

2001 FHP Special Technology Development Project Proposal

Project Status: New

Project Number:R08-2001-03

Project Title: Control of the Balsam Woolly Adelgid and in Natural Stands and Plantations of Fraser fir with an Introduced Predator *Pseudoscymnus tsugae*.

Expected Project Duration: 36 months. In evaluating the effect of a beneficial insect on the target pest population, a general rule is that reductions in pest density will take over 6-10 generations of the pest. For BWA, 6 generations would require 3 years.

Expected Completion Date of the Project: 12/31/03

Subject: Biological Control 1 Invasive Species 1 Population 2

Status of Subject Species: Non-native

Objective: 1) To determine if balsam woolly adelgid populations can be reduced below damaging levels in natural stands and plantations of Fraser fir by releases of the introduced predator *Pseudoscymnus tsugae*. 2) Establish a second colony of *Pseudoscymnus tsugae* to augment the national biological control effort for hemlock woolly adelgid and determine if BWA can increase rearing capacities of *Pseudoscymnus tsugae*.

Brief Description of Project:

- 2001 Establish colony of *Pseudoscymnus* on balsam woolly adelgid (BWA) in the NC State Insectary.
- 2001 When enough *Pseudoscymnus* are produced, a release program in a natural stand will begin.
- 2002 Continue releases for control of BWA and HWA in natural stands and plantations.
- 2002 Begin monitoring program for *Pseudoscymnus* and BWA.
- 2003 Complete monitoring for *Pseudoscymnus* and BWA.
- 2003 analysis and manuscript preparation.

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Cooperators:	<u>Name</u>	<u>Affiliation</u>	<u>Phone, E-mail, Fax</u>
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Cooperator Involvement:

<u>Name</u>	<u>Role</u>	<u>Time Commitment</u>
S. Salom	Backup source of <i>Pseudoscymnus</i> ; will provide additional rearing protocol when acquired (they are maintaining a small research colony of <i>Pseudoscymnus</i>).	2%
Association	Financial support	0%
Kathy Kidd	If additional rearing space is required, the NCDA can provide it.	0%

Justification: This proposal addresses the national priority to "*develop or refine biocontrol methods for established species (native and non-native) and established pest populations.*" The balsam woolly adelgid (BWA) is an introduced pest of true firs in North America. BWA are currently threatening the Fraser fir populations in NC, Virginia and Tennessee (Amman and Speers 1965). Tree mortality ranges from 44% on Roan Mountain, which has 10% of the total spruce-fir type in southern Appalachia, to 91% in the Great Smoky Mountains National Park (GSMNP), which contains 74% of southern Appalachia's spruce-fir type (Dull *et al.* 1988). BWA caused mortality results in significant increased fuel loading. For example, at higher elevations in the GSMNP, standing dead basal area was four times higher, and down volumes were two times higher in BWA impacted areas compared to unimpacted areas (Nicholas and White 1985). The impact BWA has on tourism is not well documented; however of the 10 million people that visit the GSMNP each year the most frequently asked question is in regards to the conspicuous tree mortality (Johnson, personal communication). The life history of the Fraser fir has effectively been cut in half by BWA. With few exceptions BWA has eliminated old growth Fraser fir, especially old growth stands. This loss of old growth habitat has had an impact on certain threatened and endangered species such as the northern flying squirrel and the spruce-fir moss spider.

Infestation of Fraser firs by BWA can cause abnormal growth as a result of salivary secretions (Amman and Speers 1965, Hain *et al.* 1991). The loss of apical dominance is one of the first symptoms of an infestation, and is of major concern to Christmas tree growers.

Pesticides have limited application in natural stands because application must be with ground equipment. Aerial spraying and/or systemic insecticides have not been successful. In Christmas tree plantations pesticide applications have become a sensitive public issue because of environmental concerns.

Predators, the only significant biological control, have been released in the past with minimal success. Those predators that became established did comparatively little to affect balsam woolly adelgid populations because they primarily fed only on the egg stage (Amman 1970).

Urgency: Old growth Fraser fir stands are virtually extinct, but young stands are replacing many of the old growth stands. Old growth hemlock stands are under a similar threat, but old growth stands are not being replaced by younger stands. Hemlock may be more endangered than Fraser fir because of poor reproduction in infested areas. Delay in implementing control strategies would result in irreversible loss.

National FHP Technology Development Priority: Priority 1: x

Technical Committee Development Priority: 4

Scope of Application: Successful development of this biocontrol technique will be applicable to fir stands and plantations throughout the regions where fir is grown and BWA is a pest. A second location for rearing *P. tsugae* would improve the supply of the predator for both BWA and HWA control.

Research Basis: Recently, a coccinellid beetle, *P. tsugae*, has been released in a number of states to control another adelgid pest, the hemlock woolly adelgid (HWA). The predator appears very promising for biological control of the hemlock woolly adelgid because it has a high degree of specificity to adelgids, is well synchronized with the life cycle of hemlock woolly adelgid, is adaptable to varying physical conditions, has a high searching efficiency and dispersal ability, has a high rate of population increase when prey numbers increase, and can survive during pest-free periods. In addition, *P. tsugae* has been observed readily feeding on balsam woolly adelgids in our lab, and was released in cages in a BWA infestation at Mt. Rogers, VA where they did survive the winter (McClure, personal communication). *P. tsugae* has two generations per year, and both larvae and adults attack all stages of adelgids. Currently, the only limitations to using the predator for a biological control program against the BWA is the limited numbers that are being mass produced by New Jersey Department of Agriculture, the only source for the predator. Mass production in the New Jersey lab is currently dependent on a supply of HWA, which can be problematic. During aestivation, no other life form of HWA is available. While the predators will feed on the aestivating HWA, they will not reproduce. Establishing a second colony for mass production should improve the supply of *P. tsugae*, especially if BWA are utilized in the rearing. While BWA also has a period of aestivation, there is less synchrony in generation development, and eggs are generally available throughout the season.

Methods: A colony of *P. tsugae* will be established in the insectary on the N.C. State University campus. We will follow the same mass rearing protocol, as the NJ Dept. of Agriculture except we will attempt to rear the predator on BWA exclusively. We will maintain a separate smaller colony on HWA in case rearing problems on BWA occur.

In both the natural stands and the plantations, the approach will be similar to the approach that has been used for releasing and evaluating the establishment and control success of *P. tsugae* in HWA infested stands. Releases on a single tree (natural stand) or group of trees (plantation) will occur in a central location. 5 monitoring trees will be established in the vicinity of the release point, 50, 100, and 200m from the release point in the 4 cardinal directions (a total of 65 monitoring trees at each site). At monthly monitoring intervals, BWA and *P. tsugae* populations will be counted on one square meter of bark surface on mature trees or 2 linear meters by 2.5 cm of bole on the younger plantation trees. The upper and lower diameter of the area on the younger trees will be measured so that a density/surface area can be determined. The exact number of release sites will depend upon our ability to mass rear the predator. We will attempt to release 10,000 beetles per site. Control plots will be established where no predator release will occur.

Measures of Success:

Standard of Success: 1) The establishment of a mass rearing facility that would provide the predatory beetle to regional cooperators. 2) The long-term establishment of *P. tsugae* in the infested release sites. 3) After 6 BWA generations, significantly fewer adelgids and adelgid-infested trees should be present in the release sites than in the control sites with no releases.

Expected Outcomes: The above standards of success will be achieved and the rearing and release of *P. tsugae* will become operational and be taken over by another agency, such as the NC Dept. of Agriculture.

Implementation of Products/methods: The NC Dept. of Agriculture has the facilities to mass rear *P. tsugae*. Rearing facilities are available in Raleigh, and a smaller facility is available in Crossnore, NC. Personnel for rearing and shipping are also available.

Products and Due Dates: By January 2004, mass-rearing protocol should be well established, and the effectiveness of *P. tsugae* as a biocontrol agent should be well established. Recommendations for the continued implementation of the program will be made and explored.

Publications: Results will be reported in peer-reviewed scientific journals.

Technology Transfer: The technology that is developed will be transferred to the NC Dept. of Agriculture for regional implementation. All necessary descriptions and protocols will be transferred to them.

Long-term Budget Request: The STDP will provide stipend support for one graduate student, salary for a part time technician, materials, supplies, and travel costs. NCSU will provide indirect costs @ 47% and a portion of the PI's salary. Additional support for materials and supplies is being requested from the NC Christmas Tree Association (NCCTA).

	Item	Requested FHP STDP Funding	Other- Source Funding	Source
FIRST YEAR				
Administration	Salary	22,878	5,089	NCSU
	Overhead		12,613	NCSU
	Travel	3,000		
Procurements	Contracting			
	Equipment			
	Supplies	957	1,000	NCCTA
Year Totals		26,835	18,702	
SECOND YEAR				
Administration	Salary	22,878	5,089	NCSU
	Overhead		12,613	NCSU
	Travel	3,000		
Procurements	Contracting			
	Equipment			
	Supplies	957	1,000	NCCTA
Year Totals		26,835	18,702	
THIRD YEAR				
Administration	Salary	22,878	5,089	NCSU
	Overhead		12,613	NCSU
	Travel	2,000		
Procurements	Contracting			
	Equipment			
	Supplies		1,000	NCCTA
	Publications	1,957		
Year Totals		26,835	18,702	
PROJECT TOTALS		80,505	56,106	

STDP Production Function

Project Number: R08-2001-03

Project Cost: \$80,505

Project Objectives:

1. To determine if balsam woolly adelgid populations can be reduced below damaging levels in natural stands and plantations of Fraser fir by releases of the introduced predator *Pseudoscymnus tsugae*.
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Benefits Not Quantified but Considered under the Forest Health Protection Program Analysis:

Avoid Tree Removal/Replacement Costs The establishment of *Pseudoscymnus tsugae* will maintain both Fraser fir and hemlock species within numerous recreation areas across the eastern United States. This is especially important in areas where Fraser fir or hemlocks are the dominant species and their loss would leave them in an unacceptable condition.

Avoid Pesticide Related costs: The establishment of *Pseudoscymnus tsugae* would help eliminate the use of pesticides in control of BWA and HWA in recreation and ornamental situations on thousands of acres across the Eastern United States. Currently Forest Health Protection provides in excess of \$120,000 annually for chemical control efforts of HWA and BWA in the Southern Region. Another benefit could be in the reduction of chemicals used for control of BWA within the large Christmas tree industry in North Carolina.

Avoid Habitat Restoration Costs: The establishment of *Pseudoscymnus tsugae* and subsequent control of HWA could eliminate the need to replace the conifer habitat bordering and protecting thousands of miles of streams and rivers. The loss of this conifer cover in many cases will leave the aquatic habitat in a condition unacceptable for many of the species that occur there. An example of this would be the loss of brook trout habitat due to the rise in water temperatures because of the loss of the hemlock protection.

Maintain Wildlife Habitat: The establishment and control potential of *Pseudoscymnus tsugae* will aid in the maintenance of the fir and hemlock forests that are primary habitat for many species including the northern flying squirrel and the Blackburnian warbler.

Protection Threatened/Endangered Species Habitat: The control of BWA will allow habitat for several listed or endangered species to exist. Examples of endangered species that require the habitat provided by mature Fraser fir are a subspecies of the northern flying squirrel, and the spruce fir moss spider. The impact of BWA on Fraser fir has been a decrease in the life span of the fir by about 50 percent. Under normal conditions fir achieves an age in excess of 100 years. The loss of the age potential of the fir dramatically affects the characteristics of the stand, which impacts the 2 species mentioned above.

Avoid Threatened/Endangered Species Listing: The establishment and subsequent control of HWA with *Pseudoscymnus tsugae* will allow both eastern and the rare Carolina hemlock to remain a

vital part of the forests of the east. Both hemlock species have potential to become endangered in their natural settings if control methods are not developed and implemented.

Enhance Visual Quality/Recreation: The control of both BWA and HWA with establishment of *Pseudotsuga tsugae* will maintain some of the most highly valued and desirable recreational settings found in the eastern United States. Fraser fir is one of 2 species found in the high elevation forests of the southern Appalachians. These forests lie proximal to the Blue Ridge Parkway in Tennessee, North Carolina, and Virginia. There are numerous recreation areas and vistas along the Parkway where Fraser fir is the focal point and key to their aesthetic value. Millions of visitors journey to these areas each year and with this comes a great deal of public concern over the continued existence of the Fraser fir forests. In the eastern United States hemlocks are key species for many of the premier recreation sites. These sites were in most cases located in their current locations due to the immeasurable aesthetic qualities of hemlock.

Assumptions:

For the purposes of this analysis the value of eastern hemlock as a timber species will be utilized. The values of Fraser fir are primarily unquantifiable thus reliable realistic economic figures are not available. The timber value of hemlock is a very small part of the overall importance of the eastern hemlocks and Fraser fir to the forests and landscapes of the eastern United States. Both hemlock species and Fraser fir have numerous immeasurable values that are not easily quantified most of which are briefly discussed above.

- The development of biological control measures for HWA will allow at least 20 % of the host trees to be maintained.
- The use of Fraser fir as a host species will increase yields of *Pseudotsuga tsugae* in rearing facilities thus increasing control potential.
- The HWA threatens to eliminate eastern, and Carolina hemlock from natural settings.
- The entire range of eastern hemlock will be infested and much of it lost within the next 30 years.
- Estimated loss of hemlocks after being infested 10 years is conservatively 50 percent.

BackgroundData:

- Number of hemlock hectares is 1.3 million.
- Approximately 325,000 hectares(25%) are currently infested.
- Total cubic foot volume of hemlocks is 12 billion.
- Total cubic feet of hemlock per hectare is 9230.7
- Stumpage value per MCF of hemlocks is \$46.87

Data from USDA-FSD-FIA reports

Calculations:

EOV without project = (325,000 hectares)*(50% loss of trees)*(9.2MCF/hectare)*(46.87 per MCF) = 70,070,650 = discounted to 21,604,182

EOV with project = (325,000 hectares)*(50% loss of trees)*(9.2MCF/hectare)*(\$46.87 per MCF)*(1.2;20% probability of success) = 84,084,780 discounted to 25,925,019

Benefit Attributed to Project: 25,925,019-21,604,182 = \$4,320,837

Benefit/Cost Ratio: 4,320,837/136,611 = 31:1

Benefit Attributed to STDP Funds: 31*\$80,505 STDP costs = \$2,495,655

PNV of Project: \$2,495,655 - \$136,611 = \$2,359,044

PNV of STDP: \$2,495,655 - \$80,505 = \$2,415,150

Literature Cited:

- Amman G.D. 1970. Phenomena of *Adelges piceae* populations (Homoptera: Phylloxeridae) in North Carolina. *Annals of the Entomol. Soc. of America*. 63: 1727-1734.
- Amman G.D. and Speers C.F. 1965. Balsam woolly aphid in the southern Appalachians. *Journal of Forestry*. 63:18-20.
- Dull C. W., Ward J.D., Brown H.D., Ryan G.W., Clerke W.H. and Uhler R.J. 1988. Evaluation of spruce and fir mortality in the southern Appalachian mountains. U.S. Forest Service, Southern Region. protection Report R8-PR 13. 92 p.
- Hain F.P., Hollingsworth R.C., Arthur F.H., Sanchez F. and Ross R.K. 1991. Adelgid host interactions with special reference to the balsam woolly adelgid in North America. *In* Baranchikov Y.N., Mattson W.J., Hain F.P. and Payne T.L. eds. *Forest insect guilds: patterns of interaction with host trees*. U.S. Dept. Agric. For. Serv. Gen. Tech. Rep. NE-153.
- Nicholas N.S. and White P.S. 1985. The effects of balsam woolly aphid infestations on fuel levels in spruce-fir forests at Great Smoky Mountains National Park. *Research/Resources Mgt. Rep. SER 74*. U.S. Department of Interior. 24 p.

