments

Soil treatments eliminate the concern for drift of insecticides from mist blowers or hydraulic sprayers, however, insecticides injected into the soil can move short distances and thus cannot be used within 50ft of waterways. Soil treatments have many advantages. They can be used on large trees with canopies beyond the reach of ground application equipment. The chemical is absorbed through the roots, and control may extend 2 to 4 years after application. The distribution and transport of the insecticide within a tree is affected by its health; trees under drought stress, with needle loss and dieback may not effectively transport the chemical. As compared to trunk injections, soil treatments have the advantage of not wounding the tree.

Soil Injection. A 75WP formulation of imidacloprid (e.g. Merit) applied using a kioritz injector around the base of infested hemlocks will be the treatment option of choice for stands of hemlocks at least 50ft away from water. Individual trees or small groups of trees that are 50ft or more away from streams will be treated using soil injection. Larger stands may be treated in increments over time using this method as well.

Tablets. Imidacloprid tablets (i.e. CoreTect) will be applied into the soil around the base of trees at a rate of 2 tablets per inch DBH. These can be used in the same areas as soil injections but have the advantage of ease of application and less equipment to carry, which is useful in hard to reach or long hike areas.

Soil Drench. Either 75WP or 75WSP formulations of imidacloprid (e.g. Merit) may also be applied using a soil drench method to treat hemlock shrubs or saplings. These treatments consist of uniformly applying the dosage in no less than 10 gallons of water per 1000 square feet as a drench and targeting the root zone. Soil drench methods would be used in areas where protecting hemlock regeneration is important.

Trunk Injection

Direct tree trunk injections will be the treatment of choice for trees or groups of trees less than 50ft from water. Treatments will be conducted in the spring and fall. Treatments will utilize a formulation of imidacloprid (i.e. IMA-jet) in conjunction with the Tree IV Viper system.

Trunk spray

Dinotefuran (i.e. Safari) can be used as soil drench, a soil injection (e.g. Kioritz) (1 oz mix per inch DBH), or as a trunk spray (at 2 oz mix per inch DBH). Trunk spray needs a surfactant. It can be used for its quick knock down effect, and is also effective against the elongate hemlock scale. It does not have the same long lasting effect of Imidacloprid.

Biological Control

The ultimate control and management of HWA will involve the long-term regulation of populations utilizing biological control agents. University and federal researchers have investigated several species of predatory beetles for biocontrol, and since the late 1990's there have been numerous experimental releases. These releases are still experimental and Maryland has participated in the evaluating the effectiveness of using these biocontrol agents at several locations over the past 11 years.

As part of this Plan, two species of lady beetles (Coccinellidae) and two species of Derodontidae beetles will be considered for release. It should be noted that these releases are still in the evaluation stage and although there is hope that they eventually play an important role in the regulation of HWA populations, they should not be looked at as a short term control measure.

Sasajiscymnus tsugae. Nearly 1 million *S. tsugae* (formally known as *Pseudoscymnus tsugae*) have been released in 15 eastern states. This species, native to Japan, has been released in several locations in Maryland since 1999. MDA is still evaluating the success of these releases. No additional releases are proposed at this time.

Laricobius nigrinus. This derodontid beetle, native to British Columbia, is one of the newer species being evaluated for HWA biocontrol. MDA is cooperating with the USFS and Virginia Tech University to evaluate the ability of this beetle to become established and reduce HWA populations. In 2003, MDA and Virginia Tech released *L. nigrinus* near Frostburg, and since then it has been released at several sites in the state. Established reproducing populations are now found at several locations in Maryland. Additional releases and monitoring efforts will be proposed as part of this plan.

Laricobius osakensis. This derondontid beetle, native to Japan is undergoing an environmental assessment. When complete, this beetle may be available for release.

Scymnus sinuanodulus is a lady beetle from China that is currently being evaluated by the US Forest Service for future releases. To date, two releases have been made with no recovery. No additional releases are proposed

Research

MDA-FPM will continue its longstanding commitments with its cooperators to explore new treatment options as they become available.

Public Land Rank	Stand Number	Stand Name	County	Total Acres	Federal Acres	DNR Acres	County/Municipal Acres
1	SAN11	SWALLOW FALLS	GARRETT	354	0	303	0
2	BLU1	HUNTING CREEK	FREDERICK	597	61	475	0
3	EVC1	ROCKY GAP GORGE	ALLEGANY	47	0	46	0
4	CAT3,4,5	FRED CITY WATERSHED/FISHING CREEK	FREDERICK	320	0	0	294
5	LIN1, 2	GUNPOWDER RD/PRETTYBOY	BALTIMORE	54	0	4	50
6	GOR1	LOSTLAND RUN 1	GARRETT	1297	0	786	0
7	HER1,2,3,4,5,6	PRETTYBOY DAM/SOUTH GUNPOWDER	BALTIMORE	25	0	20	5
8	SMI1	SOUTH MOUNTAIN	WASHINGTON	206	3	13	47
9	NOR1-8, FRG1-3	UREY RD/DEER CREEK	HARFORD	62	0	9	11
10	GOR3	LAUREL RUN	GARRETT	119	0	119	0
11	SMI3	SOUTH MOUNTAIN WARNER HOLLOW	WASHINGTON	95	0	0	81
12	BIT7-12	BIG RUN	GARRETT	1067	0	952	0
13	CAT1,2	LITTLE HUNTING CREEK	FREDERICK	4	0	2	0
14	BEL1	BEL1 COMPLEX	ALLEGANY	35	0	27	0
15	DEE1	LOSTLAND RUN 2	GARRETT	53	0	31	0
16	SMI2	SOUTH MNTN WOLFSVILLE RD	WASHINGTON	51	8	41	0
17	AVI2	WOLF SWAMP	GARRETT	162	0	60	0
18	MCH2	BEAR CREEK	GARRETT	139	0	139	0
19	BAR6,7	LITTLE SAVAGE RIVER	GARRETT	823	0	824	0
20	ART2	DEEP RUN	ALLEGANY	125	0	119	0
21	GRA14	NEW GERMANY SP UPPER POPLAR LICK	GARRETT	680	0	608	0
22	FRO1	FROSTBURG WATERSHED	GARRETT	863	0	0	607
23	OAK1,2	BULL GLADE RUN	GARRETT	55	0	54	0
24	SAN13	LOWER DEEP CREEK	GARRETT	25	0	12	0
25	AVI5	MUDLICK	GARRETT	314	0	194	0
26	BIT13,22	MONROE RUN	GARRETT	493	0	480	0
27	ACC4	LITTLE BEAR CREEK	GARRETT	269	0	246	0
28	GRA11	AMISH ROAD SWAMP	GARRETT	153	0	91	0
29	BAR1	POPLAR LICK	GARRETT	1151	0	1098	0
30	BAR12,13	SAVAGE RIVER	GARRETT	662	0	587	0
31	LON5	MILL RUN	ALLEGANY	59	0	45	0

32	SAN10	TOLLIVER RUN	GARRETT	498	0	466	0
33	705	WAGNER ROAD	ALLEGANY	57	0	39	0
34	BEL2	SIDELING HILL WMA	ALLEGANY	22	0	22	0
35	1030	BIG RUN HIKING TRAIL	ALLEGANY	56	0	56	0
36	436	YOUGH RIVER	GARRETT	21	0	1	0
37	670	WHITE ROCK RUN	GARRETT	30	0	21	0
38	BAR3	ELK LICK RUN	GARRETT	375	0	275	0
39	AVI3	UPPER POPLAR LICK	GARRETT	193	0	80	0
40	FRI1	BUFFALO RUN WATERSHED	GARRETT	114	1	0	0
41	265,247,282,292	FIFTEEN MILE CREEK	ALLEGANY	35	0	25	0
42	MCH3	DEEP CREEK LAKE ST. PARK	GARRETT	205	0	200	0
43	205	TOWN CREEK AREA	ALLEGANY	10	0	10	0
44	208	POLISH MOUNTAIN	ALLEGANY	13	0	13	0
45	288,299,248	OLD WILLIAMS ROAD	ALLEGANY	17	0	13	0
46	439,506,412	TOWN CREEK AREA GRSF	ALLEGANY	45	0	31	0
47	LON3	DANS MOUNTAIN STATE PARK	ALLEGANY	18	0	18	0
48	BAR22	BLUE LICK	GARRETT	37	0	8	0
49	BAR14	PINE SWAMP RUN	GARRETT	261	0	218	0
50	BAR10	BEAR PEN	GARRETT	348	0	316	0
51	AVI4	BLUE LICK AREA	GARRETT	834	0	780	0
52	BIT16	DRY RUN	GARRETT	196	0	158	0
53	BIT17,18,21	MIDDLE FORK DRAINAGE	GARRETT	910	0	737	0
54	BIT5	POPLAR LICK WATERSHED (PART)	GARRETT	177	0	147	0
55	GRA2	PUZZLEY RUN	GARRETT	138	0	115	0
56	BIT14	BIG RUN ST. PARK	GARRETT	622	0	537	0
57	368	EAST VALLEY RD GRSF	ALLEGANY	25	0	25	0
58	318ETAL	GRSF	ALLEGANY	259	0	230	0
59	795ETAL	C&O CANAL	ALLEGANY	59	0	59	0
60	835	LOG ROLL AREA OF GRSF	ALLEGANY	17	0	14	0
61	921, 1047	DAILEY RD GRSF	ALLEGANY	47	0	47	0
62	POO1	MONOCACY, N.R.A.	FREDERICK	3	0	3	0