# The Hemlock Woolly Adelgid and the Fate of the Eastern Hemlock

**Ebony J. Cooke**

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**Dr. Michael J. Baranski (Instructor) and Ms. Katie Bender (Assistant)**

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**The University of North Carolina at Charlotte**

**Abstract:** There are many big concerns in our nation. Many of them are environmental problems. One environmental problem in particular is the depletion of the Eastern Hemlock because of the Hemlock Woolly Adelgid. The Hemlock Woolly Adelgid has entered our nation and there has to be a way to get rid of it. Evidence will show that the Hemlock Woolly Adelgid is spreading. If it continues to spread, then the fate of the Eastern Hemlock is at risk. Experiments have been evaluated and results gathered into a data table. One experiment was done using soil injection and shows how effective that chemical was after a three week period. A data table is used to show when and where the Hemlock Woolly Adelgid began its attack in a certain state and county. The data table shows how long an area has been infected as well. There are also maps that indicate how the pest has distributed itself since its arrival. Knowing all of this is convenient because it helps the mind to come to the conclusion that the Eastern Hemlock's future is at risk. The fate of the Eastern Hemlock is truly at risk. If something is not done then the hemlock may become extinct.

**Introduction:** Our future around us is changing constantly. Every year something new is occurring. The decision is deciding whether these changes are better or worse for our environment in the long run. Countries all around the world are becoming more and more industrialized, but these new arising industries are causing harm to the environment. Industries such as logging and manufacturing companies are depleting the health of the environment. Trees provide so much for the earth. They provide humans and other animals with shelter, oxygen, shade, and even food. If the human species continues to manipulate the environment with new ways of living by introducing new species, then the tree population could die out. One tree population, the Eastern Hemlocks, has been affected greatly by the Hemlock Woolly Adelgid (HWA) .The Eastern Hemlock is a native tree within North Carolina. This tree is mainly found within the mountainous region of North Carolina. It is also found in parts of the piedmont area as well. This tree can be found as far east as Cary, NC (Eastern Hemlock). The hemlock has provided so much for the animals of nature, but what is causing the hemlock population to continuously decrease and how can it be stopped? What does the future hold for the hemlocks? In 1951, a new species was first spotted in Richmond, Virginia. This species derived from East Asia (Pest Alert). A theory is that it arrived accidentally in shipments from Asia (Invasive Species). Since it was spotted this new species has continued to spread. By 2005, the new species had established itself from Georgia up to Maine (Pest Alert). This species is called the Hemlock Woolly Adelgid *(Adelgea tsugae*) (Pest Alert). It does not look like it could be dangerous to a whole tree population, but looks can be deceiving. The HWA looks like snow upon a tree, but it just looks stuck on the tree. The fact that it is stuck is a major problem. HWA loves to feed on Eastern Hemlocks, which will cause major damage to the mountainous and part of the piedmont regions. It is amazing what this infectious species can do. Hemlock Woolly Adelgid is so tiny

that it is only 1/16 inches in length. Its color ranges from reddish-brown to purplish-black. It is known to be parthenogenetic. This means that all of the parts of this species are female and therefore go through asexual reproduction (Pest Alert). Asexual reproduction is not a good thing for the Eastern Hemlock because asexual reproduction can occur faster than sexual reproduction, so the hemlock has no time to develop an immunity to the species. HWA can rapidly continue to develop and build up on one single branch of the hemlock. The complicated adaptation about the Hemlock Woolly Adelgid is that in the hot summer months it is dormant (Pest Alert). Even though they are dormant in the hot summer months, this may increase the depletion of hemlocks in some of the piedmont area, but since the Eastern Hemlock is native to the cooler mountain regions, so the Hemlock Woolly Adelgid is constantly feeding on these trees throughout the whole year. This problem has to be stopped because if the Hemlocks die out there will not be any at high or low elevations in the mountains. This can cause severe runoff in the mountains when it rains. A runoff is the draining away of water or substances carried in it from the surface of an area of land or structure. In the mountains, of course, runoff is going to occur even if trees are at the higher elevations, but the roots from the trees are still holding that soil in place. If a native tree, such as the Eastern Hemlock, is wiped out of the mountains then there will not be many roots to hold the soil in place and will cause a severe runoff. This runoff could easily destroy the habitats below because the animals and the plants are not use to all of that soil. Since the soil and the trees have been washed away or depleted. The organisms, such as birds, who live at these higher elevations have to find a new habitat. Birds, such as the Red-eyed Viero and the Blue Jay, like to live in high, elevated areas. The destruction of the Eastern Hemlock can cause various problems for select species. Something has to be done about this. The question is how do humans stop the destruction of the Eastern Hemlock? There are techniques that can be used. The future

for the Hemlock can be changed. Only research, trials and errors, and corporation can determine what happens.

The way to find out how to kill HWA is to know the behavior of it. HWA is a tiny insect that is native to Japan and China. The actual HWA can hardly be seen with the naked eye. The white, snowy like substance that is shown on the Eastern Hemlock is what is called the “wool” of the HWA. HWA sucks all of the nutrients out of the Eastern Hemlock by feeding on the sap at the bade of the hemlock needles (source). This hinders the hemlock from getting the nutrients it needs in order to survive. HWA is causing such a restriction of nutrients that the needles on the hemlock turn from a deep green to a grayish green color. Once they turn grayish green the needles fall off. If the Eastern Hemlock does not have its needles it will starve to death. Within three to five years of HWA infecting an Eastern Hemlock, the alterations of the hemlock are noticeable (source). When HWA has set its ground, it begins to spread. Kristine Johnson said that adelgid populations can increase dramatically, since all HWA are female and reproduce asexually twice in one year. One HWA can lay up to 300 eggs at one time (source). This will truly affect the forest of the Eastern Hemlocks.

**Methods:** There are many techniques and ideas that have been put out there to stop the Hemlock Woolly Adelgid from destroying the Eastern Hemlock. There are three types of methods to stop the spread of this infection: cultural control methods, chemical control methods, and biological control methods. Every method has its own techniques. Cultural control methods include reducing invasion by adelgids, improving tree health, mechanically removing adelgids, and planting resistant hemlock species (CAES: Fact Sheets). The Hemlock Woolly Adelgid spreads very quickly. A technique is to get rid of the Eastern Hemlocks that are already infested

with *Adelges tsugae*. Scientist say that “Because birds, squirrels and deer are important dispersal agents, any effort to discourage these animals from visiting hemlocks will reduce the risk of those trees becoming infected.”( CAES: Fact Sheets) They are saying this because birds, squirrels, and deer all have something to gain from the hemlocks. Hemlocks produce a cone and the cone acts as food for squirrels. When squirrels are running through these trees the adelgid is attaching itself on their feet, so when they run from hemlock to hemlock residue is being left on the tree. Between March and June adelgid eggs are in high abundance (CAES: Fact Sheets), therefore making it highly likely that if a squirrel is on an infected tree around this time the adelgid infection has a high risk of spreading. Birds perch on these trees as well, so the same concern applies. Birds also nest in trees. Residue could be left on or in the nest, so when the wind comes and blows that nest out of the tree it blows the residue around as well: therefore increasing the spread of the infection. Deer run through trees and use the trees for shade. If the wind is blowing some of the infectious adelgid will flake off, so when a deer goes to another tree and messes around in it, then that tree now has a chance of becoming infected. This technique not only involves the animals but the trees also. Scientist think that if they cut down the trees that are already infected, then it will decrease the chances of the Hemlock Woolly Adelgid from spreading. (CAES: Fact Sheets) A couple of problems one must think about is how are humans going to stop squirrels, birds, and deer from being on or around these trees? Some may say if humans cut down the infected trees then the animals will not be spreading the adelgid, but that will not work because humans will be destroying the habitats of the animals. It is best to think of other techniques.

There may be ways to improve the health of the Eastern Hemlock, making it less susceptible to the Hemlock Woolly Adelgid. When an Eastern Hemlock is growing in a poor site or ecosystem it has a significant higher risk in having *Adelgea tsugae* attacking it. When a hemlock is in a poor environment it puts the tree under stress ( CAES: Fact Sheets). Scientists have decided that if humans maintain "good growing conditions", then it "can play an important role in the survival of the hemlock" (CAES: Fact Sheets). This conclusion was made because hemlocks, such as the Eastern Hemlock, are shallow rooted trees and when they do not have nutrients, water, they go into stress mode. The best ways to take care of the tree to keep it from becoming "sick" is to water, prune, and fertilize them (CAES: Fact Sheets).

Two techniques have been developed that involve tedious hard labor. One technique is to mechanically remove the adelgid from the Eastern Hemlock. The eggs and crawlers of the Hemlock Woolly Adelgid escape from the young hemlock twigs by wind and rain, and most of them are unable to find their way back onto the tree, so they die. (CAES: Fact Sheets) Experts think that if they "intentionally dislodge eggs and crawlers by directing a strong stream of water at infested branches periodically during April through June may be of some value of reducing HWA (Hemlock Woolly Adelgid) numbers." (CAES: Fact Sheets) The other laborous technique is to plant resistant hemlock species. A western North American hemlock species, *Tsuga heterophylla*, was found to be the most similar to the Eastern Hemlock. The adelgid can get on this tree but does not do any significant damage or harm at all. An idea is to plant these trees in the infected areas so pressure will be taken off of the infected Eastern Hemlocks (CAES: Fact Sheets). The problem with this is that scientists are not sure about the long term effects of planting these trees. They are not very sure how much build up the new species can withstand

(CAES: Fact Sheets). Further testing has to be done to determine how effective this technique will be.

When the natural method does not work the only other way to try is the chemical method. Techniques include using insecticides, soil drenches, soil injections, bark sprays, and trunk injections. An insecticide to use is one that contains either Merit, Talstar, Onyx, Astrom, or DeltaGuard( CAES: Fact Sheets). All of these can help to hinder the adelgid process. Talstar has been widely used to help hinder the process (CAES: Fact Sheets). One rule that is forced when using these chemicals is to make sure once the chemical is sprayed on the tree it does not flow, blow, or come near a water source because it possibly destroy trees that are not able to handle the toxic chemical. Scientists worry because the chemical has to be sprayed on the foliage, the leaves or body, of the tree. If the wind begins to blow the chemical can easily transported to a nearby source of water.

Soil drenches, soil injections, and bark sprays are good techniques to think about when large trees cannot be completely sprayed. Also, if someone is scared to use the previous technique then this can be used. The first thing to do is to find a place with adequate soil moisture. Once this has been done an “imidacloprid product” must be found. Some in particular include Merit 75 WP, Malice 75 WSP, and Zenith 75 WSP. Take the products and put them in the soil so that way the roots of the tree will move the product into the foliage of the tree (North Carolina Insect Notes). Once again these chemicals cannot be near the water.

If there is a water source nearby there is a technique that can be done to get around it. Trunk injections can be used. The same chemicals apply from the previous techniques; the only difference is that it must be injected into the trunk of the tree. The best time to conduct all of

these chemical experiments is in fall or spring because that is when soil moisture is at its best (North Carolina Insect Notes).

When all else fails, a biological approach is the way to go. The Hemlock Woolly Adelgid has enemies. Their names are Oribatid mite and Ladybird beetle. They are native to Japan. These species find and destroy Hemlock Woolly Adelgid in Japan, so it is possible they it can stop the ones over in North America. Scientist want to bring that species over to America to see if it can stop or even hinder the growth of the *Adelge tsugae* on the Eastern Hemlock, but further study has to be done. (CAES: Fact Sheets)

**Results:**

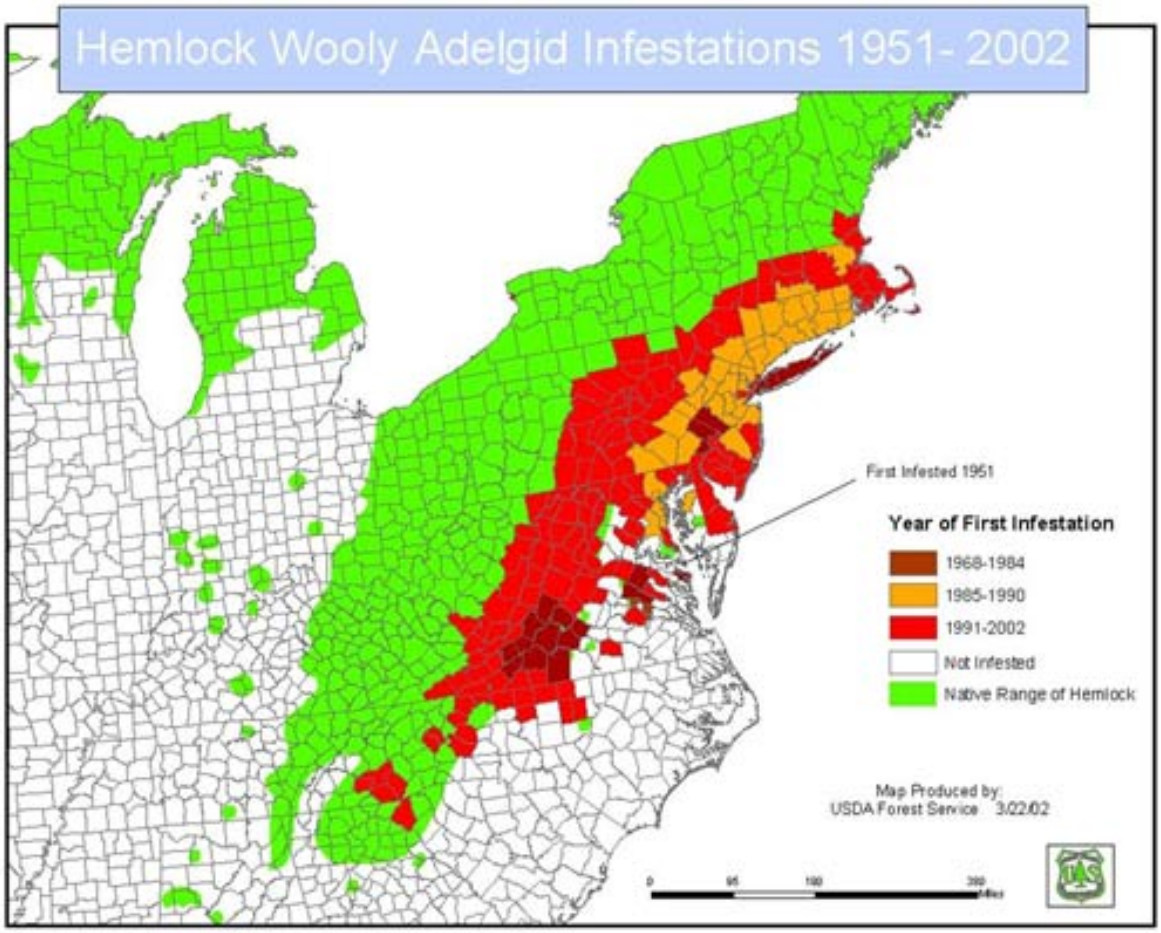

Figure 1: Hemlock Woolly Adelgid Infestions 1951-2002

(http://www.njarboristsisa.com/img/hemlockwoolly_map.jpg)

This map shows the distribution of the Hemlock Woolly Adelgid from the time it was spotted, 1951, to 2002. North Carolina started off with Native Hemlocks, but by 1991-2002 North Carolina started to become infested by adelgid. States north of North Carolina became infested earlier. In 1951, the first infected area was in Virginia. This caused the surrounding areas of Virginia to be infected by the Hemlock Woolly Adelgid. Beteen 1991-2002 the infestation dispersed itself even farther.

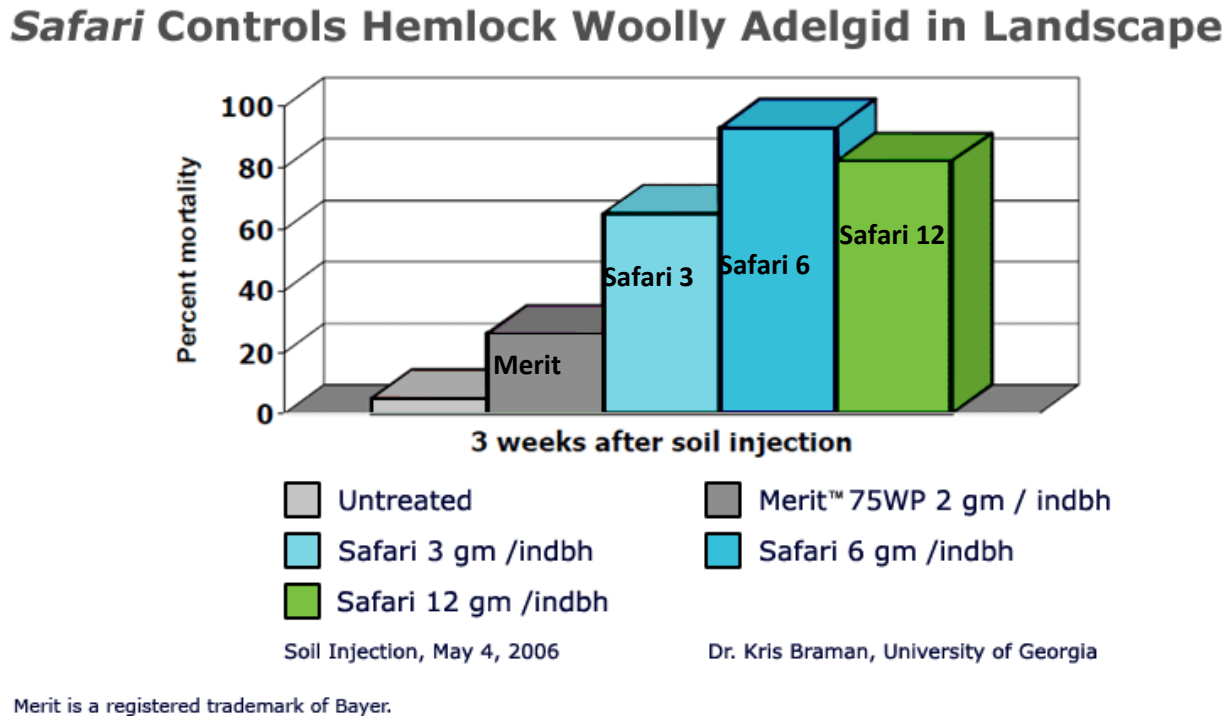


Figure 2. Effects of Safari on adelgid control

(http://www.legacytreeproject.com/images/treatment_hwa_01.gif)

The chart above is the statistical data of a chemical control method, in order to get rid of the Hemlock Woolly Adelgid on hemlocks. When Adeleges tsugae is not treated the percent mortality of this species is 5%. Using Merit it causes a 30% mortality rate in the death of the adelgid. Safari 3gm produces a 65% death rate. Safari 6gm causes the highest mortality percentage. It produces a 90% mortality percent. Safari 12gm is not as efficient as Safari 6gm, but it accumulates an 80% mortality rate.

| State | County | First Year infested | Years infested |
|---|---|---|---|
| CT | FAIRFIELD | 1986 | 26 |
| CT | HARTFORD | 1988 | 24 |
| CT | LITCHFIELD | 1990 | 22 |
| CT | MIDDLESEX | 1986 | 26 |
| CT | NEW HAVEN | 1985 | 27 |
| CT | NEW LONDON | 1988 | 24 |
| CT | TOLLAND | 1988 | 24 |
| CT | WINDHAM | 1990 | 22 |
| DE | KENT | 1999 | 13 |
| DE | NEW CASTLE | 1993 | 19 |
| DE | SUSSEX | 1999 | 13 |
| GA | BANKS | 2010 | 2 |
| GA | DAWSON | 2007 | 5 |
| GA | FANNIN | 2006 | 6 |
| GA | GILMER | 2007 | 5 |
| GA | HABERSHAM | 2004 | 8 |
| GA | HALL | 2010 | 2 |
| GA | LUMPKIN | 2006 | 6 |
| GA | MURRAY | 2010 | 2 |
| GA | PICKENS | 2010 | 2 |
| GA | RABUN | 2002 | 10 |
| GA | STEPHENS | 2006 | 6 |
| GA | TOWNS | 2004 | 8 |
| GA | UNION | 2004 | 8 |
| GA | WHITE | 2004 | 8 |
| KY | BELL | 2006 | 6 |
| KY | BREATHITT | 2010 | 2 |
| KY | CLAY | 2007 | 5 |
| KY | FLOYD | 2010 | 2 |
| KY | HARLAN | 2006 | 6 |
| KY | LAUREL | 2010 | 2 |
| KY | LESLIE | 2007 | 5 |
| KY | LETCHER | 2007 | 5 |
| KY | McCREARY | 2010 | 2 |
| KY | OWSLEY | 2010 | 2 |
| KY | PIKE | 2007 | 5 |

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|---|---|---|---|
| KY | POWELL | 2008 | 4 |
| KY | ROWAN | 2011 | 1 |
| KY | WHITLEY | 2007 | 5 |
| KY | WOLFE | 2010 | 2 |
| MA | BARNSTABLE | 1992 | 20 |
| MA | BERKSHIRE | 2000 | 12 |
| MA | BRISTOL | 1993 | 19 |
| MA | DUKES | 1998 | 14 |
| MA | ESSEX | 1992 | 20 |
| MA | FRANKLIN | 1997 | 15 |
| MA | HAMPDEN | 1989 | 23 |
| MA | HAMPSHIRE | 1994 | 18 |
| MA | MIDDLESEX | 1990 | 22 |
| MA | NORFOLK | 1991 | 21 |
| MA | PLYMOUTH | 1992 | 20 |
| MA | SUFFOLK | 1998 | 14 |
| MA | WORCESTER | 1995 | 17 |
| MD | ALLEGANY | 1999 | 13 |
| MD | ANNE ARUNDEL | 1986 | 26 |
| MD | BALTIMORE | 1986 | 26 |
| MD | CALVERT | 1993 | 19 |
| MD | CAROLINE | 2001 | 11 |
| MD | CARROLL | 1994 | 18 |
| MD | CECIL | 1992 | 20 |
| MD | FREDERICK | 1991 | 21 |
| MD | GARRETT | 2001 | 11 |
| MD | HARFORD | 1991 | 21 |
| MD | HOWARD | 1999 | 13 |
| MD | KENT | 2001 | 11 |
| MD | MONTGOMERY | 1999 | 13 |
| MD | PRINCE GEORGES | 1986 | 26 |
| MD | QUEEN ANNES | 1988 | 24 |
| MD | TALBOT | 2001 | 11 |
| MD | WASHINGTON | 1995 | 17 |
| ME | CUMBERLAND | 2010 | 2 |
| ME | LINCOLN | 2010 | 2 |
| ME | SAGADAHOC | 2010 | 2 |
| ME | YORK | 2003 | 9 |
| NC | ALAMANCE | 2001 | 11 |
| NC | ALEXANDER | 2006 | 6 |
| NC | ALLEGHANY | 2001 | 11 |
| NC | ASHE | 2001 | 11 |
| NC | AVERY | 2002 | 10 |
| NC | BUNCOMBE | 2002 | 10 |
| NC | BURKE | 2001 | 11 |
| NC | CALDWELL | 2001 | 11 |
| NC | CASWELL | 1999 | 13 |
| NC | CATAWBA | 2007 | 5 |
| NC | CHEROKEE | 2004 | 8 |
| NC | CLAY | 2002 | 10 |
| NC | FORSYTH | 1996 | 16 |
| NC | GRAHAM | 2001 | 11 |
| NC | HAYWOOD | 2002 | 10 |
| NC | HENDERSON | 2002 | 10 |

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|---|---|---|---|
| NC | IREDELL | 2010 | 2 |
| NC | JACKSON | 2001 | 11 |
| NC | MACON | 2001 | 11 |
| NC | MADISON | 2004 | 8 |
| NC | MCDOWELL | 2006 | 6 |
| NC | MITCHELL | 2001 | 11 |
| NC | ORANGE | 1999 | 13 |
| NC | POLK | 2006 | 6 |
| NC | ROCKINGHAM | 1996 | 16 |
| NC | RUTHERFORD | 2006 | 6 |
| NC | STOKES | 1995 | 17 |
| NC | SURRY | 1995 | 17 |
| NC | SWAIN | 2001 | 11 |
| NC | TRANSYLVANIA | 2006 | 6 |
| NC | WATAUGA | 2001 | 11 |
| NC | WILKES | 2002 | 10 |
| NC | YANCEY | 2001 | 11 |
| NH | CHESHIRE | 2010 | 2 |
| NH | HILLSBOROUGH | 2006 | 6 |
| NH | ROCKINGHAM | 2001 | 11 |
| NH | STRAFFORD | 2008 | 4 |
| NJ | ATLANTIC | 1992 | 20 |
| NJ | BERGEN | 1991 | 21 |
| NJ | BURLINGTON | 1991 | 21 |
| NJ | CAMDEN | 1992 | 20 |
| NJ | CAPE MAY | 1992 | 20 |
| NJ | CUMBERLAND | 1992 | 20 |
| NJ | ESSEX | 1991 | 21 |
| NJ | GLOUCESTER | 1992 | 20 |
| NJ | HUDSON | 1992 | 20 |
| NJ | HUNTERDON | 1991 | 21 |
| NJ | MERCER | 1991 | 21 |
| NJ | MIDDLESEX | 1991 | 21 |
| NJ | MONMOUTH | 1988 | 24 |
| NJ | MORRIS | 1988 | 24 |
| NJ | OCEAN | 1992 | 20 |
| NJ | PASSAIC | 1990 | 22 |
| NJ | SALEM | 1992 | 20 |
| NJ | SOMERSET | 1991 | 21 |
| NJ | SUSSEX | 1988 | 24 |
| NJ | UNION | 1992 | 20 |
| NJ | WARREN | 1988 | 24 |
| NY | ALBANY | 2003 | 9 |
| NY | BRONX | 1991 | 21 |
| NY | BROOME | 2010 | 2 |
| NY | CHEMUNG | 2010 | 2 |
| NY | COLUMBIA | 1992 | 20 |
| NY | DELAWARE | 2002 | 10 |
| NY | DUTCHESS | 1989 | 23 |
| NY | GREENE | 1999 | 13 |
| NY | KINGS | 1984 | 28 |
| NY | MONROE | 2002 | 10 |
| NY | NASSAU | 1984 | 28 |
| NY | NEW YORK | 1991 | 21 |

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|---|---|---|---|
| NY | ORANGE | 1988 | 24 |
| NY | PUTNAM | 1988 | 24 |
| NY | QUEENS | 1984 | 28 |
| NY | RENSSELAER | 2009 | 3 |
| NY | RICHMOND | 1991 | 21 |
| NY | ROCKLAND | 1989 | 23 |
| NY | SCHOHARIE | 2011 | 1 |
| NY | SCHUYLER | 2008 | 4 |
| NY | SENECA | 2008 | 4 |
| NY | SUFFOLK | 1984 | 28 |
| NY | SULLIVAN | 1991 | 21 |
| NY | TIOGA | 2010 | 2 |
| NY | TOMPKINS | 2008 | 4 |
| NY | ULSTER | 1991 | 21 |
| NY | WESTCHESTER | 1987 | 25 |
| NY | YATES | 2008 | 4 |
| PA | ADAMS | 1991 | 21 |
| PA | ALLEGHENY | 2002 | 10 |
| PA | BEAVER | 2007 | 5 |
| PA | BEDFORD | 1995 | 17 |
| PA | BERKS | 1987 | 25 |
| PA | BLAIR | 2001 | 11 |
| PA | BRADFORD | 2002 | 10 |
| PA | BUCKS | 1980 | 32 |
| PA | CAMBRIA | 2006 | 6 |
| PA | CAMERON | 2007 | 5 |
| PA | CARBON | 1991 | 21 |
| PA | CENTRE | 2001 | 11 |
| PA | CHESTER | 1986 | 26 |
| PA | CLEARFIELD | 2010 | 2 |
| PA | CLINTON | 2001 | 11 |
| PA | COLUMBIA | 1999 | 13 |
| PA | CUMBERLAND | 1995 | 17 |
| PA | DAUPHIN | 1992 | 20 |
| PA | DELAWARE | 1981 | 31 |
| PA | ELK | 2005 | 7 |
| PA | FAYETTE | 2009 | 3 |
| PA | FRANKLIN | 1991 | 21 |
| PA | FULTON | 2000 | 12 |
| PA | HUNTINGDON | 2001 | 11 |
| PA | JUNIATA | 1999 | 13 |
| PA | INDIANA | 2011 | 1 |
| PA | LACKAWANNA | 1993 | 19 |
| PA | LANCASTER | 1986 | 26 |
| PA | LEBANON | 1991 | 21 |
| PA | LEHIGH | 1988 | 24 |
| PA | LUZERNE | 1999 | 13 |
| PA | LYCOMING | 2000 | 12 |
| PA | MIFFLIN | 2001 | 11 |
| PA | MONROE | 1988 | 24 |
| PA | MONTGOMERY | 1979 | 33 |
| PA | MONTOUR | 1999 | 13 |
| PA | NORTHAMPTON | 1986 | 26 |
| PA | NORTHUMBERLAND | 1998 | 14 |

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|---|---|---|---|
| PA | PERRY | 1999 | 13 |
| PA | PHILADELPHIA | 1991 | 21 |
| PA | PIKE | 1992 | 20 |
| PA | POTTER | 2008 | 4 |
| PA | SCHUYLKILL | 1991 | 21 |
| PA | SNYDER | 1999 | 13 |
| PA | SOMERSET | 2002 | 10 |
| PA | SULLIVAN | 2000 | 12 |
| PA | SUSQUEHANNA | 2006 | 6 |
| PA | TIOGA | 2005 | 7 |
| PA | UNION | 2000 | 12 |
| PA | WAYNE | 1998 | 14 |
| PA | WESTMORELAND | 2006 | 6 |
| PA | WYOMING | 2000 | 12 |
| PA | YORK | 1987 | 24 |
| RI | BRISTOL | 1986 | 26 |
| RI | KENT | 1986 | 26 |
| RI | NEWPORT | 1993 | 19 |
| RI | PROVIDENCE | 1986 | 26 |
| SC | GREENVILLE | 2005 | 7 |
| SC | OCONEE | 2008 | 4 |
| SC | PICKENS | 2008 | 4 |
| TN | BLOUNT | 2002 | 10 |
| TN | CAMPBELL | 2006 | 6 |
| TN | CARTER | 2002 | 10 |
| TN | CLAIBORNE | 2007 | 5 |
| TN | COCKE | 2004 | 8 |
| TN | CUMBERLAND | 2010 | 2 |
| TN | GRAINGER | 2005 | 7 |
| TN | GREENE | 2004 | 8 |
| TN | HAMBLEN | 2006 | 6 |
| TN | HAMILTON | 2006 | 6 |
| TN | HANCOCK | 2006 | 6 |
| TN | HAWKINS | 2006 | 6 |
| TN | JEFFERSON | 2005 | 7 |
| TN | JOHNSON | 2004 | 8 |
| TN | KNOX | 2004 | 8 |
| TN | LOUDON | 2006 | 6 |
| TN | McMINN | 2010 | 2 |
| TN | MONROE | 2004 | 8 |
| TN | MORGAN | 2007 | 5 |
| TN | PICKETT | 2011 | 1 |
| TN | POLK | 2006 | 6 |
| TN | RHEA | 2008 | 4 |
| TN | ROANE | 2007 | 5 |
| TN | SCOTT | 2007 | 5 |
| TN | SEVIER | 2002 | 10 |
| TN | SULLIVAN | 2004 | 8 |
| TN | UNICOI | 2004 | 8 |
| TN | UNION | 2006 | 6 |
| TN | WASHINGTON | 2004 | 8 |
| VA | ALBEMARLE | 1991 | 21 |
| VA | ALLEGHANY | 1991 | 21 |
| VA | AMHERST | 1981 | 31 |

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|---|---|---|---|
| VA | APPOMATTOX | 1981 | 31 |
| VA | ARLINGTON | 1993 | 19 |
| VA | AUGUSTA | 1991 | 21 |
| VA | BATH | 1993 | 19 |
| VA | BEDFORD | 1980 | 32 |
| VA | BLAND | 1993 | 19 |
| VA | BOTETOURT | 1979 | 33 |
| VA | BUCHANAN | 2006 | 6 |
| VA | BUCKINGHAM | 2005 | 7 |
| VA | CAMPBELL | 1981 | 31 |
| VA | CAROLINE | 1977 | 35 |
| VA | CARROLL | 1992 | 20 |
| VA | CHESTERFIELD | 1993 | 19 |
| VA | CLARKE | 1993 | 19 |
| VA | CRAIG | 1993 | 19 |
| VA | CULPEPER | 2006 | 6 |
| VA | DICKENSON | 2006 | 6 |
| VA | ESSEX | 1993 | 19 |
| VA | FAIRFAX | 1991 | 21 |
| VA | FAUQUIER | 2006 | 6 |
| VA | FLOYD | 1979 | 33 |
| VA | FLUVANNA | 1993 | 19 |
| VA | FRANKLIN | 1991 | 21 |
| VA | FRANKLIN | 1971 | 41 |
| VA | FREDERICK | 1993 | 19 |
| VA | GILES | 1993 | 19 |
| VA | GRAYSON | 1993 | 19 |
| VA | GREENE | 1991 | 21 |
| VA | HANOVER | 1977 | 35 |
| VA | HENRICO | 1951 | 61 |
| VA | HENRY | 1991 | 21 |
| VA | HIGHLAND | 1993 | 19 |
| VA | KING WILLIAM | 1993 | 19 |
| VA | LEE | 2006 | 6 |
| VA | LOUDOUN | 2006 | 6 |
| VA | LUNENBURG | 1991 | 21 |
| VA | MADISON | 1991 | 21 |
| VA | MONTGOMERY | 1979 | 33 |
| VA | NELSON | 1991 | 21 |
| VA | NORTHUMBERLAND | 1971 | 41 |
| VA | ORANGE | 1993 | 19 |
| VA | PAGE | 1991 | 21 |
| VA | PATRICK | 1991 | 21 |
| VA | PITTSYLVANIA | 1971 | 41 |
| VA | PRINCE WILLIAM | 1991 | 21 |
| VA | PULASKI | 1992 | 20 |
| VA | RAPPAHANNOCK | 1991 | 21 |
| VA | ROANOKE | 1971 | 41 |
| VA | ROCKBRIDGE | 1980 | 32 |
| VA | ROCKINGHAM | 1991 | 21 |
| VA | RUSSELL | 2005 | 7 |
| VA | SCOTT | 2007 | 5 |
| VA | SHENANDOAH | 1991 | 21 |
| VA | SMYTH | 1993 | 19 |

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|---|---|---|---|
| VA | SPOTSYLVANIA | 1993 | 19 |
| VA | TAZEWELL | 2005 | 7 |
| VA | WARREN | 1991 | 21 |
| VA | WASHINGTON | 1993 | 19 |
| VA | WISE | 2006 | 6 |
| VA | WYTHE | 1993 | 19 |
| VT | WINDHAM | 2008 | 4 |
| WV | BARBOUR | 2006 | 6 |
| WV | BERKELEY | 1997 | 15 |
| WV | BOONE | 2006 | 6 |
| WV | BRAXTON | 2006 | 6 |
| WV | CABELL | 2008 | 4 |
| WV | FAYETTE | 2002 | 10 |
| WV | GRANT | 1992 | 20 |
| WV | GREENBRIER | 1998 | 14 |
| WV | HAMPSHIRE | 1992 | 20 |
| WV | HARDY | 1992 | 20 |
| WV | JEFFERSON | 1997 | 15 |
| WV | KANAWHA | 2006 | 6 |
| WV | LEWIS | 2010 | 2 |
| WV | LINCOLN | 2009 | 3 |
| WV | LOGAN | 2007 | 5 |
| WV | MARION | 2007 | 5 |
| WV | MCDOWELL | 2004 | 8 |
| WV | MERCER | 2000 | 12 |
| WV | MINERAL | 1993 | 19 |
| WV | MINGO | 2008 | 3 |
| WV | MONONGALIA | 2004 | 8 |
| WV | MONROE | 1998 | 14 |
| WV | MORGAN | 1993 | 19 |
| WV | NICHOLAS | 2002 | 10 |
| WV | PENDLETON | 1992 | 20 |
| WV | POCAHONTAS | 1993 | 19 |
| WV | PRESTON | 2002 | 10 |
| WV | RALEIGH | 2001 | 11 |
| WV | RANDOLPH | 2001 | 11 |
| WV | ROANE | 2007 | 5 |
| WV | SUMMERS | 2000 | 12 |
| WV | TAYLOR | 2010 | 2 |
| WV | TUCKER | 2001 | 11 |
| WV | UPSHUR | 2005 | 7 |
| WV | WAYNE | 2011 | 1 |
| WV | WEBSTER | 2003 | 9 |
| WV | WIRT | 2010 | 2 |
| WV | WOOD | 2008 | 4 |
| WV | WYOMING | 2005 | 7 |

Figure 3. Hemlock Woolly Adelgid Infestations by State and County ( http://na.fs.fed.us/fhp/hwa/infestations/hwa_infestations11.pdf )

The data that is shown (Figure 3) represents when and where a state and its county were infected by the HWA. It has states that have been infected in 2011, which was only a years ago. Virginia

seems to have the most infestations. HWA was spotted in Richmond,VA ,so the HWA epidemic spread rapidly throughout that area. HWA continued to accumulate in the Northeast and Southern states. A lot of the states became infected in the 2000's. HWA had a slow start, but it immediately picked up the pace and began to affect states, such as Tennessee, West Virginia, Connecticut, South Carolina, Pennslyvania, New Jersey, New York, North Carolina, etc. These states have been infected for years. Some counties in WV, such as Morgan County, have been infected for twenty years. In North Carolina some have counties have been infected for seventeen years. By taking a look at the data, several counties have been infected in the same year. Tennessee had four counties in a row that were infected by HWA in the same year. They were all infected in 2006 and have been infected for six years a piece.

**Discussion:** The distribution graph from 1951-2002 proves that the Hemlock Woolly Adelgid is truly spreading. The infestation started in Virginia and it began to spiral out from that origin. From 1968-1984, the land close to the origin became infected. This happened because an "epidemic" like the aldelgids. It, however, did not spread far. This is because when an "epidemic" starts it begins by infecting a few individuals and then it increases exponentialy. This is exactly the cause with the Hemlock Woolly Adelgid. It only infected a few places at first, but then by 1991-2002 it exploded, spreading to the north and south at a faster rate. It took 16 years (1968-1984) for just a small area to succumb in the infestation, but when it exploded it only took 11 years for that small area to become six times its size. The situation can only get worse if nothing is being done about it. It has been 10 years since 2002, so the Hemlock Woolly Adelgid has gotten worse because a set technique has not been set to get rid of the pest.

Scientists did an experiment and charted the data hoping they could possibly find a chemical controlled method that will hinder or even stop the adelgid from spreading (Figure 2). Without any treatment the percent mortality is very low, so low that the Hemlock Woolly Adelgid has no choice but to continue to spread. This proves that something has to be done, if not then the situation is not going to better. This study was done in 2006, so apparently experts are noticing that since the 1991-2002 spread that this "epidemic" is not going to stop itself. After testing different chemicals Safari 6gm had the best efficiency. Now that experts see what really seems to kill *Adelges tsugae* they need to look into it deeper and study the short and long term effects of the chemical. A pest has to be stopped. A chemically controlled method just may be the only choice there is because studies have shown that chemicals have a chance in working. The only issue is that precaution has to be taken in order to make sure no other harm is done to other environments, plants, and habitats when using chemicals. The experiment that was shown in Figure 2 was conducted by using soil injection. Soil injection is more direct because the chemical goes straight to the Eastern Hemlock's roots. The hemlock can then "inhale" the chemicals in and disperse them throughout its body. When the chemical reaches the branches and the leaves, the adelgid will be so busy sucking the life out of tree that it does not notice it is drinking a toxic chemical. The chemical will begin to break down the adelgid and stop its reproduction. This is exactly what is needed in order to kill the Hemlock Woolly Adelgid.

Figure 3 shows how quickly HWA is spreading throughout the Eastern side of the United States of America. The fact that VA was highly affected is not a surprise because HWA spiraled of from its origin. Figure 1 showed the outline of the distribution of the HWA on the Eastern Hemlock. Looking at figure 3, the damage seems much worse. The future of the Eastern

Hemlock is at risk because even in 2011 states and their counties have been infected. This proves that HWA is not going stop reproducing and killing the Eastern Hemlocks.

**Conclusion:** After close investigation of the Hemlock Woolly Adelgid on the Eastern Hemlock, it is decided that the spread of the adelgid is increasing more and more rapidly as years pass by. To stop it chemicals have to be used, such as soil injection, in order to decrease the rate at which Adelges tsugae is spreading. Research and experiments have to continuously be done because the adelgid reproduces fast, so by using a chemical it can be altered to make it react with the adelgid at a faster rate. It is time to save the Eastern Hemlock because it is not just a tree, but it is a tree that provides support to the mountains, food for animals, shelter for animals, and protection for animals. If humans to do not take charge, the Eastern Hemlock will become an extinct species.

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