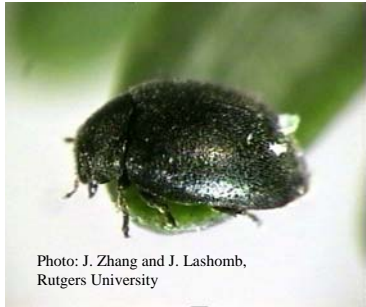


**Release of *Sasajiscymnus tsugae*, *Scymnus sinuanodulus* (Coleoptera: Coccinellidae)
and *Laricobius nigrinus* (Coleoptera: Derodontidae)
On the Hemlock Woolly Adelgid, *Adelges tsugae* (Homoptera: Adelgidae) in NJ**

Annual Report 2008



Sasajiscymnus tsugae



Scymnus sinuanodulus (female)



Laricobius nigrinus

Prepared by:

**Mark Mayer
Jennifer DeSio**

**Thomas Scudder
Thomas Dorsey**



**Division of Plant Industry
Phillip Alampi Beneficial Insect Laboratory
Trenton, NJ 08625**

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ABSTRACT

Since 1998, a total of 288,675 *Sasajiscymnus tsugae* have been released into 64 New Jersey hemlock sites. There was one overwintering recovery of *S. tsugae* made in 2008 in Colt's Neck, NJ. Overwintering recoveries of *S. tsugae* have been made at 12 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. Overwintering *Laricobius nigrinus* beetles were recovered from three of the four pre-2007 release sites in October; one recovery was from the 2005 release site in Worthington SF which is three consecutive years of recovery for that site. A total of 2,033 *L. nigrinus* were released in New Jersey in 2008. No *Scymnus sinuanodulus* were recovered in 2008.

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*. If sufficient numbers of the beetle were produced, they would be released in New Jersey and cooperating states. 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 *L. nigrinus* to the PABIL for release in northern New Jersey. VPI shipped an additional 1,000 beetles to New Jersey in 2007. The lab also received 340 field collected beetles in 2007 and 533 in 2008 collected by Dr. Richard McDonald from Seattle, WA. A total of 3,723 *L. nigrinus* have been released in New Jersey distributed among six sites.

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* that regulate HWA populations.

The first infestations of North American hemlocks were in the 1920's in British Columbia and by the 1950's the HWA was discovered on the east coast. Both of these infestations are believed to be accidental introductions from Japan. Eastern hemlocks are the succession climax trees in northern NJ forests. Hemlock is not a valuable timber tree but 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 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 for long unless a biological control effort is undertaken. In the NJDA Permanent Study Plots, the mortality due to the HWA in the heavily infested stands ranges from 38% to 100% and continues to increase.

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 is currently working with *Scymnus* spp. from China and Dr. Scott Salom of Virginia Tech is working with a Derodontid beetle, *Laricobius nigrinus*. Recently, the USFS has sponsored searches in China and Japan for some additional predators, which should be in quarantine in the US in the future.

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 coccinellids was conducted at each site through the spring and summer 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 four *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 sheet were recorded.

Figure 1. *Sasajiscymnus tsugae* Sampling and Recovery



Photo by L. Bronhard

S. tsugae and *S. sinuanodulus* beetles 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.

RESULTS AND DISCUSSION

The PABIL released *S. tsugae* through 2006 and *S. sinuanodulus* 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 of all three predators 1997 through 2008.

Table 1. *S. tsugae*, *S. sinuanodulus* and *L. nigrinus* Releases in NJ 1997 - 2008

Year	No. <i>S. tsugae</i>			No. <i>S. sinuanodulus</i>			No. <i>L. nigrinus</i>		
	Released in New Jersey	No. of Sites	No. of Sites with Recoveries	Released in New Jersey	No. of Sites	No. of Sites with Recoveries	Released in New Jersey	No. of 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
Totals	288,675	64²	18	10,335	9	0	3,723	6	3

*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

³ Two of the sites were new and

The PABIL also shipped 500 *L. nigrinus* beetles to Pennsylvania in return for the live HWA infested hemlock material that personnel from the Pennsylvania Department of Conservation and Natural Resources collect and sent to the lab to rear the beneficials. There are no heavily infested hemlock stands with sufficiently healthy trees in New Jersey that suitable for collecting rearing material. Recovering overwintering beetles to prove establishment has been a tedious and challenging process. One *S. tsugae* was recovered in 2008, five *L. nigrinus*, and no *S. sinuanodulus*.

Figure 3 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 60.5% (Mayer et. al. 2007), 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.

Figure 3. Hemlock Stands and Beneficial Insect Release Sites in New Jersey.

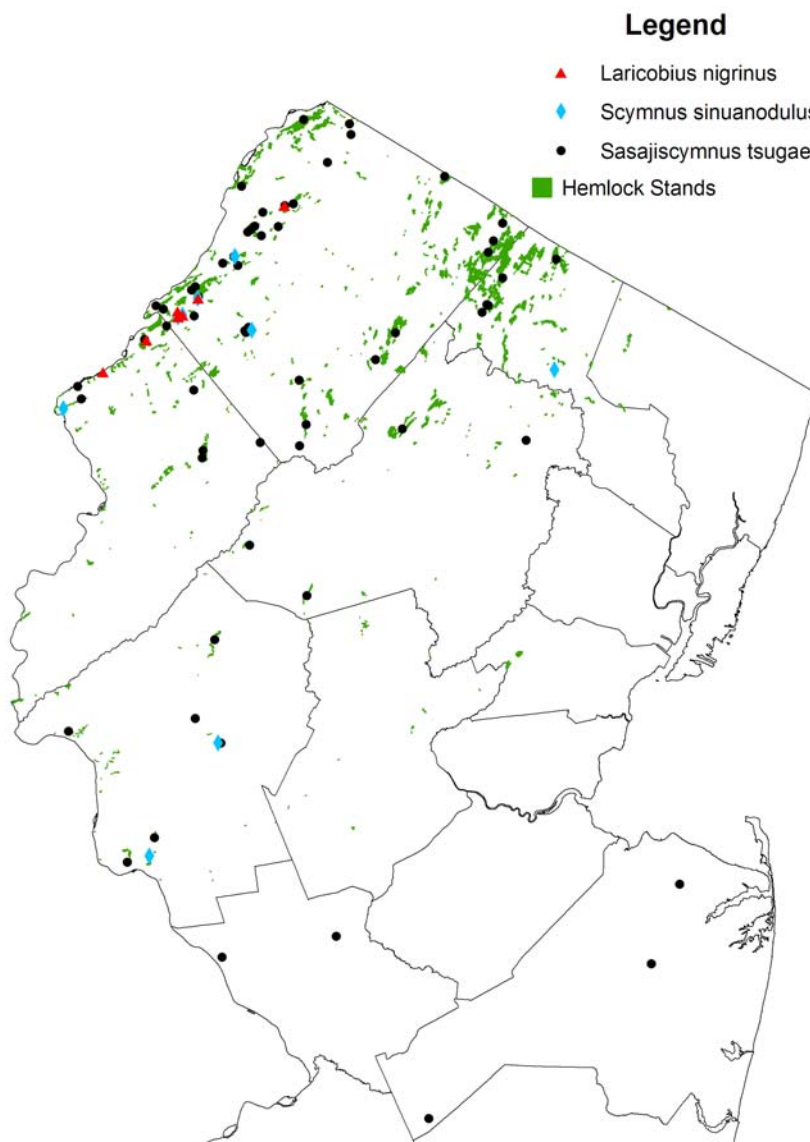
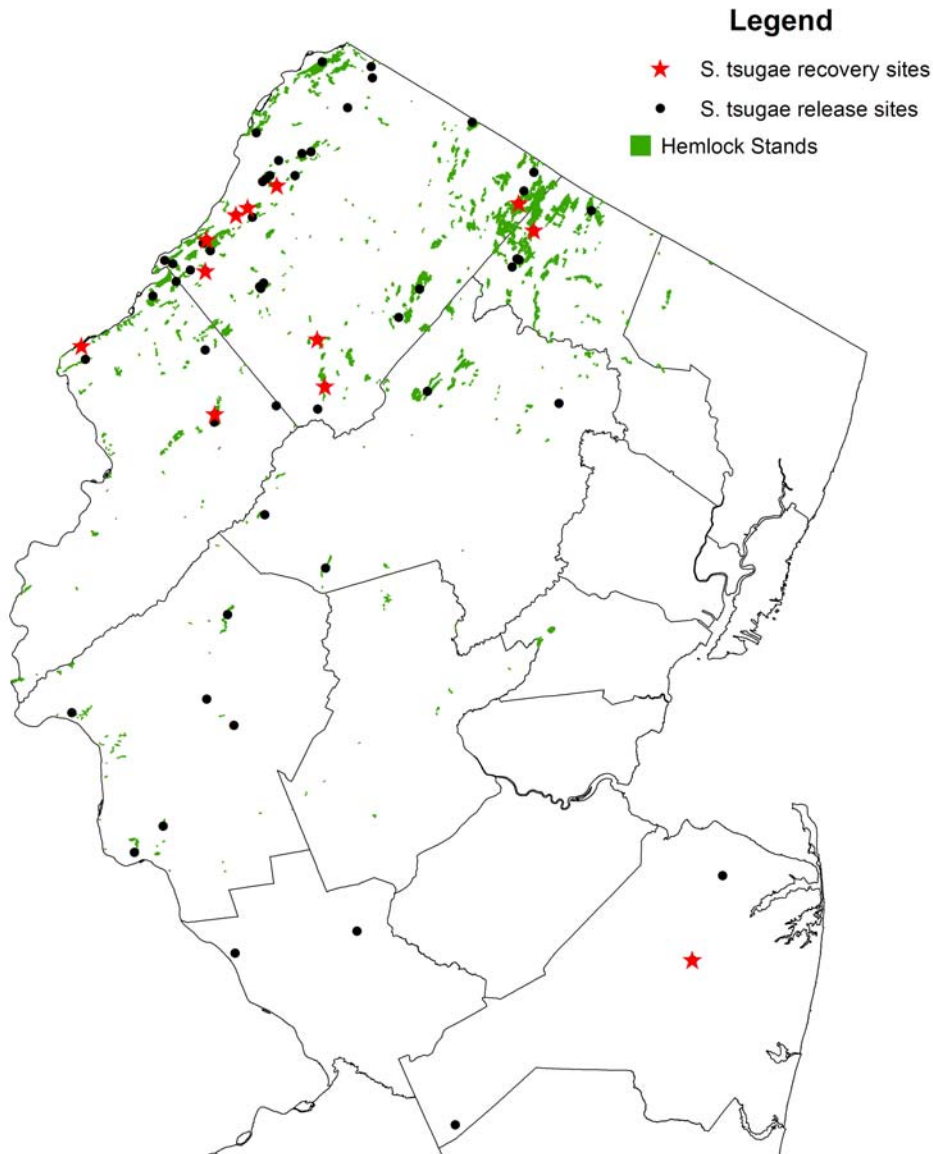


Figure 4 is a map of the release and recovery sites for *S. tsugae* over the course of the project. The majority of the recoveries are in certain areas, notably the Kittatinny Ridge in the Northwest part of the state where the hemlock stands are still healthy. The fact that so few have been recovered is disappointing.

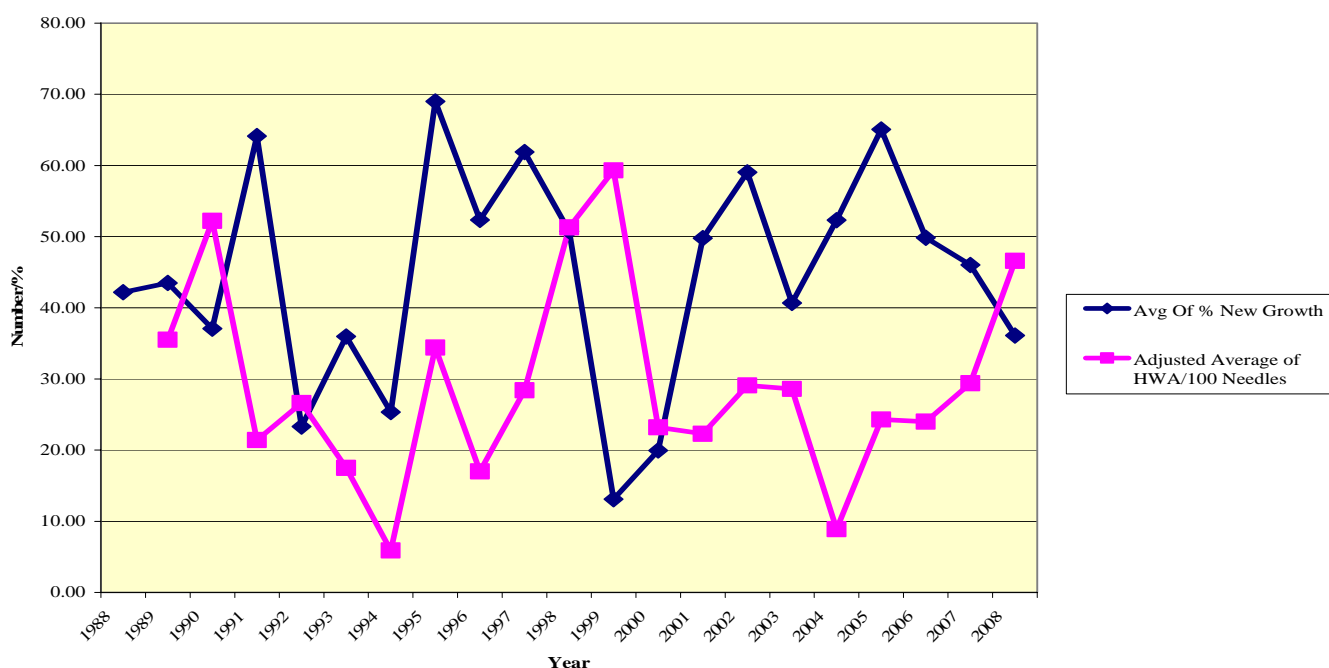
Figure 4. Release and Recovery Sites for *S. tsugae*.



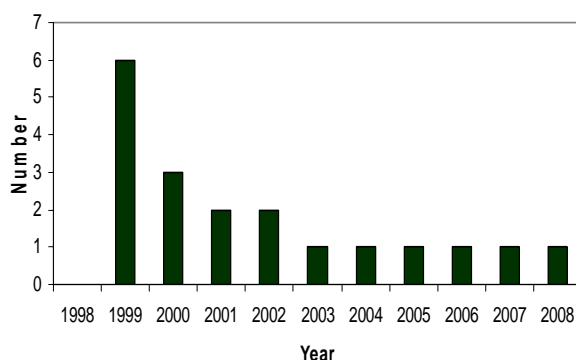
We did not expect much, if any, impact on the HWA population as yet because the number of beetles that were recovered was minimal. All introduced populations go through a lag phase in their establishment where there are too few of the new species around and it takes some time for them to enter the log phase of their population curve. The bar graph in Figure 5 shows the HWA

population and the number of *S. tsugae* recovered yearly since the first release in 1998. 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 it did in 2008 but there was no subsequent recovery of *S. tsugae*. Fewer sites were surveyed in 2008 and there were no summer staff to do the surveys which may be part of the reason that the number of recoveries was down. The increase of the HWA population in 2008 may improve the chances of recovering more *S. tsugae* recovered in 2009; as long as there is no substantial HWA winter mortality. The majority of the recoveries are along the Kittatinny Ridge in the Skylands section of NJ.

Figure 5. HWA Population, % New Growth and *S. tsugae* Recoveries in NJ 1989-2008



Number of *S. tsugae* Recoveries



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. Evans (2005, personal communication) stated that once trees lose 70% of their needles, they no longer put out new growth. 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. T

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 (see Table 2). 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).

Evidently, the beetles remain in the trees after release but can be difficult to find because of the lack of food material on the lower branches, branch dieback and the fact that they disperse to the upper canopy. Therefore, when ground surveys yield poor results, it does not mean that the 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.

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. No overwintering beetles were recovered. 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. 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 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 initial recoveries were made in 2006, 2007 and in 2008 from separate release trees. A total of 2,033 *L. nigrinus* were released in New Jersey in 2008 distributed among four sites bringing the total number of released beetles to 3,723. all but 533 of the *L. nigrinus* were released in the Hemlock Pond/Blue Mountain Lakes area of the DWGNRA at the request of the USFS. The idea being that the *L. nigrinus* will have a greater chance of

population increase in an area where they are concentrated. Beetles were recovered in October 2008 from three of the four previous release sites. The one site where there was no recovery had low populations of the HWA. These 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.

2009 Plans

In 2008, 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 eleven 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 limits our field search and survey capabilities. Also, the 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 low 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 and has established in NJ.

REFERENCES

- Cheah, C., M. Mayer, D. Palmer, T. Scudder, and R. Chianese.** 2005. Assessments of biological control of hemlock woolly adelgid with *Sasajiscymnus (Pseudoscymnus) tsugae* in Connecticut and New Jersey in Onken, B. and R. Reardon Third Symposium on hemlock Woolly Adelgid in the Eastern United States. Asheville, North Carolina, February 1-3, 2005. http://na.fs.fed.us/fhp/hwa/pub/2005_proceedings/cheah.pdf
- Evans, R.** 2005. Ecologist, Delaware Water Gap National Recreation Area.
- Hennessey, R.** 1995. Field Release of a Nonindigenous Lady Beetle, *Pseudoscymnus* sp. (Coleoptera: Coccinellidae), for Biological Control of Hemlock Woolly Adelgid, *Adelges tsugae* (Homoptera: Adelgidae). Environmental Assessment. USDA-APHIS Riverdale, MD.
- Hodek, I.** 1973. Biology of Coccinellidae. Dr. W. Junk N.V., The Hague.
- Mausel, David L. , Theresa A. Dellinger, Ashley B. Lamb, Scott M. Salom, and Loke T. Kok.** 2007. Field Instructions for Release of *Laricobius nigrinus*, a Biological Control Agent for the Hemlock Woolly Adelgid in the Eastern U.S. Department of Entomology, Virginia Tech, Blacksburg, VA.
- Mayer, M. and D.C. Allen.** 1983. *Chilocorus stigma* (Coleoptera: Coccinellidae) and Other Predators of Beech Scale in Central New York. In, Proceedings, IUFRO Beech Bark Disease Working Party Conference, USDA-FS General Technical Report WO-37: 89-98.
- Mayer, M., T. Scudder, R. Chianese, J. Sheppard and D. Palmer.** 2002. Unpublished Annual Report on Release of *Pseudoscymnus tsugae* in NJ. Phillip Alampi Beneficial Insect Laboratory, Division of Plant Industry, New Jersey Department of Agriculture. <http://www.state.nj.us/agriculture/plant/biolab.htm>
- Mayer, M., T. Scudder, C. Burdel, F. Golz, and T. Dorsey.** 2007. Unpublished Annual Report. The Effect of the Hemlock Woolly Adelgid *Adelges tsugae* (Homoptera: Adelgidae) in New Jersey Hemlock Stands. Phillip Alampi Beneficial Insect Laboratory, Division of Plant Industry, New Jersey Department of Agriculture. <http://www.state.nj.us/agriculture/plant/biolab.htm>
- Millers, I., R. Anderson., W. Burkman, W. Hoffard.** 1992. Crown Condition Rating Guide. USDA-FS Technical Report.
- Scudder, T., M. Mayer, R. Chianese, J. Sheppard and D. Palmer.** 2001. Unpublished Annual Report on Release of *Pseudoscymnus tsugae* in NJ. Phillip Alampi Beneficial Insect Laboratory, Division of Plant Industry, New Jersey Department of Agriculture.