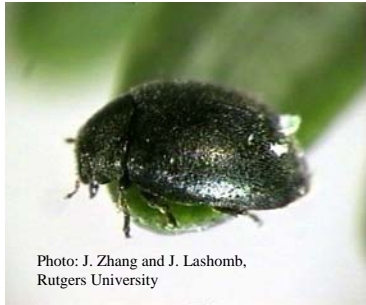


**Release of *Sasajiscymnus tsugae*, *Scymnus sinuanodulus* (Coleoptera: Coccinellidae)
and *Laricobius nigrinus* (Coleoptera: Derodontidae)
On the Hemlock Woolly Adelgid, *Adelges tsugae* (Homoptera: Adelgidae) in NJ**

Annual Report 2010



Sasajiscymnus tsugae



Scymnus sinuanodulus (female)



Laricobius nigrinus

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ABSTRACT

Since 1998, a total of 288,675 *Sasajiscymnus tsugae* have been released into 64 New Jersey hemlock sites. Overwintering recoveries of *S. tsugae* have been made at 12 different sites since 1999. Recovery of *S. tsugae* on stressed trees was difficult due to branch dieback caused by the HWA and poor tree health, which reduced the amount of new growth that the HWA feeds on. No *S. tsugae* were recovered in 2010. A total of 10,355 *Scymnus sinuanodulus* have been released in NJ in nine sites but there have been no recoveries. 51 overwintering *Laricobius nigrinus* beetles were recovered from six of the ten pre-2010 release sites in October; one recovery was from the 2005 release site in Worthington SF which is five consecutive years of recoveries for that site. A total of 5,743 *L. nigrinus* were released in New Jersey in 2010 bringing the total number of beetles released by the New Jersey Department of Agriculture to 10,537.

INTRODUCTION

In the spring of 1997, under a cooperative agreement with the United States Forest Service (USFS), the New Jersey Department of Agriculture's (NJDA) Phillip Alampi Beneficial Insect Laboratory (PABIL) received 100 *Sasajiscymnus tsugae* (Coleoptera: Coccinellidae) from Dr. Mark McClure and Dr. Carole Cheah of the Connecticut Agricultural Experiment Station (CAES) to serve as a back up to their colony. One of the goals of the PABIL was to try to further develop and refine the rearing procedures for *S. tsugae*. Beginning in 1998 and continuing through 2006, a total of 288,675 *S. tsugae* has been released into NJ hemlock stands.

In 2004, the Laboratory undertook a new program rearing a Chinese ladybeetle, *Scymnus sinuanodulus* (Coleoptera: Coccinellidae), in conjunction with the US Forest Service and Dr. Carole Cheah of the CAES. The goal was to develop a mass rearing procedure for the new species and then release the species after sufficient numbers have been produced. A total of 10,355 *S. sinuanodulus* has been released in New Jersey among nine sites through 2007.

In 2005, Virginia Polytechnic Institute and State University (VPI) shipped 300 *Laricobius nigrinus* to the PABIL for release in northern New Jersey. VPI shipped an additional 3,300 beetles to New Jersey between 2007-2009, and 4,000 in 2010. The lab also received 1,119 field collected beetles from 2007-2009 as well as 1,743 in 2010 collected by Dr. Richard McDonald from Seattle, WA. A total of 10,537 *L. nigrinus* have been released in New Jersey distributed among nine hemlock stands.

OVERVIEW

Hemlock Woolly Adelgid (HWA) is a common, but insignificant insect on ornamental and forest hemlock and spruce in Japan and China. It does not attain high densities on hemlock in Japan except for trees growing on very poor sites. There is no significant injury to the Japanese hemlocks most probably due to host resistance and the presence of native predators such as *S. tsugae*, *Scymnus spp.* and *Laricobius spp.* that regulate HWA populations.

The first infestation in the eastern US was discovered on the east coast in Virginia in the 1950's. This infestation is believed to be an accidental introduction from Japan. Eastern hemlocks are the succession climax trees in northern NJ forests and although hemlock is not a valuable timber tree, the wood is used for barns, sheds, pulpwood, and landscaping and it is ecologically important providing cover for deer, turkey, ruffed grouse, and others. About 90 species of birds use hemlock as a nesting site, roost site or winter shelter. Northern goshawk, solitary vireo, and the black-throated warbler require habitats provided by a hemlock forest and would be stressed should the hemlock stands be reduced for any reason (Hennessey 1995). Hemlock is also an important component of some of the more popular recreational areas in NJ, due to the dense canopy, cooler temperatures in summer, which provide a much-needed

respite from the heat for those who visit the stands.

In NJ, all of the hemlock stands have had some level of HWA infestation. The healthiest stands were in northern Passaic and Sussex Counties, but the majority of stands are stressed and many will not remain healthy unless a biological control effort is undertaken. In the NJDA Permanent Study Plots, the long-term mortality as of 2010 due to the HWA averages 60.7%.

HWA populations are virtually unmanageable in hemlock forests using traditional control measures. Application of chemical insecticides is impractical due to the inaccessibility of most stands, proximity to water, poor coverage of aerial spraying and/or excessive cost.

BIOLOGICAL CONTROL

In 1992, Dr. Mark McClure of the CAES initiated a trip to Japan to attempt to find and collect potential HWA predators. He collected a Coccinellid, *S. tsugae*, which showed promise and the USDA granted a permit for it's' release in 1995. Dr. Mike Montgomery of the USDA-FS has worked with *Scymnus* spp. from China and Dr. Scott Salom of Virginia Tech is working with a native Derodontid beetle, *Laricobius nigrinus* and a Japanese *Laricobius* sp. Recently, the USFS has sponsored searches in China and Japan for some additional predators, some of which are in quarantine in the US. *L. nigrinus* is also being collected in the Pacific Northwest by Dr. Richard McDonald of Symbiont Biological Pest Management.

MATERIALS AND METHODS

All *S. tsugae*, *S. sinuanodulus* and *L. nigrinus* release sites were monitored using the VPI monitoring protocols (Mausel et. al. 2007).

Monitoring for the presence of the beneficial ladybeetles was conducted at each site from the spring through late fall if sufficient hemlock woolly adelgid populations were present. If the stand at the site was in poor health or if the HWA population was low, the site was not surveyed. Surveys were conducted at 31/64 of the release sites for *S. tsugae*, all nine of the *S. sinuanodulus* release sites and in October at all nine *L. nigrinus* release sites within the state. Each site was surveyed for 2.0 people hours or until a beetle was found. A one meter square beating sheet was placed beneath several branches and the branches were struck ten times with a plastic whiffle ball bat (Figure 1). Any life stages of the beetles recovered on the beating sheet were recorded.

Figure 1. *Sasajiscymnus tsugae* Sampling and Recovery



Photo by L. Bronhard

When *S. tsugae* and *S. sinuanodulus* beetles were in production by the Phillip Alampi Beneficial Insect Laboratory they were transported to the new release sites in either Sweetheart[®], 165 oz., stock number 10T1 paper buckets covered with Sweetheart[®] 10V19S paper lids or Sweetheart[®] Flexstyle 10 oz. food cups fitted with nylon screen at the ends . There were 2,500-5,000 beetles per bucket and up to 500

beetles per cup. The cups and the buckets are filled with excelsior for increased surface area. At the release site the lid is removed and the containers and lids are placed into the branches of the tree. After five minutes, any stragglers in the buckets are gently brushed out onto the infested branches using a soft, 1-inch paintbrush. The release trees were at least moderately infested with HWA.

L. nigrinus was shipped to PABIL in plastic vials from VPI, 50 beetles per vial and were released following the protocol in Mausel, *et. al* 2007. The US Forest Service selected NJ to receive an inundative release of *L. nigrinus* in one site and 4,000 beetles were shipped to the Phillip Alampi Beneficial Insect Laboratory from Virginia Tech. The PABIL also received 1,743 field-collected *L. nigrinus* in October from Dr. Dick McDonald who collected wild *L. nigrinus* in Seattle. Of that number, 286 were released in the Stanton Station Section of the South Branch Reservation of Hunterdon County Parks. A grand total of 5,743 *L. nigrinus* have been released in 2010. This total exceeds the cumulative total of 4,794 *L. nigrinus* that were previously released from 2005-2009 and represents the largest mass release of this predator in the Northeast. The goal of the project is to investigate the survivorship of the hemlock woolly adelgid when exposed to a mass release of predators. The beetles were released at one site in the Delaware Water Gap National Recreation Area with the cooperation of the National Park Service.

RESULTS AND DISCUSSION

The PABIL released the coccinellid predators *S. tsugae* from 1998 through 2006 and *S. sinuanodulus* from 2005 through 2007. The PABIL received a new predator, *L. nigrinus*, in January 2007 so all rearing efforts have been directed toward the new species with the Coccinellids dropped from the laboratory cultures. *S. tsugae* is established in New Jersey and it is no longer necessary to rear in the laboratory. Surveys will continue for *S. sinuanodulus*. Table 1 summarizes the releases and recoveries of all three predators 1997 through 2008. More than one release can be placed into a site. With *Laricobius*, if the releases were in the same hemlock stand, then the stand was considered one release site.

Table 1. *S. tsugae*, *S. sinuanodulus* and *L. nigrinus* Releases in NJ 1997 - 2009

Year	No. <i>S. tsugae</i>			No. <i>S. sinuanodulus</i>			No. <i>L. nigrinus</i>		
	Released in New Jersey	No. of Release Sites	No. of Sites with Recoveries	Released in New Jersey	No. of Release Sites	No. of Sites with Recoveries	Released in New Jersey	No. of Release Sites	No. of Sites with Recoveries
1997*	0	0		-	-		-	-	
1998	75,500	15		-	-		-	-	
1999	65,000	13	6	-	-		-	-	
2000	50,000	13	3	-	-		-	-	
2001	30,500	6	2	-	-		-	-	
2002	40,260	9	2	-	-		-	-	
2003	17,500 ¹	5	1	-	-		-	-	
2004	15,000 ¹	2	1	-	-		-	-	
2005	230	1	1	1,530	3	0	300	1	
2006	2,185	1	1	1,500	2	0	-	-	1
2007	0	0	1	6,305	4	0	1,390	3	2
2008	0	0	1	0	0	0	2,033	4 ³	3
2009	0	0	0	0	0	0	1,071	2	2
2010	0	0	0	0	0	0	5,743	2	6
Totals	288,675	64²	12	10,335	9	0	10,537	12	7

*From a starter colony of 100 adult beetles received in May 1997

¹ includes 2,500 egg release

² This is the number of new sites, not the number of releases; some sites received more than one release in the same year or in an adjacent area nearby

³Two of the sites were new and two were augmentative releases

There are no heavily infested hemlock stands with sufficiently healthy trees in New Jersey that are suitable for collecting sufficient rearing material. Pennsylvania Department of Conservation and Natural Resources collect and sent to the lab to rear the beneficials. Recovering overwintering beetles to prove establishment has been a tedious and challenging process. No *S. tsugae* and no *S. sinuanodulus* were recovered in 2009, although *L. nigrinus* was recovered from two sites. Recovery is affected by weather conditions as the success rate is higher on sunny warmer days versus cloudy, colder days.

Figure 2 is a map of the predator release sites in the state. There are several factors that account for the low recovery rates of *S. tsugae*: First, HWA populations have been relatively low throughout New Jersey. In 1999 and 2000, the last years of high hemlock woolly adelgid populations in New Jersey, was when the most *S. tsugae* beetles were recovered. Not surprisingly, the recovery of *S. tsugae* would seem to be dependent on the amount of host material. Second, collecting becomes more difficult due to branch dieback of the lower limbs; it becomes increasingly more difficult to find branches that could be sampled using the beating sheet technique. In New Jersey, the average crown ratio for the hemlock forest is 26% (Figure 6), but crown ratios of 85-100% are needed to sample for the predators. Lastly, the *S. tsugae* beetles may have dispersed to the higher branches, (Scudder, et. al. 2001, Cheah et. al. 2005) which are unreachable by the survey personnel. Dr. Jerome Grant at the meeting of the Hemlock Woolly Adelgid Biological Control Committee at the 21st USDA Interagency Research Forum on Invasive Species (personal communication) is recovering *S. tsugae* from older sites and stated that it may take longer than we expect to establish that species.

Figure 2 also shows the release and recovery sites for *S. tsugae* over the course of the project. The majority of the recoveries are in certain areas, notably the Kittatinny Ridge in the Northwest part of the state where the hemlock stands are still healthy. The fact that so few have been recovered is disappointing. We did not expect much, if any, impact on the HWA population as yet because the number of beetles that were recovered was minimal. All introduced populations go through a lag phase in their establishment where there are too few of the new species around and it takes some time for them to enter the log phase of their population curve.

Figure 3 illustrates the HWA sistens population and the number of *S. tsugae* recovery sites by year. The most *S. tsugae* recoveries were made in 1999 which was also the year that the highest HWA population levels were observed. The beetles may not show up until the HWA population increases, although the HWA population did increase in 2008 and there was no subsequent recovery of *S. tsugae*. That may have been due to a lack of survey personnel due to retirements and budget cuts. This increase of the HWA population in 2008 was thought to improve the chances of recovering more *S. tsugae* in succeeding years but no recoveries have been made. Also fewer sites were surveyed as there were no summer staff due to budget restrictions which may be part of the reason that the number of recoveries was zero. There was only one summer staff person in 2010 who was cross utilized from the Bureau of Plant Pest and Disease control and he only worked on hemlock until July as he had to go back to his normal duties. The majority of the recoveries were along the Kittatinny Ridge in the Skylands section of NJ.

Figure 2. Hemlock Stands and Beneficial Insect Release/Recovery Sites in New Jersey.

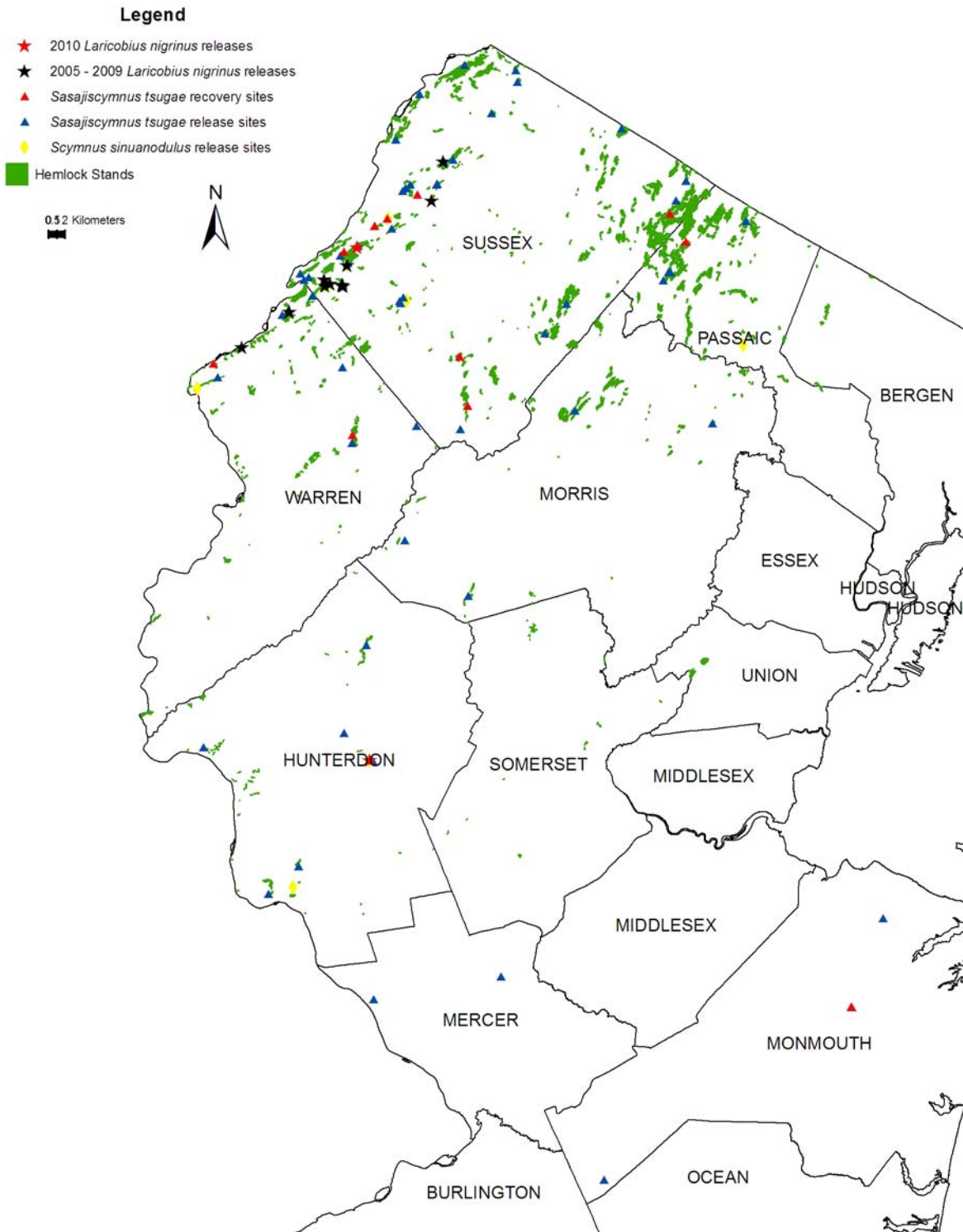
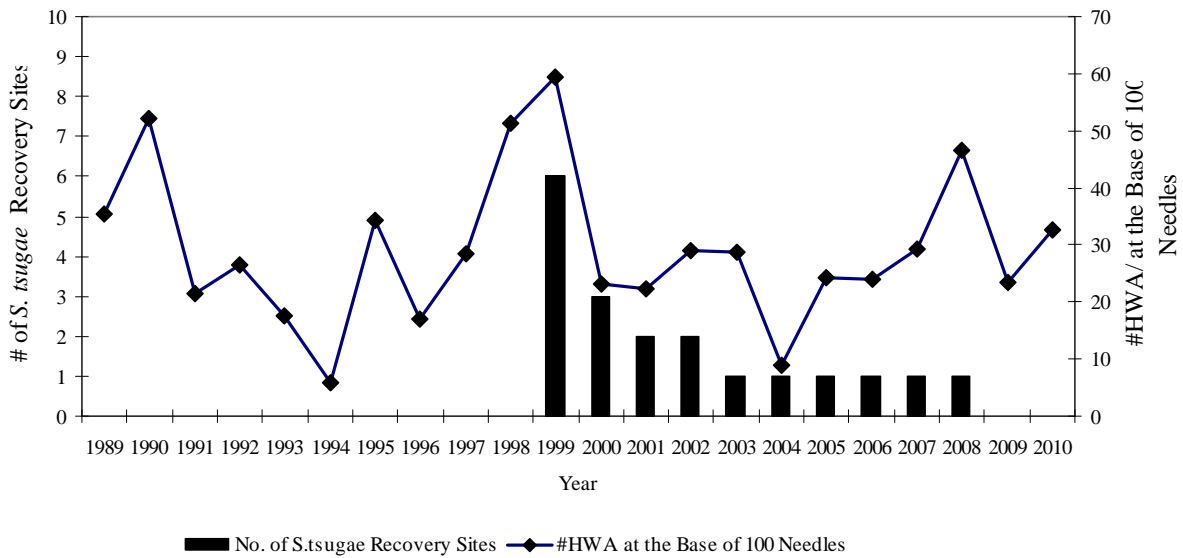


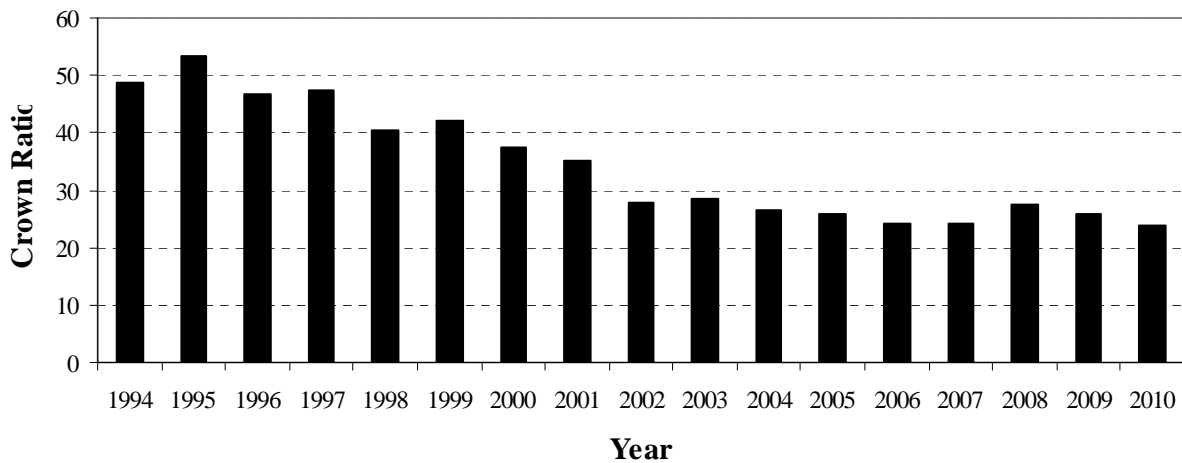
Figure 3. HWA Sistens Population and *S. tsugae* Recovery Sites in NJ 1989-2010



Cheah et. al. 2005, found that the trees in the Skylands were healthier overall than the trees in the Highlands region of New Jersey, most likely because they were infested later. The temperatures in the Skylands are slightly colder due to the higher elevations. Releasing 10,000 beetles into the middle of a forest sounds like a large quantity. However, when one considers the number of trees, the number of beetles released would be hard pressed to even have an impact on an individual tree.

Figure 4

Average Crown Ratio of Hemlock Trees in NJ 1994-2010



S. tsugae

After they have been released on a tree, *S. tsugae* tends to disperse upwards towards the canopy. As previously mentioned Drs. Carole Cheah and Mark McClure have established that the beetles overwinter on the tree and are of the opinion that the beetles are higher up in the canopy in the years following release (Personal Communication). Cheah et. al. 2005 presented data from New Jersey that showed that the beetles do move up into the trees and disperse outwards from there. Hodek (1973) has reported that coccinellids readily disperse and this may be true of *S. tsugae*. This may be one of the reasons why beetle recovery rates have been lower than expected for the number of beetles released. Observations in the laboratory corroborate field observations as the beetles move up to the top of the cages as the day progresses (D. Palmer, NJDA, personal communication). In Figure 4, the average crown ratio has declined from almost 25% from 1994 to 2010 making it difficult to find trees to sample for the beetles. There has also been a decrease in personnel the past three years due to budget cutbacks giving field staff less man hours to survey for the beetles. Therefore, when ground surveys yield poor results, it does not mean that the *S. tsugae* beetles are not present, but that they may be in the upper canopy where they cannot be sampled by ground crews. Also, in August when the HWA aestivates, it becomes difficult to find the beetles as they move elsewhere to locate food.

Scymnus sinuanodulus

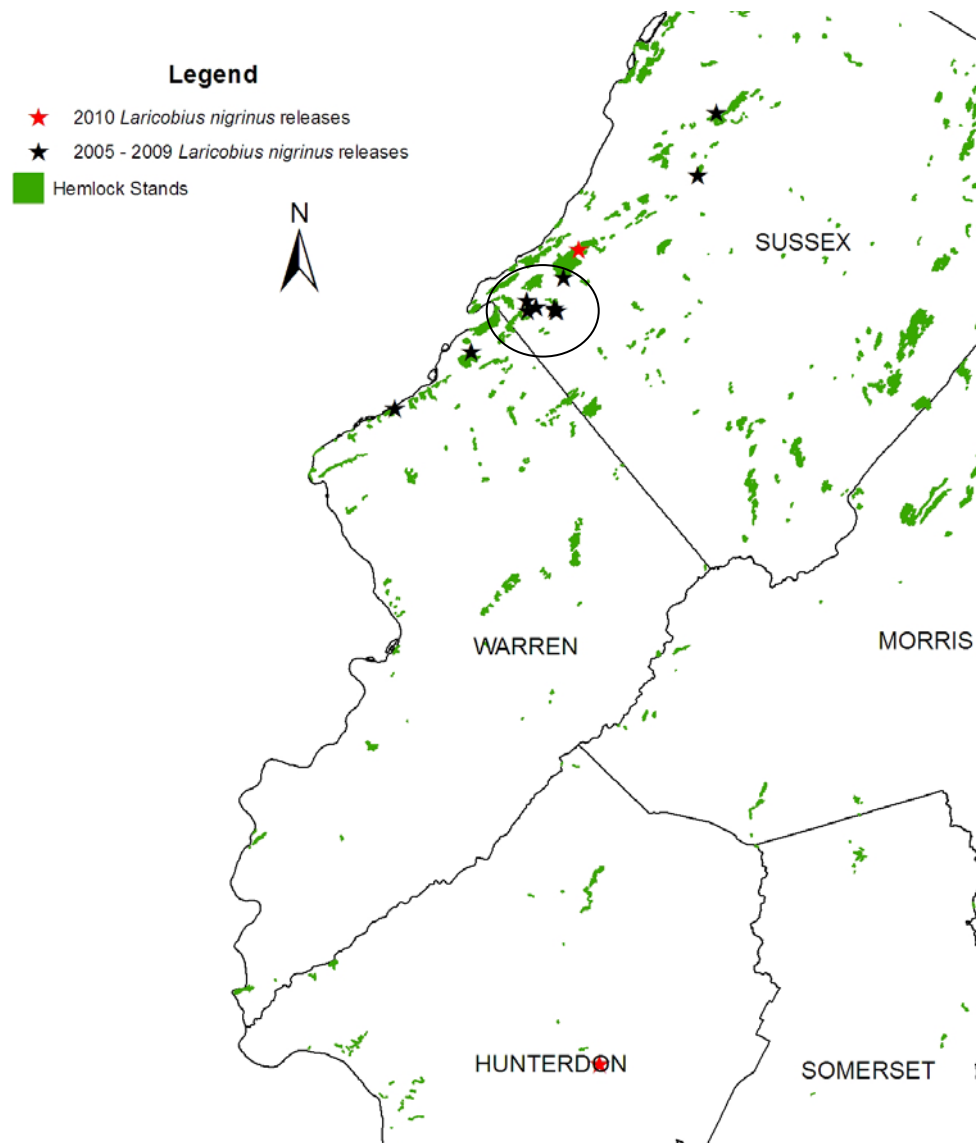
In 2005 *S. sinuanodulus* was released for the first time in New Jersey at three sites and into two additional sites in 2006. The beetles were readily found at the 2006 release sites until the middle of summer during the same season but disappeared after consuming all of the hemlock woolly adelgid. Only 10,355 *S. sinuanodulus* have been released in NJ. No overwintering beetles were recovered but based on previous field observations it appears to be too soon to determine whether the insects have established. Dr. Mike Montgomery (personal communication) of the USFS is of the opinion that the beetles may be a better ecological fit to the Southern Appalachians where they have been recovered so *S. sinuanodulus* may not overwinter in NJ. That remains to be determined.

Laricobius nigrinus

L. nigrinus is a Derodontid beetle native to the Pacific Northwest that is predacious on the hemlock woolly adelgid. The beetles are active from fall until spring whenever the temperatures exceed 0° C. The beetles, from a colony at Virginia Tech, were released for the first time in 2005 in Worthington State Forest and recoveries were made in 2006, 2007, 2008, 2009 and 2010 from separate release trees. A total of 5,743 *L. nigrinus* were released in New Jersey in 2010 distributed among four sites bringing the total number of released beetles to 10,537. The vast majority of the beetles were released above Buttermilk Falls in the Delaware Water Gap NRA with the idea being that the *L. nigrinus* will have a greater chance of population increase in an area where they are concentrated. Nearby release sites are approximately 2.5 to 5.5 km away giving the beetles a greater chance to find each other and reproduce. Staff from the National Park Service has also released 3,147 *L. nigrinus* from 2007-2009 in the Upper Van Campens Watershed and in the Camp Ken-etiwa-pec/Skyline Drive area (circled area in Figure 7, Richard Evans and Jeff Shreiner, personal communication). Beetles were recovered in October 2008 from seven of the ten previous release sites. The sites where there were no recoveries had low to zero populations of the HWA. A total of 51 beetles were recovered in 2010 with recoveries at Worthington SF made 30m from the closest release tree. The 51 beetles represents the highest

number of HWA predators ever recovered in any one year and is also the highest cumulative total for any of the beneficial species. Recoveries are also affected by the weather because there are increasing chances of success with sunnier, milder weather conditions. The *L. nigrinus* recoveries are very encouraging considering the small quantity of beetles released. Biological controls generally take many years before their populations increase to the point where they are effective. There are no other cost effective controls available to protect natural hemlock stands at this time other than biological control.

Figure 6. Release Sites for *L. nigrinus*



2010 Plans

In 2010, the PABIL intends to continue HWA predator (*L. nigrinus*) releases in the northwestern corner of the state. The goal is to release as many beetles as can be provided in high value public forested areas in northern NJ in an attempt to boost their chances of establishment.

The releases will be made according to a priority list as follows:

1. State and Federal lands, including natural lands that are located in areas in close proximity to other hemlock stands where the beetles can redistribute themselves.
2. County and municipal lands located in areas in close proximity to other stands where the beetles can redistribute themselves readily.
3. Private lands with hemlock stands (excluding landscapes).

CONCLUSION

The first fourteen years of the *S. tsugae* program have been successful in that the beetles have become established in our state as evidenced by the recoveries of adults and/or larvae at 12 of 64 sites. It is probable that *S. tsugae* is established at more sites, but the dieback of the lower branches in many sites and lack of personnel limits our field search and survey capabilities. Also, the dispersal behavior of the beetles to move up into the canopy of the tree into the healthy foliage following release makes recovery of the beetles difficult. The *S. tsugae* population is still present and their actual impact may not be fully known for some years. The Chinese ladybeetle *S. sinuanodulus* has been released but not recovered. *L. nigrinus* has been released, has established, and is increasing in population in NJ.

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