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Release of the Predatory Beetle *Scymnus coniferarum* (Coleoptera: Coccinellidae), for Biological Control of the Hemlock Woolly Adelgid (*Adelges tsugae*) in the Eastern United States

Environmental Assessment, September 2012

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I. Purpose and Need for the Proposed Action

The U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) Pest Permitting Branch (PPB) is proposing to issue permits for the interstate movement and release of the predatory beetle *Scymnus* (*Pullus*) *coniferarum* (Coleoptera: Coccinellidae). This species is native to the western United States and would be used by the applicants for the biological control of the hemlock woolly adelgid ((*Adelges tsugae*) (Homoptera: Adelgidae)) (HWA) in the eastern United States. Before permits are issued for release of *S. coniferarum*, the APHIS–PPQ PPB needs to analyze the potential impacts of the release of this agent into the eastern United States.

This environmental assessment[1] (EA) has been prepared, consistent with USDA–APHIS' National Environmental Policy Act of 1969 (NEPA) implementing procedures (Title 7 of the Code of Federal Regulations (CFR), part 372). It examines the potential effects on the quality of the human environment that may be associated with the release of *S. coniferarum* to control HWA in the eastern United States. This EA considers a “no action” alternative and the potential effects of the proposed action.

The applicant’s purpose for releasing *S. coniferarum* in the eastern United States is to reduce the severity of damage caused by HWA. HWA is native to eastern Asia and western North America (Havill and Foottit, 2007). The HWA was accidentally introduced to the eastern United States and is destructive there to the eastern hemlock, *Tsuga canadensis*, and Carolina hemlock, *T. caroliniana.* This sucking insect feeds at the base of the needles causing needle loss and abortion of buds which leads to decline in crown health and tree death after several years (Orwig et al., 2002; Eschtruth et al., 2006). It is destructive to hemlocks in landscapes and forests and has affected federal parks, recreation areas, and forests; state-managed forest lands; commercial and private landowners; and urban and suburban communities (Evans et al., 2011; Krapfl, 2011).

To date, four predatory beetles have been introduced to the eastern United States for biological control of HWA and two (*Laricobius nigrinus* and *Sasajiscymnus tsugae*) are considered to be established (Cheah et al., 2004). However, because, HWA has a group of natural enemies that control it where it is native, a full complement of predators are needed to

[1] Regulations implementing the National Environmental Policy Act of 1969 (42 United States Code 4321 et seq.) provide that an environmental assessment “[shall include brief discussions of the need for the proposal, of alternatives as required by section 102(2)(E), of the environmental impacts of the proposed action and alternatives, and a listing of agencies and persons consulted” (40 CFR § 1508.9).

more effectively control HWA in the eastern United States where it is an invasive pest. Adelgids, such as HWA, have complex multigenerational lifecycles with multiple forms appearing at different times. Specialized predators, such as *S. coniferarum*, that are part of the full complement of natural enemies where HWA is native, attack different lifecycle forms of HWA at different times of the year. For these reasons, the applicant has a need to move *S. coniferarum* from the western United States and release it into the eastern United States in order to provide an additional predator to the complement of natural enemies currently in place for more effective control of HWA.

II. Alternatives

This section will explain the two alternatives available to the APHIS–PPQ PPB—no action (no issuance of permits) and issuance of permits for interstate movement and environmental release of *S. coniferarum* in the eastern United States wherever HWA becomes established. Although APHIS' alternatives are limited to a decision of whether to issue permits for interstate movement and release of *S. coniferarum,* other methods available for control of HWA in the eastern United States are also described. These control methods are not decisions to be made by APHIS, and are likely to continue whether or not permits are issued for environmental release of *S. coniferarum*. These are methods presently being used to control HWA in the eastern United States where it is not native and has established as a pest.

A third alternative was considered, but will not be analyzed further. Under this third alternative, the APHIS–PPQ PPB would have issued permits for the field release of *S. coniferarum,* however, the permits would contain special provisions or requirements concerning release procedures or mitigating measures, such as limited release of *S. coniferarum*. No issues have been raised which would indicate that special provisions or requirements are necessary.

A. No Action

Under the no action alternative, the APHIS–PPQ PPB would not issue permits for the field release of *S. coniferarum* for the control of HWA—the release of this biological control agent in the eastern United States would not take place. The following methods are presently being used to control HWA in the eastern United States; these methods will continue under the "no action" alternative and are likely to continue even if permits are issued for release of *S. coniferarum*.

1. Chemical Control

Chemical insecticides provide an effective method to reduce HWA populations on individual hemlocks. Spraying infested trees thoroughly with insecticidal soap or horticultural oil is commonly used and highly effective in killing adelgids but two spray treatments each year are usually necessary (McClure et al., 2001). The large equipment used for spraying make this method impractical for forests. Systemic insecticides applied to the soil or tree trunks can reduce HWA populations for several years and is one of the options used to control HWA in National Parks (Webb et al., 2003; Cowles et al., 2006; Webster, 2010).

2. Restriction of Interstate Movement of Nursery Stock

Certain states have enacted quarantines to prevent the transport of HWA infected hemlock from infested states to uninfested areas in their states. Some states also restrict the import of hemlock timber with bark. States may allow shipment of nursery stock or hemlock timber if accompanied by a certificate of inspection that the items are HWA free or other compliance agreement (Gibbs, 2002). These restrictions to interstate commerce are likely to remain in place until HWA becomes widely established in these states.

3. Development of Resistant Hemlocks

The susceptible Carolina hemlock has been cross-pollinated with the very resistant Chinese hemlock to produce a hybrid cross with high resistance to HWA (Montgomery et al., 2009). Clones of these are in field trials and a new, resistant hemlock cultivar would not be available to the nursery industry for several years. Efforts are being made to identify resistant hemlocks in HWA infested stands of eastern hemlock (Caswell et al., 2008; Ingwell and Preisser, 2011).

4. Bio-insecticides

Efforts have been made to develop effective fungus-based pesticide formulations using *Lecanicillium muscarium* (formally *Verticillium lecanii*) and *Beauveria bassiana* (Cheah et al., 2004; Gouli et al., 2008).

5. Biological Control

Shortly after it was recognized as a significant pest, McClure (1987) noted that several native predators attack HWA in the eastern United States, but none were of any significance in reducing HWA density. A quantitative assessment of the resident natural enemies of HWA in Connecticut was made in 1993-1994 prior to the intentional release of exotic agents for biological control of HWA (Montgomery and Lyon, 1996). Two predatory beetles, *Laricobius rubidus* (LeConte) and *Scymnus (Pullus) suturalis* Thunberg were recovered. *Laricobius rubidus* is native to North America while *S. suturalis* is native to Europe. Both of these beetles were collected in about equal numbers from the foliage of eastern hemlock, white pine, and Scotch pine. Although it is likely that *L. rubidus* evolved on the pine bark adelgid (*Pineus strobi* (Hartig)), which attacks white pine, and *S. suturalis* evolved on the European pine adelgid (*Pineus pini* (Macquart)), which attacks Scotch pine, both beetle predators can utilize several adelgids, including HWA as hosts. Host range tests found that *S. suturalis* and *L. rubidus* feed readily and equally on HWA and *P. strobi* in no-choice situations, although *S. suturalis* is attracted more to pine foliage than to hemlock foliage (Montgomery et al., 1997). Larvae of both beetle species were found on HWA in the field, but the number per branch decreased with distance from pine (Montgomery and Lyon, 1996). Although this survey indicated that resident predators associated with pine adelgids could switch to an exotic adelgid on hemlock, recent surveys, 15 years later, have found far fewer of these two predators on hemlock (Montgomery, unpublished). A survey of natural enemies in 1997-1998 in North Carolina found several families of predators, but their numbers were too low to have any noticeable effect on HWA density (Wallace and Hain, 2000).

Because of the lack of effective natural enemies of HWA in eastern United States, natural enemies of HWA were imported from Japan, China, and western Canada (Cheah et al., 2004). A summary account of the predators imported and released follows.

The first predator released was the lady beetle *Sasajiscymnus tsugae* (Sasaji and McClure) (formerly *Pseudoscymnus tsugae*) collected in Japan and first released in 1995 in Connecticut (Cheah and McClure, 2002). More than 2 million adult *S. tsugae* beetles have been released at 513 locations in 13 states (Roberts et al., 2010). Although it is established in several states, its impact on HWA has been difficult to discern (Cheah et al., 2005; Hakeem et al., 2010).

Laricobius nigrinus, from the beetle family Derodontidae, was imported from Vancouver Island, British Columbia beginning in 1997 and several years of evaluations (Zilahi-Balogh, 2001) preceeded its field release in 2003. More recently, *L. nigrinus* adults are being collected in the Seattle, Washington area (McDonald, 2010) and in Idaho (Mausel et al., 2011) for direct release in eastern states. To date, more than 100,000 adult beetles have been released at 267 locations in 13 states (Roberts et al., 2010). Its establishment has been very good with a slow but steady yearly increase in population density of the beetle (Mausel et al., 2010; McDonald, 2010). Another derodontid beetle, *Laricobius osakensis* Montgomery & Shiyake, native to Japan, has recently been approved by APHIS for environmental release (USDA, APHIS, 2010).

More than 50 species of "*Neopullus*" lady beetles have been collected from HWA-infested hemlocks in China (Yu and Montgomery, 2008). Of these, three species that were abundant and fed specifically on adelgids were imported (Cheah et al., 2004). These species in the genus *Scymnus*, subgenus *Neopullus* have been difficult to mass rear. Field releases have been made with *Scymnus sinuanodulus* Yu & Yao and *Scymnus ningshanensis* Yu &Yao, but neither is known to have established. A third species, *Scymnus camptodromus* Yu & Liu, is undergoing further study in quarantine.

B. Issue Permits for Environmental Release of *S. coniferarum.*

Under this alternative, the APHIS–PPQ PPB would issue permits upon request and after evaluation of each application for the interstate movement and environmental release of *S. coniferarum* for the control of HWA in the eastern United States. These permits would contain no special provisions or requirements concerning release procedures or mitigating measures.

1. Taxonomic Information for *S. coniferarum*

Insect Taxonomy

Order:	Coleoptera
Family:	Coccinellidae
Genus:	*Scymnus*
Species:	*Scymnus coniferarum*
Common name	none

Scymnus coniferarum Crotch (Coleoptera: Coccinellidae) was described in 1874 from specimens collected from pine in California. The type-specimen is at the Museum of Comparative Zoology, Harvard University (MCZ). Vouchers (male and female adults) have been deposited at the National Museum of Natural History, Washington, D.C. (NMNH) and the University of Georgia Arthropod Collection, Athens, GA (UGAC).

2. Description and Biology of *S. coniferarum*

Scymnus coniferarum is a small lady beetle, about 2 millimeters in length, covered in fine, short hairs, with reddish-brown wing covers edged in black. Whitehead (1967) and Gordon (1976) provide full descriptions with figures. *Scymnus* larvae are covered with white woolly wax.

In the laboratory, *S. coniferarum* has been reared for several successive generations on HWA growing on eastern hemlock. Its life stages consist of egg, four larval instars, pupa, and adult. During the spring months, a female lays about 1 egg per day in a bud scale, male flower, or near a HWA ovisac (egg-containing capsule). At 20° C, development is rapid with the egg, larval, and pupal stages lasting about 6, 19, and 9 days, respectively (Schwartzberg et al., 2009). The beetle also develops well at 15° C.

To understand the relationship of this predator to its preferred host, HWA, the life cycle of HWA must also be understood. Adelgids, such as HWA, have complex, multi-generational, life cycles, with multiple forms, and several types of life cycles even within a single species (Havill and Foottit, 2007). The lifecycle of HWA varies depending on region. In Japan and China, where it is native, HWA is “holocyclic” and migrates between hemlock and a species of spruce. This holocycle takes two years with sexual reproduction and the formation of galls (abnormal swellings of plant tissue caused by insects) occurring on spruce, and three parthenogenetic (a form of reproduction in which an unfertilized egg develops into a new individual) generations occurring on hemlock (Havill and Foottit, 2007). In western North America, where HWA is also native, HWA is “anholocyclic” and it does not migrate to spruce—it has only two alternating, asexual, wingless generations on hemlock; the “sistens” which diapauses (a period of inactivity during which development is suspended) during the summer and develops during the fall, winter, and spring, and the “progrediens” generation which develops during spring and early summer. In the eastern United States, the life cycle is similar to that in Japan, but there is no spruce host in eastern United States on which it can reproduce (McClure, 1989).

The seasonal occurrence of *S. coniferarum* and another predator, *L. nigrinus,* as well as their host, HWA, was monitored on western hemlock in the Seattle, Washington area from October, 2010 to June, 2011. In early October, *S. coniferarum* adults were more abundant on western hemlock than adults of *L. nigrinus*, but both species were equally abundant by the end of the month. Both species were found during the cold winter months. By April, adults of *L. nigrinus* were no longer present, but *S. coniferarum* adults were abundant. The larvae of *L. nigrinus* were most abundant during April whereas larvae of *S. coniferarum* were most abundant during June. The larvae of *L. nigrinus* coincided with the eggs of the overwintering generation (sistens) of HWA and the larvae of *S. coniferarum* coincided with the eggs laid by the late spring generation (progrediens) of HWA. The larvae of *L. nigrinus* enter the soil in April to become adults and remain in the soil until the fall, whereas the larvae of *S. coniferarum* become adults in June and remain on the tree throughout the year.

3. Geographic Range of *S. coniferarum*

The known native geographical range of *S. coniferarum* is western North America (Gordon, 1985). Specimens have been collected from various species of pines in British Columbia, Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, South Dakota, Utah, and Wyoming (Gordon, 1976). Recently, several hundred specimens have been collected from western hemlock in Washington State (Montgomery et al., 2009; McDonald, 2010). It has recently been recovered from Monterey pine in Chile and Peru (Gonzalez, 2006); probably an accidental introduction since pine and adelgids are not native to South America. There is a report of it in the eastern United States (Malkin, 1945), but this may be a misidentification. Gordon (1976) recorded it in Pennsylvania, but later clarified that these were *S. suturalis* (Gordon, 1985). Considering that the species has spread intercontinentally, has been found in the Rocky Mountains as far east as the Black Hills, South Dakota, and occurs in a variety of habitats in western North America, it is possible that it is already established in eastern North America.

4. Impact of *S. coniferarum* on Hemlock Woolly Adelgid

In the field, the adults of *S. coniferarum* and *L. nigrinus* feed on all HWA stages, except nymphs that are in diapause during the summer. Diapause is a period of inactivity or rest, during which development is suspended. The larvae of both *S. coniferarum* and *L. nigrinus* target the egg stage of HWA. Larvae of *L. nigrinus* primarily attack the spring generation eggs laid in late winter to early spring while the larvae of *S. coniferarum* primarily attack eggs laid in later spring to early summer. Because these two species attack the eggs of separate HWA generations, they complement each other in reducing HWA populations. By releasing *S. coniferarum* in the eastern United States, the spring HWA generation will have a predator that it currently lacks and additional pressure will be provided to reduce HWA populations.

III. Affected Environment

A. Areas Affected by Hemlock Wooly Adelgid

1. Native and Worldwide Distribution

The HWA is native to eastern Asia and the western North America (Havill et al., 2007). It is not considered a pest in these regions (Furniss and Carolin, 1977; Cheah et al., 2004).

2. Present Distribution in the United States

The first report of HWA in eastern United States came from the Virginia Department of Agriculture and Consumer Services in 1951 on planted eastern hemlock in Richmond, Virginia (Stoetzel, 2002) and has since spread to 18 eastern states (USDA, FS, 2011). Currently, HWA infests all of the U.S. counties with Carolina hemlock and 50 percent of the U.S. counties with eastern hemlock (USDA, FS, 2011). It is the only adelgid that feeds on hemlock and its distinctive white woolly wax makes it easy for non-specialists to distinguish it from other insects on hemlock.

3. Hemlock Resources in Eastern North America

Eastern North America has two native hemlock species, *Tsuga canadensis*, eastern hemlock and *Tsuga caroliniana*, Carolina hemlock, and these species serve as the primary hosts of HWA. Eastern hemlock grows on almost 19 million acres in the United States, while Carolina hemlock is limited to the Blue Ridge of the southern Appalachian Mountains. Both hemlock species are long-lived species that, if left undisturbed, eventually dominate tree stands.

Eastern hemlock, may take 250 to 300 years to reach maturity, live for 800 years, and attain heights of 150 to 175 feet. It is the most shade-tolerant tree species in North America, capable of surviving underneath a shaded forest canopy for as long as 350 years (Quimby, 1996). Because it is so shade tolerant and long-lived, hemlock is a late successional, "climax" tree that can dominate a forest for centuries. Ward et al. (2004) provides an overview of the species and its ecological and commercial values. Eastern hemlock forests provide important habitat for a wide variety of wildlife. In the northeastern United States, 96 bird and 47 mammal species are associated with hemlock forests (Yamasaki et al., 2000). Of these, at least eight species of birds and ten species of mammals have strong ecological linkages with hemlock forest habitat. Hemlock is an important winter habitat for white-tailed deer. Many native plant species thrive in hemlock stands, including leatherwood, rattlesnake plantains, bunchberry, goldthread, bluebeard, Canada mayflower, and wood sorrels (Evans et al., 1996).

Hemlock stands are very popular recreational sites for fishing, hiking, camping, hunting, and bird watching. Hemlock is not a valuable timber species, but it is used widely for pulpwood and utilitarian uses (such as pallets). Hemlocks are valued landscape plants and are one of the most cultured and cultivated landscape trees in the United States (Swartley, 1984).

B. Insects Related to HWA and *S. coniferarum*

1. Insects Taxonomically Related to HWA

There is considerable uncertainty about the taxonomy of adelgid species, which is further complicated by the several forms produced on primary and secondary host plants (Havill and Foottit, 2007). Review of the literature indicates that there are as many as 25 species of adelgids in North America, but only 16 may be valid species, with 10 species of these native to North America (see Appendix A). In eastern North America, there are no native adelgids in the genus *Adelges*, but there are six non-native species in this genus. There are nine adelgid species of *Pineus* in eastern North America: three are Eurasian (*P. cembrae*, *P. pineoides*, *P. pini*), two are considered to be native to North America (*P. pinifoliae*, *P. similus*), two species are native to western North America (*P. boerneri*, *P. coloradensis*,) and two species are native to eastern North America (*P. floccus*, *P. strobi*). *Pineus strobi* is the most common pine adelgid in eastern North America and it has spread worldwide. *Pineus boerneri* and *P. coloradensis* were pests 30 years ago on red pine in Connecticut (McClure, 1989). All the adelgids present in eastern states are considered to be pests, with the non-native species more damaging than native species.

2. Insects Taxonomically Related to *S. coniferarum*

Although *S. coniferarum* belongs to the subgenus *Pullus*, which has more than 80 species in the United States, it is unlikely to interact with native lady beetles. No other native *Scymnus* lady beetle is known to feed on adelgids to any appreciable extent. A non-native species, *Scymnus* (*Pullus*) *suturalis* Thunberg, present in the northeastern United States is similar to *S. coniferarum* (Gordon, 1985). These two species and *S. impexus*—a native of Europe introduced for biological control of the balsam woolly adelgid in the 1960s—form a distinctive group with similar form and structure and have adelgids as hosts (Whitehead, 1967). *Scymnus suturalis'* primary host seems to be *Pineus pini* on Scots pine, but it can complete development on HWA (Montgomery and Lyon, 1996).

IV. Environmental Consequences

A. No Action

1. Impact of Hemlock Woolly Adelgid on the Environment

The infestation and damage caused by HWA in urban and forest landscapes has received considerable attention from landowners and land managers, both public, and private. Several management tactics have been implemented to reduce the infestation level of HWA and the damage and mortality it causes. The use of chemical insecticides, development of bioinsecticides and resistant hemlocks, and biological controls at current levels would be expected to continue if the "no action" alternative is chosen. The current rate of spread, and levels and trends of eastern hemlock mortality and other environmental consequences from infestation by HWA will likely continue if the "no action" alternative is chosen. These environmental consequences may also continue at some level even with the establishment of *S. coniferarum* in eastern hemlock forests, depending on its efficacy in reducing HWA populations.

a. Continued decline and mortality of eastern hemlocks

Currently, about 50 percent of the counties with hemlock in the eastern United States are infested by HWA (USDA, FS, 2011) and HWA is expected to continue to expand its range. Damage in the southern range of the hemlocks appears to be more severe (Evans et al., 2011). This may reflect the absence of low winter temperatures which can reduce HWA populations (Trotter et al., 2009). Although HWA can quickly cause a decline in the crown condition of hemlock, mortality can be rapid or take many years, depending on site conditions (Orwig et al., 2002). For example, in Shenandoah National Park, some sites experienced a rise in mortality from 8 percent to 48 percent in just two years, with several site factors deemed to be important including, elevation and which direction a slope faces (Blair, 2002). Although the rate of spread and mortality is variable, the overall expectation is that most of the hemlock in the eastern United States may be lost without more and better options to control HWA.

b. Loss of economic, social, and recreational value

Yearly monetary loss caused by HWA is estimated to be over $200,000,000 (Aukema et al., 2011). About one-half of this is expenditures by governments and citizens for control of the pest and removal of damaged trees. Loss of residential property values due to damage by HWA is estimated to total $100,000,000. Loss of hemlock landscape trees due to HWA infestations in residential properties has been estimated at $2,000–$7,000 per home (Holmes et al., 2005). Forest timber loss to landowners is estimated to be on $1,100,000 per year (Aukema et al., 2011). Hemlock has little value for lumber or pulp but has an important ecological role in forests.

Hemlock mortality can have considerable impact on recreational use of forests. Consequently, large federal parks and forests have engaged in integrated pest management (IPM) programs to address the varied recreational and ecosystem needs on their properties. For example, long term monitoring, ecosystem studies, and management efforts were begun at the Delaware Water Gap National Recreation Area in 1993 (this park was originally infested in 1989). Monitoring has shown a rapid decline and mortality and as of 2006, 28 percent of originally healthy plot trees had died and none of the remaining trees were in healthy condition (Evans and Shreiner, 2008). The Great Smoky Mountains National Park has engaged in an aggressive IPM program to respond to the infestation which threatens over 35,000 acres of hemlock dominated forest (Johnson et al., 2008).

c. Continued impacts on ecosystems

Evans (2002) commented that the “decline and loss of our remaining eastern hemlock stands could be more ecologically significant than the loss of American chestnut (*Castanea dentata*) in the early 1900s from chestnut blight” due to the fact that hemlock would not be replaced by ecological equivalent species as occurred with the loss of the American chestnut. The large scale removal of hemlock trees due to HWA-caused mortality, and in some cases the resulting salvage logging of stands is well documented (Kizlinski et al., 2002; Orwig et al., 2002; Foster and Orwig, 2006).

Impacts include negative effects on brook trout (reversal of cooler summer and warmer winter stream temperatures), carbon cycling (Nuckolls et al., 2009), soil, and water chemistry (Yorks et al., 2003). Loss of foliage and tree mortality in hemlock-dominated stands often results in the invasion of exotic and native species which provide less shade and cover during the summer and winter seasons, affecting temperature, and moisture microhabitats. In the Southern Appalachian area, hemlock has an ecohydrological function that no other forest tree can fill (Ford and Vose, 2007).

Reduction in the number and variety of species after tree mortality due to HWA has been reported extensively (Yamasaki et al., 2000; Brooks, 2001; Evans, 2002; Snyder et al., 2002; Tingley et al., 2002; Ross et al., 2003; Ross et al., 2004; Buck et al., 2005; Ellison et al., 2005; Lishawa et al., 2007). Hemlock mortality is also changing ecosystem processes, structure, and function (Jenkins et al. 1999, Stadler et al., 2005; Cobb et al., 2006; Stadler et al., 2006), and water quality (Yorks et al., 2003).

2. Impact from the Use of Other Control Methods

Current levels of the current control methods would continue if the "no action" alternative is chosen, and may continue even if permits are issued for environmental release of *S. coniferarum.*

a. Chemical Control

Control of HWA with available chemical insecticides is expensive, has environmental restrictions, and is not long lasting. The no action alternative will likely increase reliance on chemical methods to control HWA.

b. Restriction of interstate movement of nursery stock

Restrictions to interstate commerce are likely to remain in place until HWA becomes widely established in eastern states. No action may shorten the time for uninfested states to become infested.

c. Development of resistant hemlocks

The susceptible Carolina hemlock has been cross-pollinated with the very resistant Chinese hemlock to produce a hybrid cross with high resistance to HWA (Montgomery et al., 2009). Clones of these are in field trials and a new, resistant hemlock cultivar would not be available to the nursery industry for several years. Collections of hemlock seed are being made from several geographical areas in order to conserve the genetic resources of the eastern hemlocks until a permanent solution is found to reduce hemlock mortality caused by HWA (Jetton et al., 2008; Potter et al., 2008).

d. Bioinsecticides

Bioinsecticides for control of HWA are expensive and not long lasting. In addition, these are still experimental so efficacy has not been established. Biopesticides must be as effective as conventional pesticides if they are to be successful but can decrease the potential for adverse chemical insecticide impact.

e. Biological Control

The biological control agents released show promise to reduce populations of HWA, but more time is needed to find if they will be successful in providing the level of control desired. However, the addition of *S. coniferarum* that is expected to complement *L. nigrinus* would not occur and would reduce the potential for successful biological control of HWA.

These environmental consequences may occur even with the implementation of the biological control alternative, depending on the efficacy of *S. coniferarum* to reduce HWA infestations in the eastern United States.

B. Issue Permits for Environmental Release of *S. coniferarum*

1. Impact of *S. coniferarum* on Non-target Insects

a. Host specificity testing

Scymnus coniferarum did not feed on any prey offered in the laboratory other than adelgids (Appendix B). Non-preferred prey included woolly alder aphid (*Paraprociphilus tessellates*), linden aphid (*Eucallipterus tiliae*), *Taxus* mealybug (*Dysmicoccus wistariae*), and elongate hemlock scale (*Fiorina externa*) (Montgomery and McDonald, 2010).

Laboratory choice tests did not find any consistent preferences between pine adelgids (European pine adelgid, *Pineus pini* and pine bark adelgid, *Pineus strobi*) and HWA as prey. Although the beetle laid eggs on the pine bark adelgid that feeds on eastern white pine, only 16 percent of the eggs survived to the adult stage (Appendix B).

Laboratory feeding tests indicate that *S. coniferarum* is a voracious predator of HWA. Adult *S. coniferarum*, given 10 eggs, 10 nymphs and 2 adult HWA, consumed an average of 8.9 eggs, 3.4 nymphs, and 1.0 adult in 24-hours. By contrast, an adult consumed an average of only two larch adelgid eggs in 24 hours. Late instar larvae consumed all of the 25 HWA eggs they were provided within 24 hours (Schwartzberg et al., 2009.)

b. Field observations

Field observations in its area of origin indicate that *S. coniferarum* feeds on both pine and hemlock adelgids and does not use other homopterans or arthropods associated with hemlock or other woody plants as alternative food. Even though the adult stage of *S. coniferarum* was collected from western white pine infested with *Pineus pinifolia*, only one larva was collected from this host. It seems that adelgids on white pine are supplemental rather than primary hosts.

2. Uncertainties Regarding the Environmental Release of *S. coniferarum.*

a. Success in establishment in eastern United States

The climate in the Seattle area differs from the release areas of the Southern Appalachian region, primarily in having a more temperate environment and in the seasonal pattern of rainfall. That *L. nigrinus* collected from the Seattle area has been successfully established in several states in the Southern Appalachian region and is a strong indication that climatic differences should not be a barrier to the establishment of *S. coniferarum*. A model that predicts the effects of climate on species, CLIMEX, indicates that *S. coniferarum* has a high probability of establishing in much of the eastern United States.

b. Extent that native adelgids will be attacked

Establishment of *S. coniferarum* in the eastern United States would result in possible contact with only one adelgid species, *Pineus floccus*, that is not present in the western United States (Appendix A). This species has at least one generation on spruce (DeBoo and Weidhaas, 1967; Walton, 1980). *S. coniferarum* has not been found on spruce. Other adelgid species may be attacked to a limited extent, because *S. coniferarum* feeds on other adelgid species in the western United States that are also present in the eastern United States. Western conifers from which *S. coniferarum* has been collected include ponderosa and lodgepole pine. These conifers are host to *Pineus coloradensis*, which has been reported as a pest of white pine and red pine in Eastern States (Doane, 1961), but this adelgid has not been reported in many years. In a laboratory test *S. coniferarum* readily ate the eggs of what is presumed to be this species (Appendix B). Although there are many uncertainties concerning the adelgids that *S. coniferarum* may prey upon, the relationships it is expected to have with the adelgids in the eastern United States is expected to be similar to the relationships it has with these same adelgids in the western United States.

c. Success in reducing HWA populations

Only 12 percent of the introductions of biological control agents against pests have led to “complete” control of the target pests (Greathead and Greathead, 1992). Actual impacts on HWA populations by *S. coniferarum* will not be known until after release occurs and post-release monitoring has been conducted.

d. Competition or interference with established adelgid predators

The previously introduced *L. nigrinus* seems to be the biological control agent that is present in greatest number and most widely distributed (Mausel et al., 2010). Based on the co-existence of *L. nigrinus* and *S. coniferarum* in the western United States and differences in their life history, they are expected to coexist and have additive impact on HWA in the eastern United States. Likewise, *L. osakensis*, which has been approved for environmental release, and *S. coniferarum* should have a complementary effect on HWA, based on their life histories.

The lady beetle from Japan, *Sasajiscymnus tsugae*, has been widely released in the eastern United States, but its numbers remain low. It preys on other adelgids (Jetton et al., 2011) and has been recovered in Japan from marshes and on pines far from hemlock (Sasaji and McClure, 1997;

Shiyake et al., 2008). This species has a life history similar to *S. coniferarum*; thus, these two lady beetles could compete for resources.

The most direct interaction may be with a lady beetle in the same subgenus that was accidently introduced from Europe, *Scymnus* (*Pullus*) *suturalis*. *Scymnus suturalis* also feeds on both pine and hemlock adelgids, although it is seldom recovered from hemlock.

There have been no adverse interactions reported for adeligid predators. Flowers et al. (2007) studied the interactions between three predators of HWA (*L. nigrinus, S. tsugae,* and *Harmonia axyridis,* a generalist lady beetle predator) and found that they had little impact on each other and recommended multiple-predator releases for HWA.

3. Cumulative Impacts

"Cumulative impacts" is defined as the impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions regardless of what agencies or person undertakes such other actions" (40 CFR 1508.7).

Many states and counties, as well as federal, state, local, and private property ownerships conduct their own programs to manage HWA along with other invasive forest pests. Chemical, bioinsecticidal, and biological controls, along with resistant hemlock development and restrictions on movement of nursery stock as described previously in this document are used in a wide range of habitats.

Release of *S. coniferarum* is not expected to have any negative cumulative impacts in the continental United States because of its specificity to adelgids. If effective, biological control of HWA would have beneficial effects for forest and ornamental pest management programs, and may result in a long-term, non-damaging method to assist in maintaining native hemlock trees and hemlock stands in good health.

4. Endangered Species Act

Section 7 of the Endangered Species Act (ESA) and ESA's implementing regulations require Federal agencies to ensure that their actions are not likely to jeopardize the continued existence of federally listed threatened and endangered species, or result in the destruction or adverse modification of critical habitat.

APHIS has determined that based on the host specificity of *S. coniferarum* and because there are no listed species related to HWA or dependent on HWA, there will be no effect on any listed species or designated critical habitat in the continental United States. No federally listed threatened or endangered insects belong to the insect family Adelgidae (USFWS, 2012). No federally listed species are known to depend on or use HWA.

V. Other Issues

Consistent with Executive Order (EO) 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations," APHIS considered the potential for disproportionately high and adverse human health or environmental effects on any minority populations and low-income populations. There are no adverse environmental or human health effects from the field release of *S. coniferarum* and it will not have disproportionate adverse effects to any minority or low-income populations.

Consistent with EO 13045, "Protection of Children From Environmental Health Risks and Safety Risks," APHIS considered the potential for disproportionately high and adverse environmental health and safety risks to children. No circumstances that would trigger the need for special environmental reviews are involved in implementing the preferred alternative. Therefore, it is expected that no disproportionate effects on children are anticipated as a consequence of the field release of *S. coniferarum* in the eastern United States.

EO 13175, "Consultation and Coordination with Indian Tribal Governments", was issued to ensure that there would be "meaningful consultation and collaboration with tribal officials in the development of Federal policies that have tribal implications..". Consistent with EO 13175, APHIS sent letters of notification and requests for comment and consultation on the proposed action to tribes in Alabama, Connecticut, Florida, Indiana, Maine, Massachusetts, Michigan, Minnesota, Mississippi, New York, North Carolina, Rhode Island, South Carolina, and Wisconsin. APHIS will continue to consult and collaborate with Indian tribal officials to ensure that they are well-informed and represented in policy and program decisions that may impact their agricultural interests, in accordance with EO 13175.

VI. Agencies, Organizations, and Individuals Consulted

This EA was prepared by personnel from the Forest Service, Virginia Tech, and University of Georgia, and reviewed by APHIS. The addresses of participating APHIS units, cooperators, and consultants (as applicable) follow.

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Appendix A. List of adelgid species in North America (NA); hosts column gives genus of the primary and secondary host—"None" means it is anholocyclic and "?" = believed to be holocyclic but host not identified; the right column gives current North American distribution.

Species	**Taxon Validity**	**Hosts (1°, 2°)**	**Native Range**	**Occurrence in North America**
Adelges abietis (Linneaus 1758)		*Picea*, None	Europe	Continental
Adelges aenigmaticus Annand 1928	?[1]	*?, Larix*	Eastern NA	No records after 1928
Adelges cooleyi (Gillette 1907)		None, *Pseudotsuga*	Western NA	Continental
Adelges coweni (Gillette 1907)	?[2]	None, *Pseudotsuga*	Western NA	Only in Europe?
Adelges diversis Annand 1928	?[1]	?, *Larix*	Western NA	No records after 1928
Adelges lariciatus (Patch 1909)	?[1]	*Picea, Larix*	North America	Western
Adelges laricis (Vallot 1836)		None, *Larix*	Europe, NA?	Continental
Adelges nordmannianae (Eckstein 1890)	?[3]	None, *Abies*	Caucasus Mtns.	Continental
Adelges oregonensis Annand 1928	?[1]	*?, Larix*	Western NA	No records after 1928
Adelges piceae (Ratzeburg 1844)		*Picea, Abies*	Europe	Continental
Adelges tsugae Annand 1924		*Picea, Tsuga*	Asia,Western NA	Continental
Pineus abietinus Underwood & Balch 1964		None, *Abies*	Western NA	No records after 1964
Pineus boerneri Annand 1928	?[4]	None, *Pinus*	Western NA?	Continental
Pineus boycei Annand 1928		*Picea*, ?	Western NA	Western
Pineus cembrae (Cholodkovsky 1888)		*Picea, Pinus*	Eurasia	Eastern
Pineus coloradensis (Gillette 1907)		None, *Pinus*	North America	Continental
Pineus engelmannii Annand 1928	?[5]	*Picea*, ?	Western NA	Western
Pineus floccus (Patch 1909)	?	*Picea, Pinus*	Eastern NA	Eastern
Pineus patchae Börner 1926	?[6]	*Picea, ?*	North America	Status unclear
Pineus pineoides (Cholodkovsky 1903)		*Picea*, None	Europe	Eastern
Pineus pini (Macquart 1819)		None, *Pinus*	Europe	Continental
Pineus pinifoliae (Fitch 1853)		*Picea, Pinus*	North America	Continental
Pineus similis (Gillette 1907)		*Picea*, None	North America	Continental
Pineus strobi (Hartig, 1937)		None, *Pinus*	Eastern NA	Continental
Pineus sylvestris Annand 1928	?[4]	?, *Pinus*	Western NA	No records after 1928

Sources: Annand, 1928; Boerner and Heinze, 1957; Blackman and Eastop, 1994; Havill and Foottit, 2007)

[1]variants of *A. laricis* (Blackman and Eastop, 1994); *A. lariciatus* and *A. laricis* DNA different (Havill et al., 2007)

[2]*A. cooleyi* (Blackman and Eastop, 1994)

[3] *A. piceae* based on DNA barcodes (Havill et al., 2007; Zurovcova et al., 2010)
[4] these species are closely related to *P. pini*, if not the same species (Blackman and Eastop, 1994)
[5] sexupara of *P. boycei* (Boerner and Heinze, 1957; Blackman and Eastop, 1994)
[6] *P. similis* (Blackman and Eastop, 1994)

Appendix B. Host range evaluation of *Scymnus (Pullus) coniferarum* (Montgomery and McDonald, 2010)

Field observations.

The only hosts of *S. coniferarum* reported in the literature are adelgids that feed on pine (*Pineus* spp.) (Whitehead, 1967), but while collecting *L. nigrinus* from western hemlock, it has been found to be common on hemlock. From samples of trees in landscapes in the Seattle, Washington area, it was also found to be abundant on hemlocks infested with HWA and on western white pine infested with adelgids and aphids (Montgomery et al., 2009; McDonald, 2010). From October 9-19, 2004, 1,003 *S. coniferarum* and 1,417 *L. nigrinus* adults were collected from western hemlock (McDonald, pers. obs.). *S. coniferarum* was also recovered in low numbers on eastern hemlock, Carolina hemlock, and lodgepole pine growing in arboreta in the Seattle Washington area. The hemlocks were infested with HWA, the white pine with *Pineus pinifolia,* and the lodgepole pine with another *Pineus* adelgid that may be *P. coloradensis*.

It was not found on 13 species of spruce, including the following which had live adelgid galls: *Picea glehnii, P. koyamai, P. alcoquiana*, and *P. sitchensis*. *S. coniferarum* also was not recovered from Douglas-fir infested with *Adelges cooleyi* and larch infested with *Adelges laricis*. It has not been found on broad-leaved trees, shrubs, or forbs infested with aphids, mealybugs or scale insects.

Prey acceptance tests.

Several species in the insect suborder Homoptera that occur in the eastern United States were evaluated in quarantine. First no-choice tests were conducted in which a single potential prey species on its host is placed in a small covered-dish with an adult *S. coniferarum* lady beetle. The beetle's previous food was HWA, but they were starved for 24-hours prior to the test. The number of prey on the host in each dish was counted at the start of the test and recounted the next day after confinement with an adult beetle. Each test had 10 replicates and was accompanied by control dishes with an HWA adult and 10-15 eggs in the ovisac (most eggs were removed so that an accurate before and after count could be made and the adult feeding was disrupted so it stopped laying eggs).

When confined with potential prey, *S. coniferarum* fed on all of the adelgid species tested and none of the other homopteran species (Table 1). Other *Scymnus* lady beetles that are considered adelgid specialists also feed on aphids, including *P. tesselatus* (Montgomery et al., 1997; Butin et al., 2004).

Appendix B, Table 1. Feeding by adult *S. coniferarum* when confined for one day on a potential prey species that occur in the eastern United States.

Prey Species	Stage Tested	Host plant	No. eaten	Remarks
Adelgidae				
Adelges tsugae	Adult/egg	*Tsuga canadensis*	1.0 adults 18.0 eggs	Fed 3 adults and 25 eggs
"	Nymph II	"	9.9	Fed 10 nymphs
"	Neosistens	"	0.6	Diapausing, not significantly. different from zero
Adelges piceae	Adult, eggs	*Abies balsamea*	0.4 adults 4.3 eggs	Adelgid on bark
Pineus strobi	Adult, eggs	*Pinus strobus*	1.4 adults 2.4 eggs	Adelgid on twig
Pineus pini	Adult, eggs	*Pinus sylvestris*	0.6 adults 1.2 eggs	Adelgid at tip of twig
Aphididae				
Eucallipterus tiliae	Adults, nymphs	*Tilia cordata*	0.0	on underside of leaf
Paraprocipilulus tesselatus[1]	Nymph I	*Alnus serrulata*	0.0	Small colonies of the first instar nymph settled on twig.
Diaspididae				
Fiorinia externa	Adult	*T. canadensis*	0.0	Crawlers not tested
Pseudococcidae				
Dysmicoccus wistariae	Nymphs	*Taxus*	0.0	

[1] Additional testing with this species, the woolly alder aphid, found no feeding after 10 days of confinement. Of the 15 beetles confined with the aphid, 2 died, but none of the control *S. coniferarum* lady beetles reared on HWA died.

Choice tests were conducted by confining adult *S. coniferarum* with a choice of HWA on eastern hemlock or a pine adelgid (*Pineus* sp.) on its pine host. The adelgids on pine are smaller, about three-fourths the size of HWA. There was no consistent preference for HWA compared to pine adelgids (Table 2).

Appendix 2, Table 2. Number of adelgids eaten when provided a choice between a pine adelgid and hemlock adelgid on their respective hosts.

***Pineus* species**	**Source[1]**	***Pineus***	**HWA**	**Prefer**	**Variable measured**
Pineus strobi	East	49	39	ns	# eggs eaten
"		24	9	*Pineus* sp.	# adults eaten
Pineus pini	East	28	60	HWA	# eggs eaten
Pineus coloradensis[2]	West	125	47	*Pineus* sp.	# eggs eaten

[1]Collected in Washington State (West) or Connecticut (East)
[2]Tentative identification

Host preference for oviposition (egg laying) was examined by placing 10 recently received *S. coniferarum* in a one-gallon oviposition jar with a choice of HWA on eastern hemlock or *Pineus strobi* on eastern white pine (n = 5 jars). After five-days, the white pine foliage had an average of 14 beetle eggs whereas the hemlock foliage had an average of 58 eggs. This preference for hemlock to oviposit corresponds to the finding of more larvae on western hemlock than on western white pine in the Seattle area.

Host suitability tests with the pine bark adelgid

The pine bark adelgid, *Pineus strobi* Hartig, is native to eastern North America but occurs worldwide wherever species of white pine occur. It colonizes and feeds on both the tip of twigs and on the bark of eastern white pine, *Pinus strobus*. This pine often co-occurs with eastern hemlock in forests; thus, tests were conducted to determine if *S. coniferarum* could develop successfully on *P. strobi*. For this assay, *S. coniferarum* adult females were individually confined with adults and eggs of *P. strobi* on white pine bark or HWA in Petri dishes at 15^{o}C. On each host, *S. coniferarum* oviposited about 0.1 eggs per female per day. From these eggs, 19 *S. coniferarum* larvae, less than 24-hours old, were confined with *P. strobi* adults and eggs on white pine bark. Only 16 percent of the larvae successfully developed to the adult stage. While these data indicate that *S. coniferarum* will oviposit and can develop on pine bark adelgid, the low fecundity and survival is not indicative of a host that would be successfully utilized in nature.

Decision and Finding of No Significant Impact
for
Release of the Predatory Beetle *Scymnus coniferarum* (Coleoptera: Coccinellidae), for Biological Control of the Hemlock Woolly Adelgid (*Adelges tsugae*) in the Eastern United States

September 2012

The U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) Pest Permitting Branch (PPB), is proposing to issue permits for the interstate movement and release of an insect, *Scymnus coniferarum* (Coleoptera: Coccinellidae), into the eastern United States. This species is native to the western United States and would be used by the applicant for the biological control of hemlock woolly adelgid, *Adelges tsugae* (Homoptera: Adelgidae). Before permits are issued for interstate movement and release of *S. coniferarum*, APHIS must analyze the potential impacts of the release of this organism into the eastern United States in accordance with USDA APHIS National Environmental Policy Act implementing regulations (7 Code of Federal Regulations Part 372). APHIS has prepared an environmental assessment (EA) that analyzes the potential environmental consequences of this action. The EA is available from:

U.S. Department of Agriculture
Animal and Plant Health inspection Service
Plant Protection and Quarantine
Registrations, Identification, Permits, and Plant Safeguarding
4700 River Road, Unit 133
Riverdale, MD 20737
http://www.aphis.usda.gov/plant_health/ea/index.shtml

The EA analyzed the following two alternatives in response to a request for permits authorizing interstate movement and environmental release of *S. coniferarum*: (1) no action, and (2) issue permits for the interstate movement and release of *S. coniferarum* for biological control of hemlock woolly adelgid in the eastern United States. A third alternative, to issue permits with special provisions or requirements concerning release procedures or mitigating measures, was considered. However, this alternative was dismissed because no issues were raised that indicated that special provisions or requirements were necessary. The No Action alternative, as described in the EA, would likely result in the continued use at the current level of chemical, host plant resistance, bioinsecticide, and biological control methods of hemlock woolly adelgid as well as restriction of interstate movement of nursery stock. These control methods described are not alternatives for decisions to be made by the PPB, but are presently being used to control hemlock woolly adelgid in the United States and may continue regardless of permit issuance for interstate movement and field release of *S. coniferarum.* Legal notice of the EA was made available in the Federal Register on August 3, 2012 for a 30-day public comment period. Nine comments were received on the EA; eight in favor of the release of *S. coniferarum* and one in opposition. No substantive information was presented in the negative comment.

I have decided to authorize the PPB to issue permits for the interstate movement and environmental release of *S. coniferarum* into the eastern United States. The reasons for my decision are:

- This biological control agent is sufficiently host specific and poses little, if any, threat to the biological resources, including non-target insect species of the eastern United States.
- The release will have no effect on federally listed threatened and endangered species or their habitats in the eastern United States.
- *S. coniferarum* poses no threat to the health of humans.
- No negative cumulative impacts are expected from release of *S. coniferarum.*
- There are no disproportionate adverse effects to minorities, low-income populations, or children in accordance with Executive Order 12898 "Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations" and Executive Order 13045, "Protection of Children from Environmental Health Risks and Safety Risks."
- While there is not total assurance that the release of *S. coniferarum* into the environment of the eastern United States will be reversible, there is no evidence that this organism will cause any adverse environmental effects.

I have determined that there would be no significant impact to the human environment from the implementation of the preferred alternative (issuance of permits for the interstate movement and release of *S. coniferarum* into the eastern United States) and, therefore, no Environmental Impact Statement needs to be prepared.

Jeff Grode (signature) Date 9/6/12

Jeff Grode
Associate Executive Director
Plant Health Programs
Plant Protection and Quarantine
Animal and Plant Health Inspection Service
U.S. Department of Agriculture