Mid-Atlantic Invasive Plant Council

Biological Control Work Group

Motto

Biological control agents help manage invasive plants beyond where we cut, pull and spray.

Purpose and Scope

The group will investigate biological control agents relevant to the mid-Atlantic region and the eastern U.S., affecting aquatic and terrestrial species and ecosystems and provide updates and status reports to the board. We will ensure that the board is kept informed of relevant research, concerns and approvals and provided with information needed to obtain and use them.

Objectives

1. Provide review and current status of research on candidate biological control agents.

2. Provide land managers practical up-to date information on how to obtain and use approved biological control agents.

3. Provide the latest information on current distribution and success of available biological control agents in controlling target, non-native invasive plants at the established sites.

4. Describe potential or actual measures of damage by biological control agents to non-target plants at these sites.

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Background

Our tool kit for successful control of non-native invasive plants includes: preventing new invasive species from coming into the United States; manually removing established plants; treating infestations with carefully targeted herbicides; and releasing host-specific biological control agents.

Classical biological control involves the importation and release of host-specific natural enemies to help regulate pest populations (Van Driesche et al. 2010). This strategy is used to manage invasive non-native species that lack effective natural enemies in the region where they have been introduced. In order to avoid direct damage to non-target species, biological control agents must be highly host specific. Agents are brought over after being tested for host specificity in their native range and then tested in quarantine conditions in the United States. Protocol for evaluating candidate plant pathogens (Berner and Bruckart 2005) is very thorough and similar to that for development of insects and other organisms.

Safety is paramount in the use of biological control agents, particularly if they are of foreign origin. Agents are only approved for release if testing indicates a very low likelihood of non-target effects, as determined by the Technical Advisory Group for Biological Control Agents of Weeds (TAG), a group of experts that report to USDA, Animal and Plant Health Inspection Service (APHIS). Because some agents introduced into the U.S. prior to the 1980s were not completely host-specific, more value is now placed on conservation of native species; and some of these agents would not be approved for importation today (Van Wilgen et al. 2013). Although such species may provide some control, we do not recommend deliberate release where they have not yet dispersed on their own. . The safety record in the current regulatory environment is very good, including that of both insects (Pemberton 2000, Van Wilgen et al. 2013), and plant pathogens and other microbials (Barton 2004, 2012; Cook et al. 1996).

Effectiveness of classical biological control can vary, but of 49 invasive plant projects considered in a recent review (Van Driesche et al. 2010), 27% (13) achieved complete control, 33% (16) provided partial control, and 49% (24) were still in progress. Biological control can be dramatic, but results often vary depending on weather and ecological conditions, which can impose different effects on a biological control agent, the target plant, and the competitive ability of the resident community. Suppression of a target plant can also sometimes allow other non-native invasive plants to take over, and therefore restoration planting may be required in some situations (Cutting and Hough-Goldstein 2013; Lake et al. 2013).

Several invasive plant species in Mid-Atlantic natural areas (Swearingen et al. 2010) have one or more host-specific insect species that have been tested and approved for release, while others have had extensive studies conducted on host-specific insects, with petitions for release submitted to TAG, but with proposed releases still under review (TAG Petitions, 2013; see species updates, below). For some species, biological control agents may already exist in the U.S. in the form of native insects and pathogens that have adapted to the

invasive species over time, or non-native species that were accidentally introduced. These are also included in the species updates, below.

Species Updates

TERRESTRIAL PLANTS

Grasses

Japanese stiltgrass

The annual grass Japanese stiltgrass (*Microstegium vimineum*) can be highly invasive, especially on disturbed sites, and it is currently widely distributed in the eastern U.S. In Oak Ridge National Environmental Research Park, Tennessee, Japanese stiltgrass was ranked the most aggressively invasive nonnative species, based on distribution, abundance, relative difficulty of control, and ability to exclude native plant species (Fryer 2011). Two species of *Bipolaris* have been described as cause of leaf spots and necrosis of Japanese stiltgrass in the Eastern U.S.; some evidence is that disease may be suppressing local populations. Host range of these species has not been fully tested, although limited symptom development was reported on a few important grass (grain) species in artificial tests (Kleczewski et al. 2012). Research is on-going about this pathogen(s), its host, and the potential for use in biological control of Japanese stiltgrass. If you see leaf blight on Japanese stiltgrass during the growing season please contact work group member William L. Bruckart, III.

Common reed

Common reed (*Phragmites australis*) is highly invasive in eastern North America, apparently due to the cryptic introduction of a non-native subspecies (*P. australis* subsp. *australis*). A native, non-invasive subspecies (*P. australis* subsp. *americanus*) has an overlapping distribution with the invasive subspecies and appears to be declining in abundance. The presence of the native subspecies complicates biological control of this plant, since even highly host-specific insects may feed on both subspecies.

Tewksbury et al. (2002) reported 26 herbivores known to feed on *P. australis* in North America, many of which had been accidentally introduced. In Europe, more than 150 herbivore species were reported feeding on *P. australis,* some causing significant damage. Based on feeding niche, damage, and reported host specificity, nine insects were identified as having promise as potential biocontrol agents. Two of these, *Archanara geminipuncta* and *Archanara neurica* both stem-mining noctuid moths, have been studied in detail, and petitions for release of these species are currently being prepared (Lisa Tewksbury, personal communication).

Herbaceous Plants

Garlic mustard

Garlic mustard (*Alliaria petiolata*) a cool-season biennial herb, which can invade forest understories and outcompete native plants, especially spring ephemeral wildflowers. It is native to Eurasia and currently widely distributed in the northeastern U.S. and Canada. Four weevil species in the genus *Ceutorhynchus* have been extensively studied at CABI-Switzerland and the University of Minnesota. The root-crown mining weevil *Ceutorhynchus scrobicollis* has been proposed for release in North America (Gerber et al. 2009). TAG has requested additional host range tests, and the host plant test petition is currently under review (TAG Petitions 2013).

Nodding and plumeless thistles (*Carduus* species)

Species in the genus *Carduus* are all exotic to North America and many are well known noxious and invasive plants in the U.S. and elsewhere, especially in pastures. The most important pest species are winter annuals or biennials, reproducing primarily by seed. A biological control program targeting these species began in 1963. Four biological control agents have become well-established in the U.S., the thistle head weevil (*Rhinocyllus conicus*), thistle crown weevil (*Trichosirocalus horridus*), the leaf beetle *Cassida rubiginosa* (accidentally introduced), and the musk thistle rust fungus, *Puccinia carduorum*, and together these species have successfully controlled *Carduus* thistles (Kok 2001).

Unfortunately, several insect species imported for control of thistles have been found to impact native thistle species. The thistle head weevil (*R. conicus*) has caused significant population declines in several native North American thistles that also only reproduce by seed (Cripps et al. 2011). Another seed-eating weevil, *Larinus planus*, is thought to have entered the U.S. accidentally in the 1960s, and was first reported in Maryland in 1971. This species has also been shown to negatively affect populations of rare native thistle species (Havens et al. 2012). For these reasons, deliberate spread of these species is not recommended.

Canada thistle

Canada thistle (*Cirsium arvense*) is native to Eurasia, but has been spread inadvertently throughout temperate regions of the world. It is a widespread perennial weed of agricultural and ecological areas in the northern and southwestern states in the U.S. A classical biological control program for Canada thistle was initiated in North America in 1959. However, nearly 50 years after the first agent releases, successful control of this species has not been achieved (Cripps et al. 2011). There are probably no additional arthropod agents specific enough to be imported into North America targeting Canada thistle (Cripps et al. 2011), but there may be potential with pathogens. The rust fungus

Puccinia punctiformis is specific to Canada thistle, and is present in all states where the plant is found. Establishment of epiphytotics of the rust, and concomitant biological control, has proven difficult, but has recently been demonstrated to be readily achievable in field tests in the U.S. and three other countries Berner et al. 2013).

Knotweeds

Japanese knotweed (*Fallopia japonica*), giant knotweed (*F. sachalinensis*), and the hybrid between these two, *F. x bohemica*, also known as Bohemian or hybrid knotweed, are large herbaceous perennials that have spread throughout much of North America, especially in riparian areas. Between 2007 and 2012, four natural enemies from knotweed's native range were tested as potential biological control agents for knotweeds in North America--a leaf beetle, two moths, and a psyllid (Grevstad et al. 2013). Partners in this biocontrol project include the U.S. Forest Service Forest Health Technology Enterprise Team, Washington State Department of Agriculture, CABI- Biosciences United Kingdom, and Agri-Food and Agriculture Canada. Only one of these species was found to be suitably host specific, the psyllid *Aphalara itadori*. Two different biotypes of the psyllid were evaluated—a northern biotype (from Hokkaido), collected from giant knotweed, and a southern biotype (from Kyushu) collected from Japanese knotweed. In 2011, the last of the pre-release laboratory testing was completed for both biotypes.

Host specificity tests were carried out using over 70 different native and economically important North American Plant species. Additional tests were used to quantify oviposition preferences and ability for a population to persist on non-targets. The results indicate a high level of host specificity to knotweeds, but differences in performance of the two biotypes on the three knotweed species (*Fallopia japonica*, *F. x bohemica*, and *F. sachalinensis*). This means that both biotypes will likely be needed for effective control against all knotweed species and genotypes in North America. The psyllids were found to be effective, reducing the growth and biomass of potted knotweed plants by 50% in just over one psyllid generation (Grevstad et al. 2013). The psyllid has been proposed for release (TAG petitions 2013), but APHIS is still studying the petition and TAG reviewer comments and other material before responding with the petitioner. This insect has been released in England and Wales since 2010 with no apparent negative effects, and therefore its eventual approval in the U.S. seems likely.

Purple Loosestrife

Purple loosestrife (*Lythrum salicaria*) is widespread across the U.S. Three insect biocontrols were approved for release in the early 1990s and have been successfully reducing loosestrife infestations in freshwater wetlands across the northern states where the heaviest infestations occur. Purple loosestrife leaf-feeding beetles (*Galerucella* species) can be purchased from the Phillip Alampi Beneficial Insect Rearing Laboratory, New Jersey

Department of Agriculture (see Resources) or moved from established populations within a state. The Maryland Department of Natural Resources is training Maryland residents who spend time outdoors in habitats where purple loosestrife may grow to recognize the plant and report its locations to DNR using an on-line or paper reporting form and to photograph them when possible. Those locations are mapped and assessed in order to allow DNR staff to evaluate the potential for biocontrol releases (see Resources).

Shrubs

Winged burning bush

Two closely related members of the bittersweet family (Celastraceae) -- winged burning bush (*Euonymus alatus*), a shrub, and winter creeper (*Euonymus fortunei*), a perennial vine, are exotic introduced ornamentals that are invasive in natural areas. According to the Invasive Plant Atlas of the United States, they are both invasive throughout the northeastern U.S. (see Resources). Euonymus scale, *Unaspis euonymi*, is an accidentally introduced insect that infests both species, and can weaken and kill these. However, because it is a generalist and feeds on both native and non-native species in this family, it is not recommended as a good candidate for biological control.

Multiflora Rose

Multiflora rose (*Rosa multiflora*) occurs throughout the eastern half of the United States and in Washington and Oregon. At least two native or naturalized pests help keep it in check to some extent. One is a native eriophyid mite, *Phyllocoptes fructiphilus* that transmits an RNA virus that causes Rose Rosette disease. Diseased plants are now known on the East Coast, and the disease has caused reduction of multiflora rose densities in certain areas. Symptoms include compaction of lateral branches into "witches brooms" and both stunting and reddening of shoots. Diseased plants are weakened and often die as a result.

The rose-seed chalcid (*Megastigmus aculeatus* var. *nigroflavus*), a wasp, was introduced accidentally from Europe. Although it can reduce seed yield of *R. multiflora*, it has limited potential to reduce reproduction (Jesse et al. 2013). An important drawback to both the virus and the chalcid wasp is that ornamental roses are susceptible and damaged from these organisms. A USDA Beltsville study shows that native rose rosette disease is harmless to several native roses. Research on the effects of the evidently native rose rosette disease has revealed that it is harmless to native roses. The native species of roses (*Rosa setigera*, *R. virginiana*, and *R. palustris*) and the naturalized *R. rugosa* seem to be very resistant to possibly immune to the disease (see Resources).

Trees

Tree-of-Heaven

Tree-of-heaven, *Ailanthus altissima*, was deliberately introduced as an ornamental species in the 1700s, and has now been reported in 30 states. The Asian weevil *Eucryptorrhynchus brandti* is being studied at Virginia Tech (Herrick et al. 2012). The only non-target species that the weevil has showed some acceptance of is corkwood, *Leitneria floridana*, which is listed as a threatened species in Florida, and therefore the initial petition for release was denied by TAG in 2012. The research group is continuing to study the insect's potential host range, and hopes to resubmit the petition (Tom McAvoy, Virginia Tech, personal communication).

A native, soil-borne vascular wilt fungus, *Verticillium nonalfalfae*, has been found killing large numbers of *Ailanthus altissima* trees in south-central Pennsylvania and north-western Maryland, and this fungus appears to be quite host specific (Schall and Davis 2009a, b). Natural, long-range dissemination of this fungus is limited, and researchers are currently working on determining the best way to use it. In addition, it is unclear at this point how or whether use of this pathogen should be regulated. *Atteva punctella*, the ailanthus webworm, is thought to be native to southern Florida and Central America, and has apparently expanded its host range and distribution onto tree-of-heaven, where it can cause serious damage, especially to seedlings and small plants (Ding et al. 2006).

Vines

Mile-a-Minute Weed

Mile-a-minute weed (*Persicaria perfoliata*) is an invasive annual vine that was accidentally introduced into Pennsylvania in the 1930s and has since expanded its range throughout much of the northeast (see Resources). The host-specific weevil *Rhinoncomimus latipes* was approved for release in 2004, and has been released throughout the range of the host, with considerable though somewhat variable success (Hough-Goldstein et al. 2012). The weevils are being mass-reared by the Phillip Alampi Laboratory in New Jersey, and can be obtained from that Laboratory or moved from established populations within a state. A plant pathogen, *Colletotrichum gloeosporioides* from Turkey (Berner, et al., 2012) is being evaluated in host range tests at the USDA, ARS, Foreign Disease-Weed Science Research Unit (FDWSRU), at Ft. Detrick, MD. Propagation materials of plant relatives in the Polygonaceae family are needed to complete these host range tests.

Swallowworts

Two invasive swallow-worts, pale (*Vincetoxicum rossicum*) and black *(V. nigrum*), are well established in the northeastern U.S. and are expanding in the mid-Atlantic region and southern Canada. A

biological control agent (*Hypena opulenta*), a moth, was recently approved for release in Canada (see Resources). This species has been tested on 76 plant species, with no larval survival on any tested genus other than *Vincetoxicum*. Based on current evidence, the two invasive species targeted are the only *Vincetoxicum* species currently in North America; however, all related species (including those considered congeneric with the target plant species by some botanists) were also tested and found not to allow survival of *H. opulenta* (R. Casagrande, personal communication). A petition for field release of this host-specific moth in the U.S. has been approved by TAG and is currently in the post-TAG review process through USDA-APHIS.

AQUATIC PLANTS

Eurasian Watermilfoil

Eurasian watermilfoil (*Myriophyllum spicatum*), is the most significant aquatic weed in the continental United States based on high cost of control efforts (Cock et al. 2008). High densities of Eurasian watermilfoil negatively affect wildlife and fish populations and recreational use. It is abundant in the Chesapeake Bay and tidal Potomac River (Swearingen et al. 2010). A classical biological control program was initiated for *M. spicatum* in 1965, with U.S. and overseas researchers surveying parts of the native range in Europe and Asia for specialist natural enemies (Cock et al. 2008). More than 20 species were identified as feeding on *M. spicatum*, but few were seriously investigated to determine their potential. Cock et al. (2008) summarize species that were found and propose additional research that could lead to viable classical biocontrol.

Since the early 1990s, researchers have been studying the potential of the native milfoil weevil, *Euhrychiopsis lecontei*, to control populations of Eurasian watermilfoil (Menninger 2011). This weevil has been found to prefer the Eurasian species over its native host, northern watermilfoil (*M. sibiricum*). Milfoil weevils are found throughout the northern continental United States and portions of Canada. Eurasian watermilfoil control in lake management projects has been conducted through augmentation programs, where these weevils are reared in mass numbers and introduced into infested water bodies. EnviroScience, Inc. offers milfoil weevils as a commercial product, where clusters of milfoil containing eggs and larvae are attached to watermilfoil stems in an infested lake. However, few evaluations of this process have been published, and the one peer-reviewed paper on its effectiveness (Reeves et al. 2008) showed little effect. An alternative augmentation strategy, releasing adult weevils, is being studied (Menninger 2011).

Parrotfeather

A relative of Eurasian watermilfoil is parrotfeather (*Myriophyllum aquaticum*), a native of South America and invasive in about 20 states along the East and West coasts and

throughout the southern U.S. (see Resources). Biological control agents are not currently available for this exotic species but potential agents exist in South America and are being investigated. A complex of insects feed on parrotfeather in its native habitat, including a leaf-feeding beetle which has been found to be very host-specific and has been imported to control parrotfeather in South Africa (Cilliers 1999).

Giant salvinia

Giant salvinia, *Salvinia molesta*, was first detected in North America at a small pond in South Carolina in 1995, where it was eradicated with herbicides. Extensive infestations were later discovered in large drainages in Texas during 1999, and it now occurs in at least 12 states mainly in the southeastern U.S. from eastern Texas through eastern North Carolina (Tipping et al. 2008). In the summer of 2000, a small population was discovered in ornamental ponds in Washington, D.C. but it was quickly eradicated (Swearingen et al. 2010). The weevil *Cyrtobagous salviniae* has been used successfully in at least 15 countries to reduce the dominance of *S. molesta* in invaded freshwater ecosystems, and was used successfully in Texas and Louisiana (Tipping et al. 2008). However, this weevil is not always effective, because it is less tolerant of cold temperatures than Giant salvinia. In 2005, salvinia weevils that were released into the River Bend Swamp of Pender County, North Carolina, did not overwinter, while the Giant salvinia plants survived (see Resources).

Hydrilla

Hydrilla (Hydrilla *verticillata*), is a submersed aquatic that roots in the soil and grows upwards, producing thick floating mats at the water's surface. It is believed to be native to Asia or Africa but is now globally distributed and was first introduced into North America as an aquarium plant in the 1950s. Hydrilla is now the most severe aquatic plant problem in the southern U.S. (Center et al. 2013). It has expanded its range north to New England, and is found in much of the Potomac River, in Virginia and Maryland freshwater tributaries of the Chesapeake Bay, in the Delaware portion of the Nanticoke River, most southern Delaware ponds, and in sites in eastern Pennsylvania (Swearingen et al. 2010). Hydrilla out-competes native submerged aquatic vegetation and can quickly fill a pond or lake, making the water body unsuitable for recreational uses. Herbivorous fish such as sterile grass carp have been used for hydrilla control where allowed by law. A host-specific semi-aquatic weevil, *Bagous hydrillae*, was released in the southern U.S. during 1991-1996, but was thought not to have established. In 2009, adult *B. hydrillae* were collected in southern Louisiana, suggesting that this weevil species has persisted and dispersed widely in the southeastern U.S. However, *B. hydrillae* does not seem to be suppressing hydrilla (Center et al. 2013).

European Water Chestnut

European water chestnut (*Trapa natans*) is an invasive aquatic plant native to Europe and Asia. It was first observed in the United States in Massachusetts in the late 1800s. Its current distribution is the mid-Atlantic and northeastern U.S., with the most serious problems being reported for the Connecticut River valley, Lake Champlain region, Hudson River, Potomac River and the upper Delaware River (Swearingen et al. 2010). This species can form dense floating mats, and its sharp fruits can cause painful wounds, making control efforts a challenge. The most promising species for biological control is *Galerucella birmanica*, a leaf beetle (Ding et al. 2006, 2007), but so far no petitions have been submitted to TAG.

Water Hyacinth

Water hyacinth (*Eichhornia crassipes*), is a South American species that can survive in the mid-Atlantic under mild winter conditions. Three insects have been released in Florida as biological controls of water hyacinth: two weevils, *Neochetina eichhorniae* and *N. bruchi* (released in 1972 and 1974, respectively), and a pyralid moth, *Sameodes albiguttalis* (released in 1977) (Center et al. 1999). So far satisfactory control has not been obtained with biological control agents alone, but integrated control may be feasible (Center et al. 1999; Center and Dray 2010).

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Maryland Department of Natural Resources Biocontrol Releases (Purple Loosestrife):
http://dnr.maryland.gov/wildlife/Plants_Wildlife/PurpleLoosestrife/index.asp

Phillip Alampi Beneficial Insect Rearing Laboratory, New Jersey Department of Agriculture:
http://www.state.nj.us/agriculture/divisions/pi/prog/beneficialinsect.html

Mile-a-minute current range:
http://www.eddmaps.org/midatlantic/distribution/midatlantic.cfm?sub=3065
http://ag.udel.edu/enwc/research/biocontrol/mileaminute.htm).

Swallow-wort biocontrol
http://www.sciencedaily.com/releases/2013/09/130927182942.htm

Knotweed biocontrol
http://www.sciencedirect.com/science/article/pii/S1049964413000030)

Purple loosestrife
Maryland Department of Natural Resources Biocontrol Releases
http://dnr.maryland.gov/wildlife/Plants_Wildlife/PurpleLoosestrife/index.asp

Multiflora rose – insect and disease controls
www.nps.gov/plants/ALIEN/fact/romu1.htm
www.mdinvasivesp.org/archived_invaders/archived_invaders_2006_05.html
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Winged burning bush and winter creeper distributions
http://www.invasiveplantatlas.org/subject.html?sub=3023
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Parrotfeather distribution
http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua003.html

Giant salvinia
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