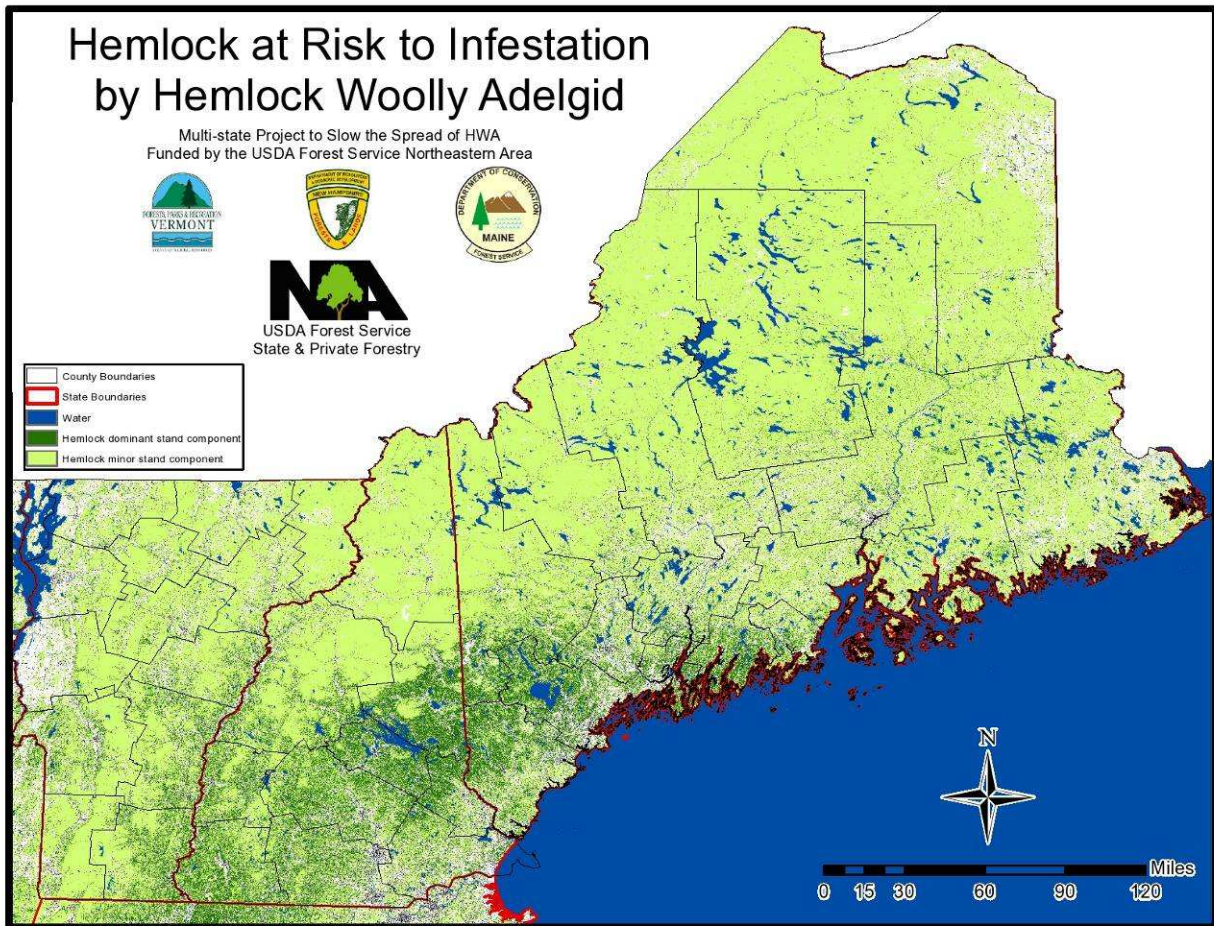


Slow-The-Spread Management of Hemlock Woolly Adelgid In Northern New England:

A Coordinated Regional Approach



This project was funded by a USDA Forest Service, State and Private Forestry
Competitive Grant Initiative

Abstract

This project addressed hemlock woolly adelgid management at the northern edge of its distribution in New England. Hemlock landscapes comprise approximately 3.5 million acres of forestland in the three-state area.

Communication and cooperation has been fostered through development of a coordinated program to slow the spread of hemlock woolly adelgid in the northern New England states of Maine, New Hampshire and Vermont. This has resulted in strengthened regional partnerships and increased management efficiency.

Activities were focused on eradication of outlying populations, suppression activities at the leading edge, integrated management in the infested area, monitoring of changes in distribution boundaries and outreach to potentially affected landowners and industries and to the general public.

Cover: Map, Ryan Hanavan USDA Forest Service, NA; Vernal Pool Hemlock, HWA Ovisacs, MFS; Biopesticide application, USDA Forest Service, NA

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LIST OF ABBREVIATIONS USED IN THIS DOCUMENT

EHS Elongate hemlock scale (*Fiorinia externa*)

HWA Hemlock woolly adelgid (*Adelges tsugae*)

Ln *Laricobius nigrinus* (Derodontid beetle, hemlock woolly adelgid predator)

MDA, PI Maine Department of Agriculture, Plant Industry

ME BPL Maine Bureau of Parks and Lands

MFS Maine Forest Service

NA USDA Forest Service, State and Private Forestry, Northeastern Area

NH DFL New Hampshire Division of Forests and Lands

St *Sasajiscymnus tsugae* (Coccinellid beetle, hemlock woolly adelgid predator)

USDA United States Department of Agriculture

APHIS-PPQ Animal and Plant Health Inspection Service-Plant Protection and Quarantine

USDI United States Department of the Interior

UVM-ERL University of Vermont Entomological Research Laboratory

VT FPR Vermont Department of Forests, Parks and Recreation

PROJECT SUMMARY

This project developed a coordinated program to slow the spread of hemlock woolly adelgid (HWA) in northern New England. The focus was on eradication of outlying populations, suppression activities at the leading edge, integrated management in the infested area, monitoring of changes in distribution boundaries and outreach to potentially affected landowners, industries and the general public. The period covered in this report is July 2009 through September 2011.

Overall accomplishments:

- Surveys conducted to outline the infestation, detect spread and monitor eradication.
- Volunteers trained to conduct surveys through landowner, conservation and industry groups.
- Outreach conducted to create public awareness.
- Stakeholder input solicited on HWA management.
- Pesticides, experimental pesticides, and/or tree removal used on selected sites for eradication or risk reduction.
- Biocontrols used to reduce adelgid populations and establish natural enemies.
- Assessment plots established to monitor infestation dynamics and impacts.
- Quarantines between states adjusted and maintained through information, compliance agreements and inspections.
- Biocontrol agents established across the northern edge.
- Public involvement encouraged.
- Disruption of wood-using industries minimized.
- Management strategies demonstrated in colder climates.
- Intentional information exchange opportunities established through conference calls, meetings and use of Google Share site.
- Communication between states and between state and federal agencies improved leading to increased efficiency in managing this and other forest health issues.



University of Maine Forestry Students
Scan a Beat Sheet for Predators (Credit
MDA, PI)

THE THREAT and THE THREATENED RESOURCE

The HWA is a tiny insect from East Asia that attacks forest and ornamental hemlock trees. It feeds on young twigs, causing needles to dry out and drop prematurely and causing branch dieback. Damage from the insect has led to widespread hemlock decline and high levels of hemlock mortality in forests south of our region. Key ecosystem functions are compromised by hemlock decline and mortality. Hemlock survival appears to be prolonged and decline slowed in northern regions with colder winter temperatures. However, HWA is still one of the most



Canopy Dominant Riparian Hemlocks (Credit ME BPL)

significant contributing agents to the National Risk Map and losses in excess of 10 percent of basal area are expected in the region within the next ten years (Krist et al. 2007).

The hemlock resource in northern New England covers approximately 3.5 million acres (see cover map, derived from USDI Geological Survey 2011). Unique ecological services provided by hemlock contribute to critical wildlife habitat and riparian area integrity. Hemlock also has widely praised aesthetic benefits in natural and ornamental settings and is a significant component of the local wood products industry.

Maine, New Hampshire and Vermont are each at different stages in responding to HWA. The three states have varied administrative structures and have had different approaches to HWA response. Increased communication across the region

has resulted in an enhanced knowledge base and tool-set for each of the states.

The insect was first detected in New Hampshire forests in 2000, in 2003 it was found in Maine forests and the first forest detections in Vermont were in 2007. A well established area of infestation is apparent in southern York County in Maine, as well as on several islands and coastal peninsulas. More scattered infestations are apparent moving further inland. A similar situation exists in the southern tier of towns in New Hampshire, with more diffuse populations in towns to the north. Diffuse populations appear to have just reached much of the infested area of Vermont. The Connecticut River appears to have provided a path for advanced northerly movement in both New Hampshire and Vermont. The coast appears to be a fast track for adelgid spread to the east in Maine. Both Maine and New Hampshire also have detections of elongate hemlock scale (EHS) in forest and ornamental settings which compounds the threat of HWA.

SURVEY

Detection survey methods were standardized between the three states, based on established survey protocol and manager experience. Standardization contributes to the integrity of quarantines and other efforts to slow-the-spread of HWA.

At a minimum, all towns bordering towns with known infestations of HWA were surveyed. In each border town at least five high risk sites were visited. High risk sites included locations near water, travel corridors, housing developments and infestations in neighboring towns. A minimum of 200 branches per site were examined for HWA. Research suggests that at this sampling intensity, the likelihood of missing a detectable population is low (Costa and Onken 2006). Across the region, manager experience suggests an



A Detection Survey is Conducted in Vermont (Credit VT FPR)

increased likelihood of detection with concentration on high risk sites.

All three states exceeded the detection survey targets during the project period. Additional surveys were conducted where resources allowed, where risk was perceived to be high for HWA establishment, and where new detections dictated additional survey. During the project period 23 new infested towns were detected in Maine and New Hampshire and one new infested town was found in Vermont. Maine had three new county detections: Cumberland, Lincoln and Sagadahoc Counties. New Hampshire regulated one new county due to detection of more widespread infestations (Cheshire) and Vermont had no new counties detected. Several of the newly detected areas in Maine are well established and have likely existed for five or more years.

	Year 1		Year 2		Project Period
	Towns Surveyed	Number of Sites	Towns Surveyed	Number of Sites	New Infested Towns
Maine	44	113	81	265	23
New Hampshire	53	265	62	310	23
Vermont	14	74	14	73	1

Survey Highlights

Vermont recruited and trained volunteers to assist in detection surveys. The Maine Forest Service *Take a Stand for Hemlock* HWA detection and monitoring training materials were adapted for use in Vermont and nine training sessions were held. Over the course of the project, 181 citizens were trained to identify HWA and assist in conducting surveys. Volunteers were provided survey materials, and received periodic updates on HWA by email. Eighty volunteers assisted with surveys at 48 locations in Year 1 and in Year 2, 27 citizen monitors assessed 30 of the survey sites.



A Maine Forest Service District Forester Starts Volunteers on a Cruise Line at Vaughan Woods State Park (Photo Credit ME BPL)

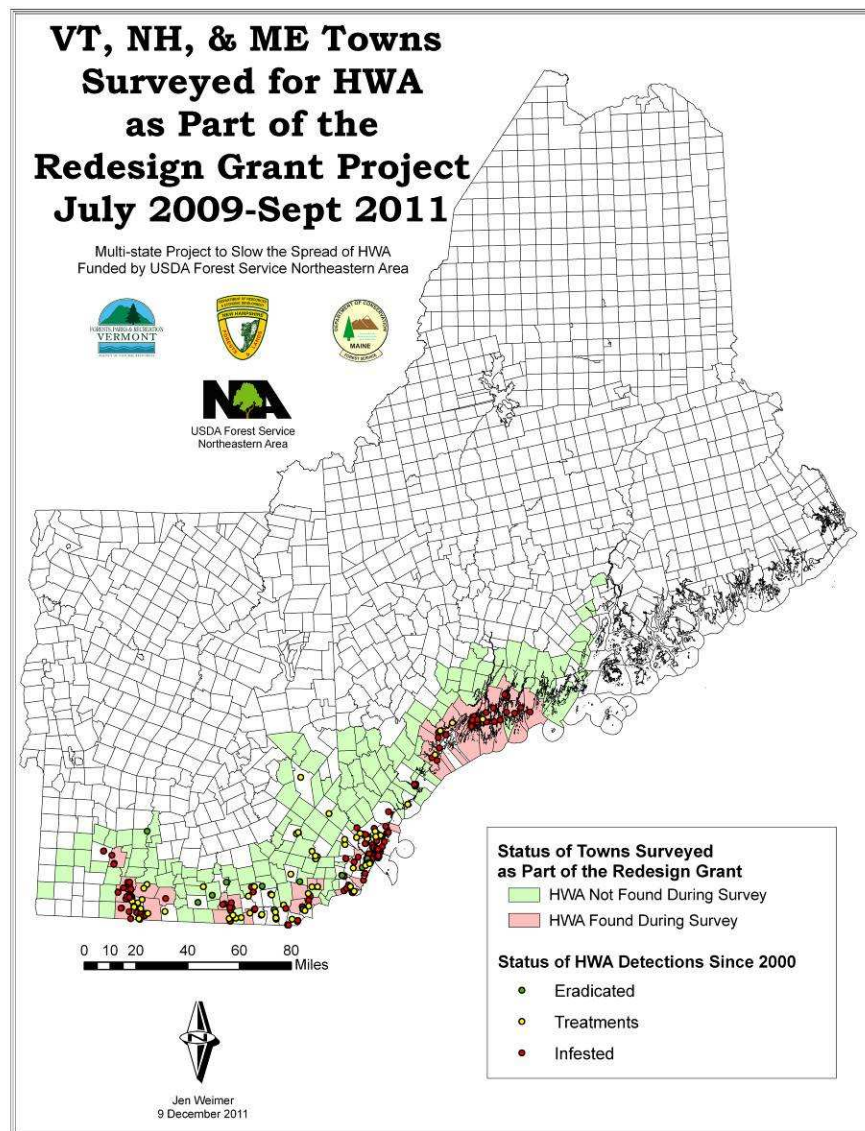
One hundred sixty acre Vaughan Woods State Park in South Berwick, Maine is treasured locally for its majestic hemlocks. Two special *Take A Stand* volunteer surveys and a staff survey were conducted in Year 2 of the grant at this special place. The first, attended by 15 volunteers, was what has been termed a sweep, where volunteer groups look at as much hemlock as possible to detect adelgid. This resulted in the first detection of adelgid at the park. The second survey, a monitoring survey, set up a Costa-like sample (Costa and Onken 2006) on a grid of forest inventory points. This covered the stand, and detected no adelgid, indicating that less than two

percent of the stand was infested, and that the infestation was below the detection threshold for the survey. In addition a rough estimate of hemlock abundance was gathered for the park managers at 555 survey points. This event was supported by more than 40 volunteers with 25

conducting the actual survey. A follow up intensive delimiting survey focusing on the water courses in the park was conducted by staff in an attempt to locate sufficient adelgid for biocontrol release. This effort uncovered three patches of infested trees along a feeder stream to the Salmon Falls River, inoculative releases of *Sasajiscymnus tsugae* were conducted at two of these locations.

New Hampshire's Pisgah State Forest is in close proximity to new infestations in Winchester and Chesterfield. A supplemental survey for HWA there revealed a small infestation along the Kilburn Trail. A combination of chemical and cultural controls was used at the site. The core of the infestation was cut and the trees along the edge of the cut were treated with basal stem applications of Safari. The cut branches were left onsite and covered with a tarp for eight weeks while the adelgid desiccated. Posters for HWA/EHS and Asian longhorned beetle/emerald ash borer were posted at all major trailheads throughout the park.

2009-2011 Surveyed Towns and Hemlock Woolly Adelgid Detections Since 2000



OUTREACH

Outreach is critical to early detection and supports appropriate management and quarantine compliance. Outreach is a first step in engaging volunteers, and invites public involvement in government decision-making.

Some outreach needs are local, while others cross state lines. Where needs cross state lines, the states have collaborated to develop new outreach material. Where the needs are state-specific, or to accommodate state specific printing capacity, resources have been saved by adapting shared materials for local use.

All cooperators use a broad array of platforms for outreach, and each has different strengths. In a region of our size, especially in an age of electronic media, outreach events in the three states have significant impact beyond state and even regional boundaries. The concurrent USDA APHIS-PPQ/USDA Forest Service funded Forest Pest Outreach and Survey Project in the Northeast complemented our efforts to raise awareness about this particular invasive insect.

Workshops and presentations were common modes to disseminate information. Target audiences included arborists, foresters, loggers, park managers, land trusts, municipal organizations, landowners, homeowners, teachers, students and others. More than 150 workshops were presented with the combined audience exceeding 4000 participants. The states each have a presence at local fairs, trade shows, garden shows and similar events and distribute information about HWA at these and other venues. In Maine, a volunteer developed an HWA/EHS costume to be used at such events.

Web presence is important across the region¹, with cooperators amplifying state Web communications. Social media use is still developing. New Hampshire has a forest health oriented Twitter account²; Maine takes advantage of Department of Conservation and cooperator Facebook pages³ to publish highlights; and Vermont has incorporated HWA information into the new multi-organization *Vermont Invasives*⁴ Website.



Hemlock Woolly Adelgid and
Elongate Hemlock Scale Costume
(Credit MDA, PI)

¹ <http://www.maine.gov/doc/mfs/HWAOverview.htm>, <http://nhdf.org/forest-health/hemlock-woolly-adelgid.aspx>, <http://www.vtfpr.org/protection/hwaupdate.cfm>

² <http://twitter.com/NHDFL>

³ <http://www.facebook.com/pages/Maine-Department-of-Conservation/57426456796> and others.

⁴ <http://www.vtinvasives.org/>

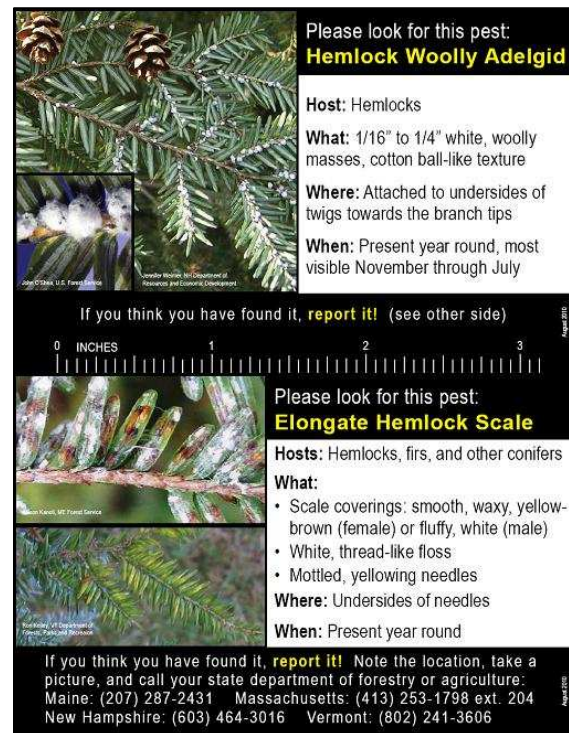
Additional information is distributed in pieces written for newsletters and similar publications for audiences including The Nature Conservancy, the New England Society of American Foresters and the woodland owner associations and other green industry groups.

Outreach Highlights

Maine. Press Releases and Media Alerts distributed by Jeanne Curran, the Department of Conservation's Public Information Officer, generally got widespread and often immediate attention. One such press release generated a story on Public Radio International's *Living on Earth*⁵ which was broadcast on approximately 300 public radio stations. An opinion piece discouraging spring and summer bird feeding was written for and published in Northern Woodlands Magazine.⁶

The Maine Vital Signs⁷ program has become an important partner in HWA outreach. Maine Forest Service staff respond to reports of invasive forest insects, participated in panel discussions of invasive species for 7th and 8th grade teachers and helped develop fact sheets for identification of hemlock and HWA. A forum post challenging users to look for HWA prompted Vital Signs staff to create a hemlock woolly adelgid field mission.⁸ Through this joint effort, school teachers, students and citizen volunteers have been energized and empowered to contribute to the effort to slow-the-spread of HWA in Maine.

Two publications with basic information about HWA were developed and made available on-line and in print. The first was a two page fact sheet about HWA designed to provide important background information for homeowners and professionals in an easily reproduced format (black and white).⁹ It adapted existing information about the pest with a Maine specific message. The second was a wallet card developed with assistance from Deborah Muccio with the USDA Forest Service, NA and feedback from the cooperating states. The purpose was to



Wallet Card Developed By Cooperators
(Credit USDA FS, NA)

⁵ <http://www.loe.org/shows/segments.html?programID=10-P13-00028&segmentID=8>

⁶ <http://northernwoodlands.org/articles/article/another-view-its-time-to-reconsider-spring-and-summer-bird-feeding>

⁷ <http://vitalsignsme.org/>

⁸ <http://vitalsignsme.org/mission-hemlock-woolly-adelgid>

⁹ <http://www.maine.gov/doc/mfs/HWAFactSheet.htm>

have a small, durable, graphic intense publication that would be useful to a broad audience for identification and reporting of HWA and EHS.

New Hampshire. As new towns were discovered with small HWA infestations the University of New Hampshire, Cooperative Extension Service sent a letter to each postal patron in that town. The letter reported the detection and encouraged the recipient to review an enclosed pamphlet and inspect hemlock trees for any signs of infestation. Dozens of calls from recipients were received and most pest problems were not HWA but at least five infestations have been discovered using this outreach method.

Help Protect our Trees!

STOP THE SPREAD OF HWA!



Hemlock tree infested with Hemlock Woolly Adelgid



Look for white cottony masses on the undersides of branches



Close-up of Hemlock Woolly Adelgid

An Infestation of this insect has been found in your area.

Hemlock Woolly Adelgid (HWA) is an exotic insect new to NH. This insect has caused extensive tree mortality in other states. We need your help to save the hemlock resource in our state. Please contact the Forest Health Office if you suspect you have this insect.

What you can do to help:

- ✓ Check your hemlocks to see if HWA is present.
- ✓ If it is, note the exact location of the suspect tree.
- ✓ Contact the NH Forest Health Office to report your find.

NH Division of Forests and Lands
Forest Protection Bureau
Forest Health Office



PO Box 1856
Concord, NH 03302
(603) 464-3016
www.nhdf.org

Above: Pamphlet Enclosed in Letters from New Hampshire Cooperative Extension (Credit NH DFL)

Towns Receiving Mailing From New Hampshire Cooperative Extension

Town	Number of Patrons
Greenfield	684
Mason	604
Winchester	1,905
Milton	1,765
Milton Mills	285
Chesterfield	303
New Durham	1,290
Alton Bay	1,416
Amherst	3,960
Newmarket	1,726
Farmington	1,572
Nottingham	1,717
Westmoreland	707
Rindge	2,244
Temple	603
New Ipswich	1,974
Bennington	547

Wallet cards modified from the card described above were produced and distributed to help publicize the need to look for HWA and EHS. New Hampshire has better capacity for printing such specialized color documents than the other two states which allowed faster production of this important outreach document.

Vermont. Hemlock woolly adelgid materials were posted on the Vermont Forestry Division website, vtforest.com, including an annual revision of the *Vermont Invasive Forest Pest Update: Hemlock Woolly Adelgid*, and a documentary on HWA was prepared and posted by VermontTV.net on the agriculture channel.¹⁰ Stakeholder input on hemlock woolly adelgid

¹⁰ <http://www.vermonttv.net/player/./index.html?menuID=8&flvID=2>

management was solicited at a public involvement meeting for the state-owned Roaring Brook Wildlife Management Area.

Vermont worked with the local media to publicize information, including a press release on the *Laricobius* release and on an award given to the arborist who originally detected HWA in Vermont. These resulted in articles in the Rutland Herald, the Brattleboro Reformer and the Bennington Banner, and a feature story on *Laricobius* on Vermont Public Radio.

ASSESSMENT and TECHNICAL TRANSFER

Winter Mortality

Winter mortality was assessed to some degree by each of the states in the grant period. A minimum standard was agreed upon to examine at least 100 adelgids per site and to take samples from at least ten trees. Vermont and Maine had temperature recorders available in at least a subset of the sites. Mortality varied widely between sites, and except for in Vermont in 2010-2011 was too low to keep HWA populations from expanding (Paradis *et al.* 2008). Vermont’s efforts are detailed below.

	Average Winter Mortality of Sistens Generation		
	Maine	New Hampshire	Vermont
Winter 2009-2010 (Rank, average temperature departure from normal ¹)	17% (112 th of 115, +2.9°C)	50% (97 th of 115, +1.1°C)	25% (-18°C avg. min T) (96 th of 115, +1.3°C)
Winter 2010-2011 (Rank, average temperature departure from normal ¹)	50% (-22°C avg min T) (80 th of 116,+1.2°C)	64% (59 th of 116, -0.9°C)	87% (-25°C avg min T) (59 th of 116, -0.7°C)

¹ Source: Statewide summary tables, Northeast Regional Climate Center 2011. Coldest winter would be 1st, higher rank indicates a warmer winter.

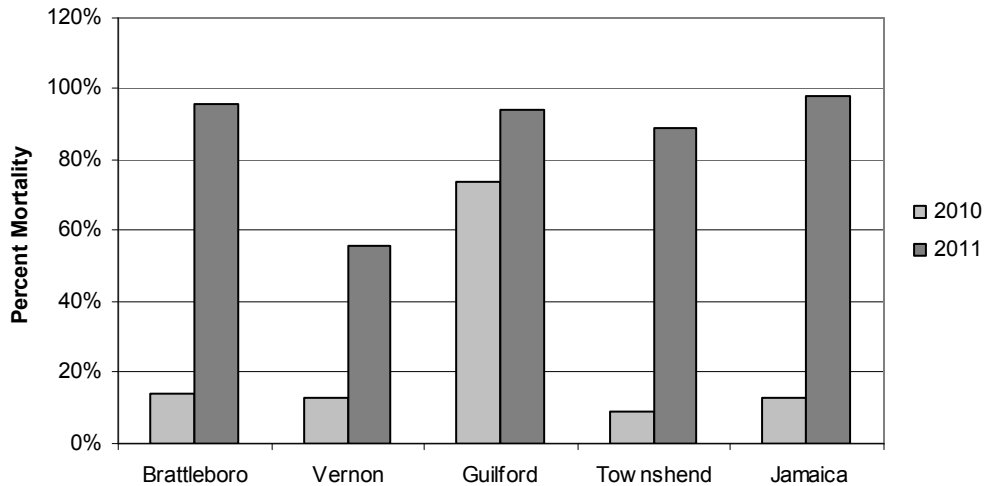
In Vermont overwintering mortality was assessed at five locations with iButton data loggers (manufactured by Dallas Semiconductor Corp.). These were installed at the sites in December (by 12/4/09 and 12/13/10) and removed in April (4/6/10 and 4/6/11). Hemlock branch tips with new growth were sampled, in 2010, between April 13 and April 28, and in 2011, on April 6. At least 100 new sistens were examined under a dissecting microscope to determine the numbers of live and dead adelgids.

Winter mortality of HWA during the winter of 2009-2010 was light, resulting in an upswing in the population. Mortality was 74% at the site with the coldest recorded temperature, in Guilford. Mortality averaged 12% at the other four sites. In winter 2010-2011 mortality increased and reached thresholds thought to be necessary to curtail population growth (Paradis *et al.* 2008). This increased mortality corresponded with colder winter temperatures. Across the region the winter of 2009-2010 was warmer than average, and the winter of 2011-2012 was slightly cooler than average in New Hampshire and Vermont and slightly warmer than average in Maine (Northeast Regional Climate Center 2011).

Winter Mortality of HWA at Five Vermont Locations

Town	Winter 2009-2010			Winter 2010-2011		
	Minimum Temperature	Percent Dead	Number Examined	Minimum Temperature	Percent Dead	Number Examined
Brattleboro	-17°C	14%	100	-26°C	96%	787
Vernon	-17°C	13%	100	-24°C	56%	1022
Guilford	-20°C	74%	148	-26°C	94%	676
Townshend	-18°C	9%	4483	NA	89%	414
Jamaica	-19°C	13%	14,023	-24°C	98%	528
Average	-18.2°C	24.6%		-25°C	87%	

Percent Winter Mortality of HWA at Five Vermont Locations



Silvicultural Study

During the summer of 2009 a cooperative study with Dr. MaryAnn Fajvan at the USDA Forest Service Northern Research Station was identified and prepared in New Hampshire. The subject of Dr. Fajvan's work, and this assessment project, is "Integration of Silvicultural Strategies for Hemlock Management in Eastern Forests Threatened by Hemlock Woolly Adelgid (*Adelges tsugae*)" (Fajvan 2008). Using data collection templates from Fajvan's study the NH Division of Forests and Lands monumented and measured ten-24th acre plots in six different ten acre blocks within a large timber sale operation at Forest Peters Wildlife Management Area in Northwood, NH. These 60 plots were established and measured before the timber harvest in 2009 and again after the harvest in 2010. Five blocks received a thinning and one block was left un-cut as a control. Our goal for the future of this assessment project is to monitor for HWA and remeasure the plots as HWA begins to establish itself in the research area. The USDA Forest Service Northern Research Station will continue to include this study area in any subsequent analysis of hemlock health in managed forests in a post infestation paradigm.

Monitoring

Maine used the sampling protocol developed by Costa and Onken (2006) to monitor several sites across the region in Year 1. The results show a range of infestation status for the stands examined. This survey was not fully implemented in the second year due to the expanded survey area and demands on staff time.

Up to one hundred trees were sampled at each site. At this sample size the threshold detection level of the survey is two percent and results under 16% are said to be imprecise. Two of the stands were below the threshold detection levels in Year 1 and one in Year 2. One revisited site had a detectable increase in infestation levels between the two measurement cycles (9% increase in one year).

Costa-Method Monitoring Surveys at Sites Known to be Infested

Town	Type	% Infested Year 1	% Infested Year 2
Freeport (WNW1)	Biocontrol	--	16%
Kittery (GI4)	Biocontrol	100%	--
Kittery (KIT1)	Biocontrol	100%	--
Kittery (KLT1)	Biocontrol	45%	--
Saco (FBSP1)	Biocontrol	1%	3%
South Berwick (VWSP 1)	Biocontrol	--	Below threshold
York (YWD1)	Biocontrol	20%	29%
Kennebunkport	General	50%	--
Kittery	General	24%	--
South Berwick	General	Below threshold	--
South Berwick	General	7%	--

CONTROL

Quarantine

All three northern New England states have hemlock woolly adelgid quarantines that address nursery stock and forest products. One of the goals of the multi-state project was to amend state quarantines so that Maine, Vermont and New Hampshire had as similar regulations as possible. All three state quarantines now offer a compliance agreement option for forest industry groups wanting to import hemlock forest products from infested counties. Risk mitigation measures are required and the sites are



Quarantines Limit Disruption to Wood-Using Industries and Mitigate Risk of Accelerated HWA Spread by Forest Products (Credit MFS)

inspected for the presence of hemlock woolly adelgid.

During the project period the New Hampshire quarantine was updated. Vermont's quarantine was reviewed; although no changes were made, a significant outreach effort was conducted to facilitate compliance. Maine has started the process to expand the internal quarantine to encompass all known municipalities and update the quarantine. An initial meeting with stakeholders to discuss potential changes to the current rule was held on March 30, 2011. This was productive, but the rule-making process did not move forward in the grant period.

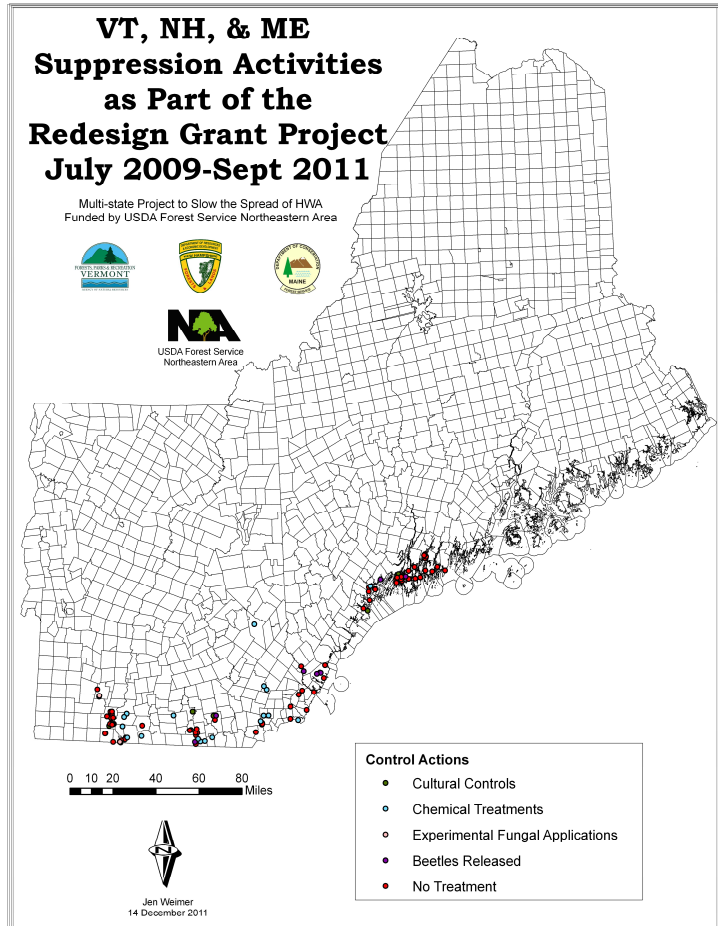
Quarantine Highlights

In 2009 and 2010 the New Hampshire State Forest Nursery cooperated with the Forest Health Program to annually transplant 10,000 hemlock seedlings to allow these seedlings to grow an extra year. An outreach letter and prospectus was then sent to all landscapers and nurseries in Maine, New Hampshire and Vermont to inform them that a local source of larger hemlock root stock was available. The project was designed to stem the flow of hemlock nursery stock coming from infested southern and western regions of the Country. 6,000 of the first 10,000 available seedlings were sold in May of 2011.

Vermont's response to invasive forest pests is guided by the Invasive Forest Pest Action Plan, which is updated annually. A supplement specific to hemlock woolly adelgid response is also updated annually.

To slow the spread of hemlock woolly adelgid, outreach was conducted on the State of Vermont Joint Quarantine #2: Hemlock Woolly Adelgid. After 196 wood-product processing facilities were contacted regarding the quarantine, seven new hemlock woolly adelgid compliance agreements were completed. All seven sites with compliance agreements were inspected for the presence of hemlock woolly adelgid on any nearby hemlocks.

In addition, information on the quarantine was presented to foresters at the VT Forest Health Information Meeting in April 2010, and to loggers at three workshops conducted as part of the Logger Education to Advance Professionalism program.



Summary information about Hemlock Wood Products Considerations was made available on the Web.¹¹ This includes a table, *Overview of Quarantine Requirements for Moving Hemlock Wood Products from Vermont to Sites in the Region*.

Bio-Control

Established natural population controls such as generalist predators are not effective in keeping HWA below damaging thresholds. Therefore, the USDA Forest Service recommends that a suite of biological controls be established in an attempt to achieve effective control (USDA Forest Service 2005). The states worked toward this goal, focusing on predators proven to establish in the area (*Sasajiscymnus tsugae*) and predators most likely to be climatically matched to the area (*Laricobius nigrinus* collected in Idaho). In addition Vermont cooperated in an experimental application of a fungal biopesticide (Costa 2010) and all states provided material for researchers investigating agents of disease in natural HWA disease outbreaks.

Predator Beetles

Two species of predator beetles which appear to be important predators of HWA in its native range have been released in the three states.

Laricobius nigrinus (Ln) predator beetles were released in all three states. Maine received a shipment of 500 lab-reared Ln beetles in March of 2010 at short notice due to poor weather conditions in the southern region. These were released on water district property in York, ME. In cooperation with Dr. Dave Mausel from the University of Massachusetts Ln were released at two infested sites in Vermont and three in New Hampshire. In Vermont two releases of 202 beetles occurred in 2009: beetles collected from Idaho were released in Brattleboro and beetles collected from the Seattle area were released in Vernon. In New Hampshire, 500 Ln from Idaho were released in Amherst in 2009 and in 2010, 500 Ln from Idaho were released at each of two sites, one in Merrimack and the other in New Ipswich.

Maine has successfully recovered *Sasajiscymnus tsugae* (St) at prior release sites in York County, indicating successful establishment of the species in this region. Acquisition of St beetles in Maine during the project period was supported by grants from USDA APHIS-PPQ and the Maine Outdoor Heritage Fund. In 2010, 9000 St were purchased from Forever Green Environmental Services and were released at five sites from Harpswell to York and 47 Maine-grown St were relocated from a site in Kittery to one in York. In 2011, 7000 St were purchased from Forever Green Environmental Services and 10,000 were received from a USDA APHIS-PPQ cooperating laboratory. These were released at six sites spanning the known extent of HWA.

A sampling protocol for monitoring predators was adapted for the region and enhanced with photos of the target species, life cycle information and guidance for sample timing.¹² Sampling was conducted at release sites in all three states and predators were recovered in each state.

¹¹ <http://www.vtfpr.org/protection/hwawoodproductconsiderations.cfm>

¹² <http://www.maine.gov/doc/mfs/documents/HWAPredMonitoringNNE.pdf>

**Northern New England Predator Beetle Recoveries
July 2009-September 2011**

Species	Locations (Quantity)	Mo. Year
<i>Laricobius nigrinus</i> (Ln) (Lab-origin)	York, ME (1)	Nov. 2009
	Saco, ME (1), York, ME (1)	Apr. 2010
	Kittery, ME (2), York, ME (6)	Nov. 2010
Ln (Idaho strain)	Brattleboro, VT (1)	Nov. 2010
<i>Sasajiscymnus tsugae</i> (St)	Kittery, ME (28), Seabrook, NH (1)	Nov. 2009
	Kittery, ME (7), York, ME (1)	Apr. 2010
	Kittery, ME (48), Saco, ME (1)	Nov. 2010
	Seabrook, NH (1)	Apr. 2011

Fungus

Disease Outbreak Investigated. An epizootic (disease outbreak) was noticed in HWA populations in southern New Hampshire in 2008. Symptoms were similar to previously reported outbreaks in Massachusetts. New Hampshire staff contacted the University of Vermont Entomological Research Laboratory (UVM-ERL) for help in determining the cause of the adelgid population crash. In 2009 UVM-ERL received USDA Forest Service grant funding to make preliminary investigations into the identity of the disease-causing organism (project no. 09-CA-11420004-204). All three states submitted material for analysis, and several fungal agents were isolated and identified (Parker *et al.* 2010).



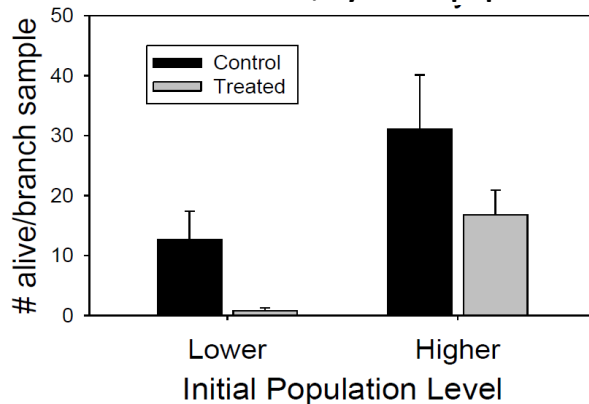
Fungal growth masks HWA on this hemlock twig
(Credit NH DFL)

Mycotal with MycoMax Trial. In cooperation with Dr. Scott Costa, the biopesticide Mycotal was experimentally applied, using hydraulic sprayer equipment, to ten hemlock trees in Townshend State Park, Vermont. Mycotal contains the insect-killing fungus *Lecanicillium muscarium*, and was applied in a whey microfactory formulation (MycoMax). Ten additional trees served as controls.

A fact sheet, *Experimental Mycotal Treatment for Suppression of HWA*, was prepared for public information prior to the application.

Results from the monitoring of aestivating sistens four weeks after application indicate the hemlock woolly adelgid populations were significantly impacted. In the experimental group with low pre-treatment populations, fungus treated trees had counts of live hemlock woolly adelgid 1/16th of the controls. For trees with initially high populations, the fungal treatment reduced the number of insects to nearly ½ of controls. The data also indicated the percentage mortality of crawlers that had successfully settled on hemlock branches was significantly greater on trees treated with fungi. A substantial amount of fungus had persisted four weeks post-treatment.

Average number of live hemlock woolly adelgid sistens on ten Mycotal-treated and ten control trees four weeks after treatment, by initial population level (Costa 2010).



Chemical Control

The three states demonstrate a spectrum of approaches to chemical management of hemlock woolly adelgid.

Maine contracts with a pest control company for management of HWA in locations with a high risk of artificial spread of the insect through human activities or when apparent outlier infestations are detected. In the project period scale and adelgid infestations were targeted in Kennebunk and Kennebunkport (York County). Chemical controls are generally not applied by state contractors in forested situations, although they have not been ruled out where containment is deemed cost effective and possible or on high-valued trees. In the more generally infested area, advice and assistance is provided for control.

New Hampshire forest health staff applies pesticide to all new HWA detections that can be treated chemically. In the grant period they piloted the use of a basal bark application method with dinotefuran. Two dinotefuran products were newly labeled for use with a basal bark application in 2009 and both have been used. Those products are Safari manufactured by Valent and Transtect manufactured by Rainbow Tree Care Scientific.

This basal application of dinotefuran has a small footprint as little or no pesticide reaches the soil and may have fewer adverse environmental impacts than other systems. It has been proven effective and works much faster than applications made to the soil. Translocation through the bark allows material to reach infested branches more quickly than application to the soil. Dinotefuran is also highly effective against elongate hemlock scale. In New Hampshire, 24 sites with five to



New Hampshire's Forest Health Program Coordinator Conducts a Basal Bark Application of Dinotefuran (Credit NH DFL)

50 trees were treated with a basal bark application of dinotefuran.

The State of Vermont has not conducted direct chemical control of HWA. Instead, information about management and control has been prepared and made available to landowners, homeowners, foresters, and tree care professionals.

In August 2010, the document *Hemlock Woolly Adelgid in Vermont- Recommendations for Landowner Response*¹³ was released in print and on the internet. Recommendations are made for managing infested hemlock trees in both a landscape/ornamental setting and in a forested area. General suggestions for keeping trees healthy and slowing the spread of HWA were also made.

In June 2011, a joint workshop was held in New Hampshire to provide detailed information on HWA chemical control (see box right). In August 2011, a workshop for Vermont landowners and homeowners was held. The workshop covered the basic biology of the insect and demonstrated treatment methods that are appropriate for homeowners.

PARTNERSHIPS

Communication in the three state region was enhanced during this project period. Two face-to-face meetings were held in New Hampshire. These were supplemented by conference calls (monthly or as needed), add-on discussions at regional meetings and a Google Share site established by the USDA Forest Service, NA.

In addition to increasing collaboration between the state and federal forest health departments, the cooperators worked to cultivate and diversify partnerships with other organizations and individuals impacted by HWA (see table next page). These partnerships

Chemical Control-Education and Outreach

All three states provide technical assistance to homeowners and professional pesticide applicators seeking advice for HWA management. During the grant period in addition to the one-on-one contact, print and on-line guidance for chemical controls were developed. Vermont developed a fact sheet and workshop specifically geared towards homeowners with threatened hemlocks. Maine surveyed licensed pesticide applicators and developed a list of applicators that control hemlock woolly adelgid, their application capabilities and the territories they serve.

In 2011 an in depth HWA control workshop targeted to licensed pesticide applicators was developed by New Hampshire and Vermont forest health departments and the University of New Hampshire Cooperative Extension. The first of these workshops was held in June 2011 on the Vermont-New Hampshire border. Information about hemlock woolly adelgid, hemlock physiology pertinent to control, and control options were presented by experts from the region and beyond. Several control options were also demonstrated during an outdoor session. The workshop was very well received and a second such workshop is planned for 2012 in the Maine-New Hampshire border region.

¹³ http://www.vtfpr.org/protection/documents/VTFPR_August2010HWAinVermont.pdf

augmented our work and allowed us to contribute to broader-scale efforts to reduce impacts from the HWA. All aspects of slow-the-spread management were enhanced by cooperators.

Additional Partners in Slow-the-Spread Management of HWA at the Northern Edge

Activities	Partners	Areas of Involvement
Detection and monitoring surveys	Landowners; volunteer detectors; cooperative extension; Harvard University; Connecticut Agricultural Experiment Station, media outlets	Study sites; conduct detection surveys; provide opportunities to increase public awareness and citizen detections through direct mailings and publicity
Outreach	Professional and civic organizations; land trusts; state and national parks; garden clubs; schools; local, state and federal government organizations; private companies; colleges and universities; individuals; media outlets	Venues, publicity and demand for workshops and trainings; presentation of segments; organization and presentation of independent sessions; transmission of outreach messages
Management plan review	Fish & wildlife agencies, pesticide advisory boards, stakeholders	Technical and public review
Quarantine	Forest products industry; public and private foresters; loggers; arborists; nurseries; landscapers; state departments of agriculture, New Hampshire State Forest Nursery	Assist with information and education; cooperate in quarantine maintenance; develop a local source for landscape trees
Adelgid predators-release and monitoring	University of Massachusetts, USDA APHIS-PPQ, Rearing Laboratories, Connecticut Agricultural Experiment Station; Virginia Tech; Maine Outdoor Heritage Fund; fish and wildlife agencies; landowners; conservation commissions	Release sites; monitoring assistance; beetles for release; support for releases; taxonomic support; permits for release; data management
Fungal control	University of Vermont; forest landowners	Guidance in trial design, conduct applications and evaluations; taxonomic support; sites for trials
Chemical control	Pesticide boards; Connecticut Agricultural Experiment Station; Cooperative Extension	Advice; technical support

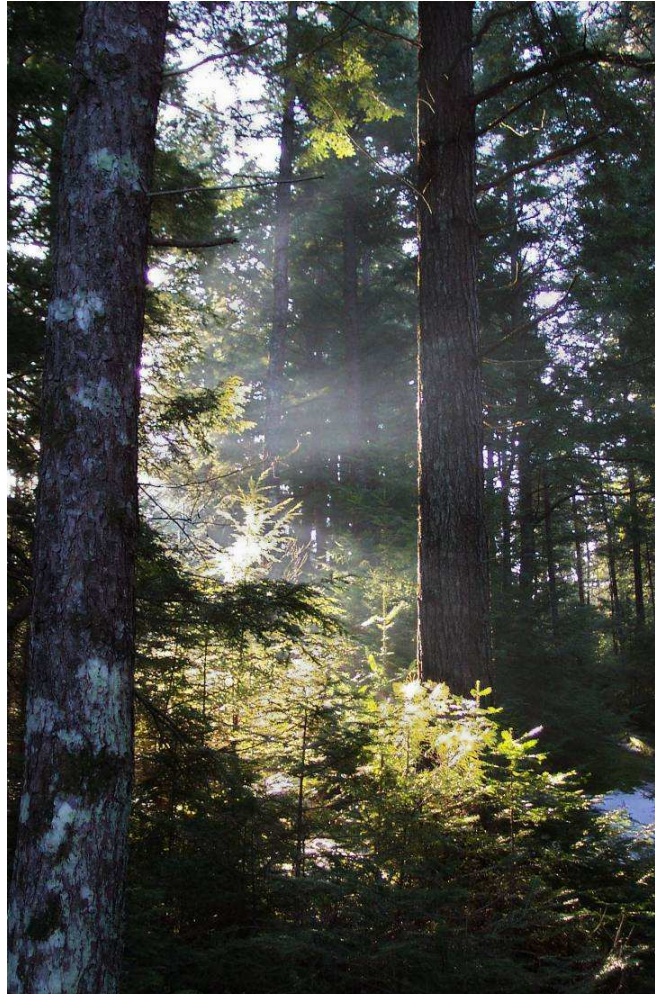
LOOKING FORWARD

The *Slow-the-Spread Management of Hemlock Woolly Adelgid at the Northern Edge* redesign grant created a successful framework for cooperative management of hemlock woolly adelgid in the northern New England states. Partnerships between state forest health organizations

and between state and federal organizations were strengthened. Relationships with local and regional stakeholders in hemlock management were also enhanced.

The project provides a solid foundation for ongoing work on cooperative hemlock woolly adelgid management. In FY2011 the states were awarded a Competitive Allocation grant from the USDA Forest Service, NA that will build upon work done under the redesign grant. Specific focus of the new grant includes:

- Further investigation into the fungi identified in the New Hampshire HWA epizootic;
- Identification of high priority sites for HWA and EHS management and implementation of management at those sites;
- Development of a best management practices guide for resource managers in northern states;
- Work with forest industry to reduce the risk of insect spread while causing minimal disruption to the utilization of hemlock wood products;
- Improve citizen awareness and involvement in detection of EHS and HWA;
- Continue and enhance monitoring of distribution, impacts and cold-hardiness of HWA;
- Continue monitoring and release of predators;
- Sustain and enhance collaborative efforts in response to hemlock health threats across the three-state region.



Hemlock is a Significant Component of the Forest across 3.5 Million Acres in the Three State Region (Credit MFS)

We will focus more broadly on hemlock health, addressing two invasive insect threats to the species and prioritizing implementation of management. Efforts will also concentrate on providing practical information to resource managers, augmenting impact assessments and continued improvement of communication in the region.

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