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Field release of *Diaparsis jucunda* (Hymenoptera: Ichneumonidae), *Lemophagus errabundus* (Hymenoptera: Ichneumonidae), and *Tetrastichus setifer* (Hymenoptera: Eulophidae) for biological control of the lily leaf beetle, *Lilioceris lilii* (Coleoptera: Chrysomelidae) in the Contiguous United States.

Environmental Assessment, August 2017

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I. Purpose and Need for the Proposed Action

The Washington State Department of Agriculture (WSDA) is proposing to release three insect parasitoid species for the biological control of the nonindigenous lily leaf beetle (LLB), *Lilioceris lilii*. 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 these agents to control infestations of the LLB within Washington State. This EA considers the potential effects of the proposed action and its alternatives, including no action. Notice of this EA was made available in the Federal Register on July 13, 2017 for a 30-day public comment period. One comment was received on the EA by the close of the comment period. The commenter was against the release of the agents, but did not raise any substantive issues.

LLB is an invasive defoliating beetle (Coleoptera: Chrysomelidae) native to Eurasia (Orlova-Bienkowskaja, 2012) that is an aggressive pest of lilies (*Lilium* spp.) and fritillaries (*Fritillaria* spp.) as larvae and adults. It was introduced to Montreal, Canada, in 1943, and later in Connecticut (LeSage, 1983; Dieni et al., 2106), and has since spread into 11 states and nine provinces (LeSage and Elliott, 2003; Majika and LeSage, 2008; Majika and Kirby, 2011; Maier, 2012; Hicks and Sellars, 2014; Murray et al., 2016; Cappuccino, 2017). In New England the beetle has been a serious pest of garden and landscape lilies, in many cases causing so much feeding damage that lilies become unusable landscape plants (LaSage, 1992). LLB has also been documented from native lily species (Ernst et al., 2007; Bouchard et al., 2008; Blackman et al., 2016; Murray et al., 2016), and it will probably feed on every lily and fritillary in North America. LLB's native range encompasses nearly all of Europe and parts of North Africa, and it will likely establish in much of the United States. Without controls the beetle will continue to have economic impacts on the landscape and nursery industry, and is poised to further threaten the many lily and fritillary species of conservation concern in North America.

WSDA proposes to release three parasitoids into the environment of Washington State for the purpose of reducing LLB populations. The biological control agents are known to attack LLB consistently in its European range and in the northeastern United States, where they have already been released. The agents comprise *Diaparsis jucunda* (Hymenoptera: Ichneumonidae),

[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.

Lemophagus errabundus (Hymenoptera: Ichneumonidae), and *Tetrastichus setifer* (Hymenoptera: Eulophidae) (hereafter "these agents"). All are parasitoids of the larval stage of LLB. A parasitoid is an insect whose larvae (immature stage) live as parasites that eventually kill their hosts. Initial releases of parasitoids are planned for the summer of 2017. Post-release monitoring, including impacts on LLB and the spread and establishment of the parasitoids will be conducted.

The applicant's purpose for releasing these agents is to reduce the severity of infestations of the invasive LLB in Washington State. A native of Eurasia, LLB has recently emerged as an aggressive pest of lilies (*Lilium* spp.) and fritillaries (*Fritillaria* spp.) in the United States and Canada. The pest has expanded its range rapidly over the past decade, and is now found in several northeastern and central states, across Canada, and in Washington State (LeSage and Elliott, 2003; Majika and LeSage, 2008; Majika and Kirby, 2011; Maier, 2012; Hicks and Sellars, 2014; Cappuccino, 2016; Murray et al., 2016). The beetle is a ready flier and is easily transported in potted lilies. Both adults and larvae are voracious feeders and completely defoliate plants repeatedly, eventually leading to plant death. The species has major impacts on home gardens and commercial landscapes, and in areas with heavy infestations lilies and fritillaries are frequently abandoned or replaced with other plants due to the difficulty of control. The beetle also feeds on native species, including several of federal, state, or provincial conservation concern (Bouchard et al., 2008; Blackman et al., 2016). As the beetle spreads unchecked it will likely threaten these rare species, such as the federally listed endangered *Lilium occidentale* that occurs in California and Oregon.

Prior to recent classical biological control efforts in New England there has been no evidence of effective native or naturalized natural enemies of LLB in North America (Livingston, 1996; Tewksbury, 2014). Existing management options for LLB are time-consuming, expensive, temporary, and have non-target impacts. For these reasons, the applicant has a need for environmental release of demonstrably host-specific and effective biological control agents. In New England and eastern Canada, where the agents have been established for several years, parasitism rates of LLB by these agents frequently reaches 70-100 percent - establishing a long-term, environmentally responsible control of this threat to native species and specialty crops.

APHIS has responsibility for taking actions to exclude, eradicate, and/or control plant pests under the Plant Protection Act (7 United States Code (U.S.C.) 7701 *et seq.*). APHIS has been delegated the authority to administer these statutes and has promulgated quarantines and regulations (7 CFR 319) which regulate the importation of commodities and means of conveyance to help protect against the introduction and spread of harmful pests. The underlying strategy of the proposed program is to reduce LLB population densities in infested areas and slow its spread into new areas.

II. Alternatives

APHIS considered two alternatives in response to the need to control LLB and contain infestations: (1) no action and (2) biological control by the release of the three parasitoids, *D. jucunda, L. errabundus,* and *T. setifer* (the preferred action). Both alternatives are described briefly in this section and the potential impacts of each are considered in the following section. Although APHIS's alternatives are limited to a decision on whether to issue permits for release of these agents, other methods available for control of LLB are also described. These control methods are not decisions to be made by APHIS, and their use may continue whether or not permits are issued, depending on the efficacy of these agents to control LLB. These methods are presently being used to control LLB by public and private concerns.

A third alternative was considered, but will not be analyzed further. Under this third alternative, APHIS would have issued permits for the field release of these agents; however, the permits would contain special provisions or requirements concerning release procedures or mitigating measures. No issues have been raised that would indicate special provisions or requirements are necessary.

A. No Action

Under the no action alternative, APHIS would not issue permits for the field release of these agents for the control of LLB in Washington State, and the release of these agents would not occur in the western United States. The following methods are presently being used to control LLB; these methods will continue under the "No Action" alternative.

1. Mechanical and Cultural Control

Mechanical control of LLB is achieved by detecting and hand-removing beetle larvae, which are subsequently destroyed. Adult beetles may also be hand removed or knocked from plants, and destroyed. Other approaches include replacing susceptible lilies with varieties better able to tolerate beetle feeding or removing lilies entirely from planting beds. The latter has been one the most common responses to LLB outbreaks in North America (LeSage, 1992).

2. Chemical Control

Several broad-spectrum pesticides (e.g., carbaryl, malathion, imidacloprid) can provide control of LLB (Livingston, 1996; Stack, 2009; Sweir, no date). Most of these chemicals are highly toxic to pollinators and other non-target invertebrates. Alternative chemical control mechanisms include the application of neem oil and spinosad, both of which must be reapplied frequently during the early larval instars. Chemical control is likely to be used by commercial applicators and growers as well as untrained gardeners; the latter presents potential health risks to users and their families through improper application and storage.

3. Biological Control

No natural enemies of LLB have been discovered in North America. Surveys in Europe found several parasitoids of LLB, three of which are highly species or genus specific. These three are: (1) *Diaparsis jucunda*, (2) *Lemophagus errabundus*, and (3) *Tetrastichus setifer*. All three species are established in New England, and are providing effective control. With time they may disperse to Washington State, although this would require more or less contiguous distribution of LLB. Since LLB has a patchy distribution in the west probably due to spread through commerce, natural dispersal of the parasitoids could be exceedingly slow and is not guaranteed.

B. Issue Permits for Environmental Release of these agents (Preferred Alternative).

Under this alternative, APHIS would issue permits for the field release of these agents for the control of LLB. These permits would contain no special provisions or requirements concerning release procedures or mitigating measures.

1. Biological Control Agent Taxonomic Information

a. Taxonomy

Diaparsis jucunda (Holmgren, 1860) (Hymenoptera: Ichneumonidae). No common name.

Lemophagus errabundus (Gravenhorst, 1829) (Hymenoptera: Ichneumonidae). No common name.

Tetrastichus setifer Thompson, 1878 (Hymenoptera: Eulophidae). No common name.

b. Location of voucher specimens

Voucher specimens of *D. jucunda* are deposited in the USDA/Agricultural Research Service (ARS) Systematic Entomology Laboratory, Washington, D.C., and at the Insect Biological Control Laboratory at the University of Rhode Island. Specimens of *D. jucunda* originally collected in Europe during surveys and experiments to identify acceptable LLB biocontrol agents were identified by Klaus Horstmann (Gold et al., 2001; Kenis et al., 2002), who had previously described the morphology (Horstmann, 1971).

Specimens of *L. errabundus* are deposited in the USDA/ARS Systematic

Entomology Laboratory, Washington, D.C., and at the Insect Biological Control Laboratory at the University of Rhode Island. Specimens of *L. errabundus* originally collected in Europe during surveys and experiments to identify acceptable LLB biocontrol agents were identified by Klaus Horstmann (Gold et al., 2001; Kenis et al., 2002).

Voucher specimens of *T. setifer* are deposited in the USDA/ARS Systematic Entomology Laboratory, Washington, D.C., and at the Insect Biological Control Laboratory at the University of Rhode Island. Specimens of *T. setifer* originally collected in Europe during surveys and experiments to identify acceptable LLB biocontrol agents were identified by John LaSalle (Gold et al., 2001; Kenis et al., 2002).

c. Natural geographic range, other areas of introduction, and expected attainable range in North America

The natural range of *D. jucunda* includes Sweden, Finland, Denmark, Germany, and the Czech Republic (Horstmann, 1971). The species was found by Haye and Kenis (2004) at most European survey sites. *Diaparsis jucunda* attacks all larval stages and is the dominant parasitoid of *L. lilii* in central and southern Europe, with total parasitism in the last instar averaging about 60 percent in lily fields, 74 percent in gardens, and 90 percent on the wild *Lilium martagon* (Kenis et al., 2002; Scarborough, 2002; Haye and Kenis, 2004). These areas fall into USDA Plant Hardiness Zones 5 and 6 (average minimum winter temperature -29˚C to -23˚ C to -23˚ C to -18˚ C). Based upon the European distributions, it appears *D. jucunda* will perform better in the inland and more northern sites of the Pacific Northwest. Its North American distribution should be constrained primarily to areas where LLB occurs because it is specific to larval hosts in the genus *Lilioceris* (Haye and Kenis, 2004; Casagrande and Kenis, 2004), a genus that does not naturally occur in North America (White, 1993).

Lemophagus errabundus is an abundant parasitoid of *Lilioceris* spp. in northern Germany, Scandinavia, the Netherlands, Belgium, and western France, with parasitism rates reaching over 70 percent in late instars (Kenis et al., 2002; Salisbury, 2003; Haye and Kenis, 2004; Rämert et al., 2009). These areas have ocean-moderated temperatures and fall within USDA Plant Hardiness Zones 7 and 8 (average minimum winter temperature -18˚ C to –12˚ C and -12˚ C to -7˚ C). Great Britain and the Netherlands also have maritime climates, and *T. setifer* and *L. errabundus* are the predominant parasitoids (Kenis et al., 2002; Salisbury, 2003). Based upon the European distributions, it appears that *L. errabundus* is suited for maritime-influenced parts of the Pacific Northwest, generally west of the Cascade mountain range (USDA Plant Hardiness Zones 6 and 7). Its North American distribution will be limited to areas where LLB occurs since it is specific to larval hosts in the genus *Lilioceris* (Haye and Kenis, 2004), a genus that does not naturally occur in North America (White, 1993).

Tetrastichus setifer is found throughout much of Europe in many disparate climatic conditions, ranging from high altitude mountainous regions to warmer maritime habitats (Tewksbury, 2014). The species was present in all regions investigated, was most abundant in Germany and Sweden (Salisbury, 2003; Haye and Kenis, 2004; Kroon, 2009), and in concert with *L. errabundus*, was responsible for most parasitism in Sweden (Rämert et al., 2009). Based on *T. setifer*'s wide European distribution, it should be able to successfully establish throughout much of North America. Its North American distribution will be limited to areas where LLB occurs because it is specific to larval hosts in the genus *Lilioceris* (Haye and Kenis, 2004), a genus that does not naturally occur in North America (White, 1993).

d. Source of the culture/agent in nature (name of collector, name of identifier)

The agents were originally collected in Europe for testing and subsequent release in New England by ARS and APHIS scientists, in collaboration with the University of Rhode Island and the Centre for Agriculture and Bioscience International. Agents that will be permitted for release in Washington State will be collected in the wild from established populations in New England by the University of Rhode Island, Biological Control Laboratory.

e. Life history (including dispersal capability and damage inflicted on LLB)

Diaparsis jucunda is a univoltine species whose adults are active from May-July. This wasp can produce more than 360 eggs, usually laying a single egg per host, and attacks all four larval instars of LLB (Haye and Kenis, 2004). Wasp larvae kill the host after it has entered the soil to pupate. Mature larvae overwinter for at least five months in the host cocoon (Cappuccino et al., 2013). Field parasitism rates subsequent to releases in Rhode Island and Massachusetts ranged between 4–100 percent, and were 34.5 percent on average (Tewksbury, 2014). The greatest recorded dispersal distance was approximately 20 kilometers (km) from release sites after four years (Tewksbury 2014).

Lemophagus errabundus is a univoltine species whose adults are active from mid-May-June. This solitary wasp attacks the second through fourth instar of LLB larvae. Wasp larvae kill the host after it has entered the soil to pupate. Adults overwinter in the host cocoon (Casagrande and Kenis, 2004). Field parasitism rates subsequent to releases in Rhode Island and Massachusetts ranged from 4–94 percent, and were 38.7 percent on average (Tewksbury, 2014). The greatest recorded dispersal distance was approximately 12 km from release sites after nine years (Tewksbury, 2014).

Tetrastichus setifer is also a univoltine species active as adults for several weeks in the spring. This gregarious wasp lays multiple eggs in beetle larvae and attacks all four larval instars. Wasp larvae kill the host after it has entered the soil to pupate. Mature larvae overwinter for at least 5 months in the host cocoon (Cappuccino et al., 2013). Parasitism rates subsequent to releases in Rhode Island, Massachusetts, and Connecticut ranged from 4–100 percent, and was 56.2 percent on average (Tewksbury, 2014). The greatest recorded dispersal distance was approximately 19 km from release sites after 13 years (Tewksbury, 2014).

f. History of past use of these agents

Diaparsis jucunda was released in Rhode Island, New Hampshire, and Maine between 2003 and 2007 and has successfully established (Tewksbury, 2014). *Lemophagus errabundus* was released in Rhode Island and Maine between 2003 and 2007 and has successfully established (Tewksbury, 2014). *Tetrastichus setifer* was released in Massachusetts, Rhode Island, New Hampshire, and Maine between 1999 and 2006, and has successfully established (Tewksbury, 2014). The latter species was also released in Ontario in 2010 and Connecticut in 2013, and has successfully established in both locations (Cappuccino et al., 2013; Tewksbury, 2014). In New England, where *T. setifier* has been established the longest, LLB populations have dropped notably (Tewksbury, 2014).

g. Pathogens, parasites, hyperparasitoids of these agents and how to eliminate them from the culture of the agents

No pathogens, parasites, or hyperparasitoids have been observed attacking these agents in North America. *Lemophagus errabundus* is attacked by the ichneumonid hyperparasitoid *Mesochorus lilioceriphilus* Schwenke in Europe (Kenis et al., 2002). This species does not occur in North America, although other species of *Mesochorus* do. Biological control agents used for the proposed release will be collected in the wild in the overwintering stage, and monitored for disease and hyperparasitoids. Only healthy agents will be used for releases. If any diseased organisms are discovered, they will be sent to insect pathologists for analysis.

h. Standard Operating Procedures stating how agent will be handled in quarantine.

Specimens of these agents used for release will come from populations already established in the United States. Once a release permit is issued by APHIS, quarantine procedures will no longer be necessary for releases of these agents in other areas of the contiguous United States.

III. Affected Environment

A. North American *Lilioceris* species and Related Taxa

White (1993) revised the subfamily Criocerinae, which comprises the tribes Criocerini and Lemiini, with 4 and 42 species each, respectively (Appendix 1). All species in the tribe Criocerini are introduced to North America. Three of these, *L. lilii*, *Crioceris duodecimpunctata*, and *C. asparagi*, are agricultural pests. The fourth, *L. cheni*, is the only other species of *Lilioceris* in North America and was introduced as a biological control agent for air potato (*Dioscorea bulbifera*) in Florida (Overholt et al., 2016). Only five species in the sister tribe Lemiini are likely to occur in Washington, one of which is the European introduction *Oulema melanopus*, the cereal leaf beetle (Appendix 1; White, 1993), itself a target of a successful classical biological control effort using *Tetrastichus julis* (Harcourt et al., 1977).

B. Lily Resources of North America

The known hosts of LLB include over 80 species or varieties of *Lilium* and *Fritillaria* (Ernst et al., 2007; Bouchard et al., 2008; Salisbury, 2008; Salisbury et al., 2010; Blackman et al., 2016; Murray et al., 2016). The beetle has been recorded feeding on at least 13 other genera in 9 families, although evidence suggests that the beetle can only complete development on *Lilium* and *Fritillaria* (Salisbury, 2008; Salisbury et al., 2010). A possible exception, and new host record, is provided by Blackman et al. (2016) who observed all life stages of LLB on *Streptopus lanceolatus* (an understory perennial plant belonging to the family Liliaceae native to the forests of North America) in Québec. LLB will clearly be an ongoing pest issue for cultivated lilies. Of equal concern is its impact on native lilies and fritillaries, of which there are 48 and 24 native species, subspecies, or varieties, respectively. Many of these are of conservation concern at the state or federal level, with three federally endangered species - all of the latter in the western states. Susceptibility and damage varies by species, but a systematic and comprehensive assessment of host plant suitability has not been conducted across the genera.

Lilies and fritillaries are prized for their blooms, whether the showy and enormous Asiatic hybrids or the subtle, fleeting flowers of fritillaries. The aesthetic value of lilies and fritillaries extends to wild lands, where the flowers are a significant visual feature during their bloom, adorning alpine ridges, swampy bottomlands, and desert shrublands alike (Strumse, 1996; Donovan, 2007; Junge et al., 2009). Wild pollinators utilize wild lilies and fritillaries, exploiting the pollen and nectar resources of their large blooms (e.g., Horning and Webster, 2009).

IV. Environmental Consequences

A. No Action

1. Impact of LLB in North America and the Pacific Northwest

LLB occurs throughout Eurasia, from Siberia to Northern Africa and from England to China (Yu et al., 2001; Haye and Kenis, 2004). Based on the LLB's Eurasian distribution and the wide range already recorded in North America, it will likely spread throughout the northern and central United States wherever host plants grow (Gold, 2003; Kenis et al., 2002). The beetles will certainly spread through the sale and movement of potted plants and associated soil. LLB are also strong fliers, allowing for natural dispersal. There are no federal quarantines in place specifically to control this pest, and any regulations promulgated by state and other jurisdictions have been insufficient to slow its spread.

If no action is taken the LLB will continue to spread throughout Washington State and the Pacific Northwest, as it has in the Eastern states and provinces. In the absence of native predators, parasitoids, or diseases, LLB will certainly impact native lily populations, including species that are already threatened or endangered in parts of their range (e.g., Ernst et al., 2007; Bouchard et al., 2008). Both larvae and adults are voracious feeders that can completely defoliate plants, causing immediate loss of aesthetic value and death after a few seasons.

2. Impact from Use of Other Control Methods

The continued use of physical, chemical, and biological control at current levels would result if the "no action" alternative is chosen, and may continue even if permits are issued for environmental release of these agents.

a. Mechanical and Cultural Control

Mechanical control of LLB by squishing larvae, eggs, and adults can have success in small gardens when pursued by dedicated individuals. However, this technique is unsuited to large-scale production of lily and fritillary bulbs, and is even untenable for most home gardeners. There is also no appreciable likelihood of extensive hand control in natural areas where the pest would impact native plants. Ultimately, mechanical and cultural controls will not be able to control LLB populations.

b. Chemical Control

Malathion, imidacloprid, and carbaryl are all effective against LLB (Livingston, 1996; Stack, 2009; Swier, no date). These chemicals are non-selective, and imidacloprid is currently under investigation as a potential contributor to declining pollinator populations (e.g., Blacquière et al., 2012; Lundin et al., 2015; Woodcock et al., 2016). Alternative chemical control mechanisms include the application of neem oil and spinosad, both of which must be reapplied frequently during the early larval instars and as new eggs hatch (Stack, 2009). Despite the availability of broad-spectrum pesticides and feeding deterrents for LLB control, chemical application alone has not been sufficient to control populations in its introduced range. The beetle has continued to expand its geographic range (e.g., Hicks and Sellars, 2014; Murray et al., 2016) and has invaded wild lily populations (Bouchard et al., 2008; Blackman et al., 2016).

All pesticides are best applied in the spring, early in the beetle's life cycle; this is also when many native pollinators (e.g., bumble bees) are establishing colonies, and are thus especially vulnerable to pesticide application. There is no likelihood of chemical control in natural areas where the pest would impact native plants. Even if chemical control was feasible in natural areas throughout the west, wide use of pesticides could have myriad non-target effects on pollinators and other invertebrates of conservation concern.

c. Biological Control

The fecal shield with which LLB larvae cover themselves appears to act as an effective deterrent to generalist predators and parastioids, while being attractive to the specialists that feed upon this species (Eisner et al., 1976; Schaffner and Müller, 2001). No native predators or parasitoids have been discovered that are able to control LLB. All three parasitoid species that have been previously released against *Lilioceris lilii* (*Tetrastichus setifer*, *Diaparsis jucunda*, and *Lemophagus errabundus*) have been recovered following release in the northeastern states. The parasitoids released in the eastern states and provinces will likely spread naturally, although the patchy distribution of LLB in the northern provinces, and the relatively slow dispersal ensure that natural spread of these agents will likely take many decades**.**

B. Issue Permits for Environmental Release of These Agents (preferred alternative)

1. Environmental and Economic Impacts of the Proposed Release of These Agents

a. Known impacts on vertebrates including humans

These agents are obligate parasitoids of leaf beetle larvae, specifically the genus *Lilioceris*. They will rarely come into contact with humans or other vertebrates. All three wasps are tiny and incapable of stinging or biting. Neither wasp family (Ichneumonidae and Eulophidae) has known adverse impacts on humans or other vertebrates.

b. Direct impact of these agents (e.g., intended effects on LLB, direct effects on non-targets)

Surveys for natural enemies of *Lilioceris lilii*, and the congeners *L. merdigera* and *L. tibialis* have been conducted in Europe by several authors. Beetle adults, larvae and eggs were collected from Germany, the Netherlands, Belgium, Austria, Italy, France and Switzerland in private gardens, non-sprayed commercial fields and on wild populations of *Lilium* spp. Despite more than a thousand collections, no parasitoids have been reared from adult beetles (Haye and Kenis, 2004). *Anaphes* sp. (Hymenoptera: Mymaridae) was reared from *L. lilii* and *L. merdigera* eggs. Larval parasitoids of *L. lilii* included *Diaparsis jucunda*, *Lemophagus pulcher* (Szepligeti), *L. errabundus* (all Hymenoptera: Ichneumonidae), *Tetrastichus setifer* (Hymenoptera: Eulophidae), and *Meigenia* sp. (Diptera: Tachinidae) (Haye and Kenis, 2004). The hyperparasitoid *Mesochorus lilioceriphilus* Schwenke (Hymenoptera: Ichneumonidae) was reared from *Lemophagus* spp. (Haye and Kenis, 2004). Survey results and host specificity of related parasitoids known to attack other Criocerinae (e.g., *Crioceris asparagi* attacked by *Lemophagus crioceritor*, (Hendrickson et al., 1991) *Diaparsis jucunda*, *L. pulcher*, *L. errabundus*, and *Tetrastichus setifer*) were acceptable candidates for further research to develop a classical biological control program (Casagrande and Kenis, 2004). These species were the most widely distributed, were generally restricted to *Lilioceris*, and as a group regularly provided between 25 and 78 percent parasitism (Haye and Kenis, 2004). Three of these, *Diaparsis jucunda*, *L. errabundus*, and *T. setifer*, were ultimately released in North America for LLB control.

Diaparsis jucunda attacks all larval stages of LLB in central and southern Europe, with total parasitism in the last instar averaging about 60 percent in lily fields, 74 percent in gardens, and over 80 percent in the wild (Kenis et al., 2002; Scarborough, 2002; Haye and Kenis, 2004). *Lemophagus errabundus* attacks the second through fourth instar beetle larvae, with parasitism rates approaching 40 percent in Benelux countries (Belgium, the Netherlands, and Luxembourg) and adjacent France (Haye and Kenis, 2004). Parasitism rates for *Tetrastichus setifer* are similar, although it was most abundant in northern Germany and England (Salisbury 2003, Haye and Kenis 2004).

Each of these agents has been an effective parasitoid of LLB in North America. *Tetrastichus setifer* was first released in plots in Massachusetts and Rhode Island from 1999–2003. The parasitism rates of larvae sampled in Massachusetts were 37 percent in 2002, 100 percent in 2003, and 57 percent in 2004. The average number of LLB larvae per stem declined from 7 per stem in 2000, down to 1 per stem in 2004. The parasitism rates of the larvae sampled in Rhode Island were 95 percent in 2003, and 75 percent in 2004. The average number of LLB larvae per stem declined from 6 per stem in 2001, down to 2 per stem in 2004 (Tewksbury et al., 2005). Once establishment of *T. setifer* was documented at the release plots, additional releases were made in Rhode Island, Massachusetts, Maine, Connecticut, New Hampshire and Ontario, Canada. *Tetrastichus setifer* has been able to establish in all locations and has spread at least 32 km from the release sites. Based on collection data *T. setifer* can spread about 1 km a year. Monitoring at recovery sites (sites where the wasps were not released) from 2004–2013 found LLB larvae parasitized by *T. setifer* at rates of 4–100 percent (Tewksbury, 2014).

Releases of *Lemophagus errabundus* were made from 2003 to 2007 at release plots in Rhode Island and Massachusetts. Establishment of *L. errabundus* was first confirmed in 2005 at a residential site 1.2 km away from a release plot in Massachusetts. It was again found in 2006 at a home garden 2.9 km away from the Massachusetts release plot. Parasitism rates were tracked at a home garden 4 km away from the Massachusetts release plot from 2009 to 2013. Peak parasitism levels were 9 percent in 2009, 50 percent in 2010, 78 percent in 2011, and 94 percent in 2012. In 2013 no LLB larvae were found at the site. Monitoring at recovery sites from 2005-2012 found LLB larvae parasitized by *L. errabundus* at rates of 4–94 percent. Based on collection data *L. errabundus* can spread about 1 km a year (Tewksbury, 2014).

Diaparsis jucunda was released in Maine, Massachusetts, New Hampshire, and Rhode Island from 2003 to 2007. Overwintered *D. jucunda* were first recovered in 2007 in a home garden in Rhode Island four years after the first release. *Diaparsis jucunda* was also documented in 2007 in four home gardens in Maine one year after release. *Diaparsis jucunda* is now established in all four states. From collections made in Massachusetts and Maine, *D. jucunda* has been found to have spread 15–20 km from release sites, and has the ability to spread 4–5 km a year. Monitoring at recovery sites from 2007-2013 found LLB larvae parasitized by *D. jucunda* at rates of 4–100 percent (Tewksbury, 2014).

All pre-release research and post-release observations indicate that these agents should have no non-target effects on genera other than *Lilioceris*. To evaluate the effects of these agents on non-target insects, host specificity testing was conducted at CABI Bioscience in Switzerland and the University of Rhode Island (URI) Biological Control Laboratory. If an insect species only attacks one or a few closely related insect species, the insect is considered to be very host-specific. Host specificity is an essential trait for a biological control organism proposed for environmental release. Host specificity tests are used to determine how many insect species these agents might attack, and thus assess the risk to non-target species. The strategy used for selecting insects for testing was based on these criteria: (1) phylogenetic affinity to target (shared species, genus, family, or superfamily), (2) ecological similarity to target (shared food plant or feeding niche), (3) known hosts of other *Diaparsis*, *Lemophagus*, and *Tetrastichus* species, and (4) outgroup species (different subfamilies and family).

Insects related taxonomically to LLB would be the most likely to be attacked by the proposed biological control organisms (Louda et al., 2003). *Lilioceris lilii* belongs to the subfamily Criocerinae in the family Chrysomelidae. There are 44 species of Criocerinae in America north of Mexico, in the tribes Criocerini and Lemiini (White, 1993; Arnett, 2000). The only genera in the tribe Criocerini in North America are *Lilioceris* and *Crioceris*. All four species of this tribe in North America are introduced species; three are pests and one is an intentional introduction for biological control (Appendix 1). *Lilioceris cheni*, introduced to control air potato (*Dioscorea bulbifera*) in Florida is the only other *Lilioceris* in the United States (White, 1993; Overholt et al., 2016). Forty-one species of Lemiini, in the genera *Lema*, *Neolema*, and *Oulema* occur in America north of Mexico (White, 1993; Arnett, 2000).

Three species of *Lilioceris* were tested in host specificity trials; *L. lilii*, and the European congeners *L. merdigera* and *L. tibialis* (Kenis et al., 2002; Casagrande and Kenis, 2004). North American species in Criocerinae used in host specificity testing included *Oulema melanopus, Crioceris asparagi,* and *Lema daturaphila* (reported under the synonym *L. trilineata* in previous research), representing two of the three genera native to North America (Kenis et al., 2002; Casagrande and Kenis, 2004). The researchers also included four other chrysomelids: the imported willow leaf beetle (*Plagiodera versicolora* Laicharting) and the Colorado potato beetle (*Leptinotarsa decemilineata* [Say]) in the subfamily Chrysomelinae, and two Galerucinae, *Galerucella calmariensis* (L.) and *G. pusilla* Duftschmidt, both introduced for biological control of purple loosestrife (*Lythrum salicaria* L.). The phytophagous Mexican bean beetle *Epilachna varivestis* Mulsant (Coleoptera: Coccinellidae) was also included.

Tetrastichus setifer, *Diaparsis jucunda*, and *Lemophagus errabundus* only parasitized beetle larva in the genus *Lilioceris*. One exception was the parasitism by *T.* setifer of a single specimen of *Lema daturaphila* from the tribe Lemiini during 278 no-choice and choice trials. The researchers ascribed this to reduced space in a single no-choice experiment (Casagrande and Kenis, 2004; Haye and Kenis, 2004). *Lemophagus pulcher* was ultimately rejected as a release candidate because it preferentially attacked the other *Lilioceris* species included in the host specificity testing, and also attacked (although infrequently) *L. daturaphila* and *C. asparagi* (Kenis et al., 2002; Casagrande and Kenis, 2004). Host-specificity testing and post-release observations indicate that these agents should only attack beetles in the genus *Lilioceris*, and thus should have no non-target impacts on species in other genera.

The potential effects on the biological control project for air potato that relies on *L. cheni* must also be considered. *Lilioceris cheni* was released in Florida to control the invasive plant *Dioscorea bulbifera*, the air potato (Overholt et al., 2016). The beetle appears to be having good control, and it could conceivably compromise that control if these agents were to begin attacking *L. cheni*. *Tetrastichus setifer* and *L. errabundus* may parasitize *L. cheni* given the opportunity; both species were recorded attacking other European *Lilioceris* although *L. cheni* is less closely related to LLB than the other tested congeners. However, in almost all experiments, *T. setifer* and *L. errabundus* preferred LLB (Casagrande and Kenis, 2004). *Lilioceris cheni* is a confirmed specialist on *D. bulbifera*, avoiding even other species in that genus (Pemberton and Witkus, 2010; Lake et al., 2015). Its range will be limited to that of its introduced host plant, which in North America includes most of Florida, and scattered parts of Alabama, Mississippi, Louisiana, Texas, and Georgia. If the range of these proposed biocontrol agents and *L. cheni* eventually overlap, it will likely be through natural spread southward along the Atlantic from where they were released in the northeastern United States.

2. Effects on the Physical Environment and Indirect Effects of the Release of These Agents

a. Effects on physical environment (e.g., water, soil, and air resources)

There are no known or conceivable direct effects of these agents on the physical environment. All are miniscule wasps that are obligate parasitoids of the target beetle. Indirect effects on the physical environment are likely to be salutary, primarily via reduced pesticide use by untrained gardeners and professional landscape management companies subsequent to establishment of these agents and natural control of the target pest.

b. Indirect effects (e.g., potential impacts on organisms that depend on LLB or non-target species including potential competition with resident biological control agents)

Successful management of LLB using these biological control agents should only result in positive, indirect effects on U.S. municipalities, land owners, the nursery industry, regional biodiversity, and any organisms dependent on *Lilium* or *Fritillaria* spp. Non-human organisms most directly affected by LLB-associated loss of lilies or fritillaries will be those directly dependent on flowering plants, such as pollinating insects and specialist herbivores (e.g., Powell and Opler, 2009; Wolf and Thorp, 2011). Lily leaf beetle does not feed on any plant genera that are considered noxious weeds or otherwise invasive. There is no evidence of other species relying on LLB as a food resource. Reduced populations of LLB subsequent to control by these agents should have no negative impacts on other species.

3. Uncertainties Regarding the Environmental Release of these agents

Upon release of any biological agent in a novel range there is always the possibility that it may attack other non-target insects. Host specificity testing is conducted to assess the risk of this occurring through the implementation of choice-tests which address the preference of the test subject when multiple prey are available, and through no-choice tests, which assess the behavior and attack rates of the test species in the absence of multiple prey species. These tests are conducted with host and non-host species to calibrate the degree of specificity, or lack thereof, of the biological control agents. Species closely related to the target pest are the most likely to be attacked (Louda et al., 2003), and host specificity testing should include an array of closely related species. These may include congeners that would be most at risk from host switching, and other species within the same tribe, subfamily, and family. The further the taxonomic distance from the target pest, the less likely non-generalist biological control agents are to switch hosts.

Host specificity trials for these agents demonstrate that they are highly host specific (Gold, 2003; Casagrande and Kemis, 2004). In addition, these agents have already been released in the northeastern United States and they have been effective in controlling LLB and have not had non-target impacts.

4. Cumulative Impacts

“Cumulative impacts are 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).

APHIS has not established quarantines to prevent the movement of LLB within the United States. Mechanisms that could limit spread that are already in place include phytosanitary measures relevant to international trade, and state or provincial regulations. Thus far these do not appear to have been effective in limiting the spread of LLB in North America, and the range and population density of LLB is likely to increase. Survey efforts for LLB are conducted only at state or local levels. Aside from the existing biological control programs in the eastern states and provinces there are no mechanisms in place to slow the spread of LLB.

Homeowners apply insecticides to protect high-value lilies in the landscape, or remove lilies from planting beds entirely. Insecticide applications and plant removals provide a temporary local reduction of LLB but do not result in long term control. These measures also have little or no salutary effect on wild or unmanaged lily and fritillary populations.

Release of these agents will have no negative cumulative impacts in the contiguous United States because of their host specificity to LLB, other than potential impacts on non-target *L. cheni*. However, based on host-specificity testing conducted, impacts to *L. cheni* are expected to be minimal because these agents preferred LLB to other *Lilioceris* species, and the environmental range of the two insects only overlaps slightly. Effective biological control of LLB will have beneficial effects to current LLB management activities, and should result in protection of lily resources in both human managed and wild landscapes.

5. 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 or endangered species or result in the destruction or adverse modification of critical habitat.

Release of these biocontrol agents will have no effect on listed insects or other arthropods in the United States. The three biological control agents are specific to *Lilioceris* species, and there are no federally listed insects that are related to *Lilioceris* species. They would also not parasitize pollinators of federally listed plants because pollinator species are also unrelated to *Lilioceris*. These insect species would not be toxic if consumed by any listed mammal, bird, reptile, or amphibian. Therefore, APHIS has determined that the release of *Diaparsis jucunda* (Hymenoptera: Ichneumonidae), *Lemophagus errabundus* (Hymenoptera: Ichneumonidae), and *Tetrastichus setifer* (Hymenoptera: Eulophidae) will have no effect on any federally listed species in the contiguous United States.

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 these agents and 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 these agents.

VI. Agencies, Organizations, and Individuals Consulted

This EA was prepared by Washington State Department of Agriculture and APHIS. The addresses of participating APHIS units, cooperators, and consultants (as applicable) follow.

U.S. Department of Agriculture
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Environmental and Risk Analysis Services
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U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine, Plant Health Programs
Permitting and Compliance Coordination
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Appendix 1. Criocerinae (Coleoptera: Chrysomelidae) of America north of Mexico

Taxon	PNW Distribution	North American Distribution	Recorded Host Plant Families	Notes
Tribe: Criocerini				
Lilioceris				
lilii (Scopoli)	WA	WA, NE US, central and E Canada	Liliaceae	Introduced, lily pest
cheni Gressitt and Kimoto		FL	Dioscoreaceae	Introduced, air potato biological control
Crioceris				
asparagi (Linnaeus)*	WA, OR, ID	Northern US, plus AL and SC	Asparagaceae	Introduced, asparagus pest; *Tetrastichus asparagi* introduced for biological control
duodecimpunctata (Linnaeus)	WA, OR, ID	Northern US, most frequent in NE[1]	Asparagaceae	Introduced, asparagus pest
Tribe: Lemiini				
Lema				
balteata LeConte		AZ	Solanaceae	
circumvittata Clark		AZ, FL	Solanaceae	
confusa Chevrolat		FL	Solanaceae	
conjuncta Lacordaire			Sapindaceae	
maderensis White		AZ, FL		
melanofrons White		AL, NC	Solanaceae	
nigrovittata (Guérin)		AZ, CL, TX	Solanaceae	

opulenta Gemminger & Harold		TX	Solanaceae, Asteraceae, Malvaceae, Poaceae, Cucurbitaceae	
ornata Baly				
pubipes Clark		South central US	Cucurbitaceae, Amaranthaceae	
puncticollis (Curtis)		SK, NB Canada	Asteraceae	Introduced, Canada thistle biological control. Probably extirpated.
solani Fabricius		Eastern US to Texas	Solanaceae, Fabaceae, Brassicaceae	
trabeata Lacordaire		Arizona to Florida	Solanaceae, Cucurbitaceae	
daturaphila White*	OR	US into Southern Canada	Solanaceae	
trivittata trivittata Say	CA	US into Southern Canada	Rosaceae, Poaceae, Asteraceae, Asteraceae, Fabaceae, Solanaceae, Malvaceae	Native, minor pest of Solanaceae
Neolema				
adunata White	BC	Southern border of BC		
cordata White		Central and Southeastern States	Cyperaceae, Asteraceae, Rosaceae, Commelinaceae	
albini Auctorum				
*ephippium (*Lacordaire)		FL, LA	Commelinaceae, Asteraceae	
gundlachiana (Suffrian)		FL		
jacobina (Linell)		TX, MS, KS	Commelinaceae	
ovalis White		AZ, TX diagonally to IN	Commelinaceae, Brassicaceae	
quadriguttata White		TX, MS, KS		
sexpunctata (Oliver)		Southeastern US	Commelinaceae, Lauraceae, Araceae, Fabaceae	

Oulema				
arizonae (Schaeffer)		AZ	Commelinaceae	
brunnicollis (Lacordaire)		Southeastern US	Asteraceae	
coalescens White	BC	Southern border of BC		
collaris (Say)		Southeast and central US	Commelinaceae	
concolor (LeConte)		AZ, NM	Pteridaceae	
cornuta (Fabricius)		Eastern US		
elongata White		TX, LA	Commelinaceae	
laticollis White		FL	Commelinaceae	
longipennis (Linell)		South central US	Commelinaceae	
maculicollis (Lacordaire)		Southeast US	Convolvulaceae	
margineimpressa (Schaeffer)		AZ		
melanopus (Linnaeus)*	WA, OR	Northern US and southern Canada	Poaceae	Introduced cereal pest; *Tetrastichus julis* introduced for biological control
melanoventris White	BC	Canada		
minuta White		FL		
palustris (Blatchley)		Eastern US into Canada	Commelinaceae, Asteraceae, Araceae, Convolvulaceae	
simulans (Schaeffer)		Central UA	Commelinaceae	
texana (Crotch)		TX, LA, IA, CO	Cyperaceae	
variabilis White		AZ, OK, TX	Commelinaceae, Fabaceae, Cyperaceae,	

*Used in host specificity trials

Decision and Finding of No Significant Impact
for
Field release of *Diaparsis jucunda* (Hymenoptera: Ichneumonidae), *Lemophagus errabundus* (Hymenoptera: Ichneumonidae), and *Tetrastichus setifer* (Hymenoptera: Eulophidae) for biological control of the lily leaf beetle, *Lilioceris lilii* (Coleoptera: Chrysomelidae) in the Contiguous United States
August 2017

The U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) is proposing to issue permits for release three parasitoids into the environment for the purpose of reducing lily leaf beetle (LLB), *Lilioceris lilii* (Coleoptera: Chrysomelidae) populations. The biological control agents are known to attack LLB consistently in the northeastern United States, where they have already been released. The agents are *Diaparsis jucunda* (Hymenoptera: Ichneumonidae), *Lemophagus errabundus* (Hymenoptera: Ichneumonidae), and *Tetrastichus setifer* (Hymenoptera: Eulophidae) (hereafter "these agents"). Before permits are issued for release of these agents, APHIS must analyze the potential impacts of the release of these agents into the contiguous 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
Pests, Pathogens, and Biocontrol Permits
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 environmental release of these agents: (1) no action, and (2) issue permits for the release of *Diaparsis jucunda, Lemophagus errabundus,* and *Tetrastichus setifer* for biological control of LLB. 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, cultural, mechanical, and biological control methods for the management of LLB. These control methods described are not alternatives for decisions to be made by APHIS, but are presently being used to control LLB in the United States and may continue regardless of permit issuance for field release of the agents. Notice of the EA was made available in the Federal Register on July 13, 2017 for a 30-day public comment period. One comment was received on the EA by the close of the comment period. The commenter was opposed to the release of the agents but did not raise any substantive issues.

I have decided to authorize the APHIS to issue permits for the environmental release of *Diaparsis jucunda, Lemophagus errabundus,* and *Tetrastichus setifer*. The reasons for my decision are:

- These agents are sufficiently host specific and pose little, if any, threat to the biological resources, including non-target insect species, of the contiguous United States.

- The release will have no effect on federally listed threatened and endangered species or their habitats in the contiguous United States.

- *Diaparsis jucunda, Lemophagus errabundus,* and *Tetrastichus setifer* pose no threat to the health of humans.

- No negative cumulative impacts are expected from release of the agents.

- 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 *Diaparsis jucunda, Lemophagus errabundus,* and *Tetrastichus setifer* into the environment will be reversible, there is no evidence that this organism will cause any adverse environmental effects. In addition, these agents have already been released in the northeastern United States.

I have determined that there would be no significant impact to the human environment from the implementation of the action alternative and, therefore, no Environmental Impact Statement needs to be prepared.

Vickie Brewster for

Colin Stewart, Assistant Director
Pests, Pathogens, and Biocontrol Permits
U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine

16 Aug 2017
Date