Invasive Species Best Management Practices

INVASIVE SPECIES MANAGEMENT ADIRONDACKS

The Nature Conservancy

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Contact Information

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TABLE OF CONTENTS

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Introduction

Invasive species, as defined by Presidential Executive Order 13112, are species that are non-native to an ecosystem under consideration whose introduction causes, or is likely to cause, economic or environmental harm or harm to human health. The negative impacts invasive species have on natural and human systems are well documented. Once an invasive species becomes established, early detection and rapid response is critical to mitigating impacts and achieving successful eradication. As infestations increase in size and abundance, they become progressively more difficult and costly to manage and may never be completely eradicated (Figure 1). Some species have no effective control options.

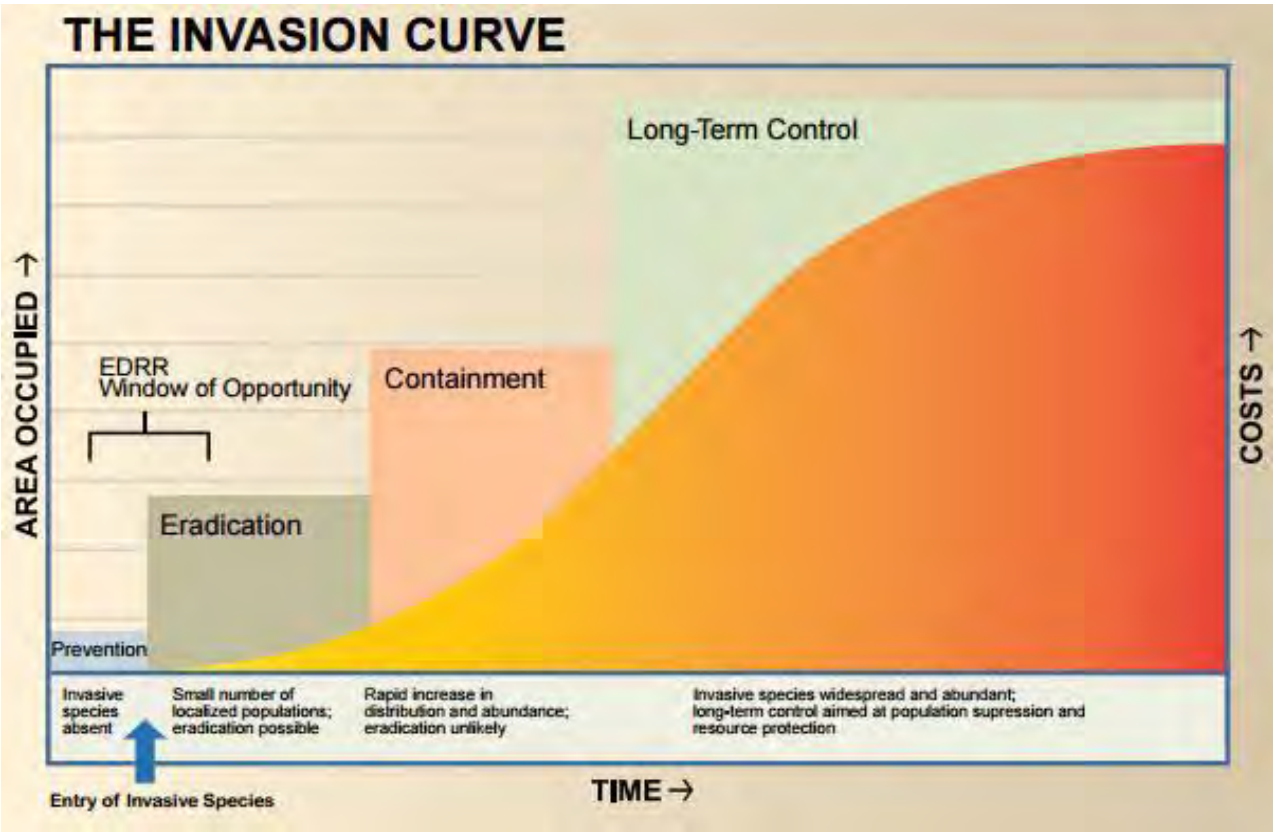

Figure 1. The Invasion Curve [1]: Identifying an invasive species infestation soon after establishment greatly increases the potential for eradication and reduces management costs.

The Nature Conservancy's (TNC) Adirondack Park Invasive Plant Program (APIPP) was founded in 1998 and serves as the Adirondack Partnership for Regional Invasive Species Management (PRISM), one of eight PRISMs across New York State (NYS). In 2008, APIPP received dedicated state funding through the invasive species line of NYS's Environmental Protection Fund (EPF), as administered by the NYS Department of Environmental Conservation (NYSDEC), to become the first formally recognized Partnership for Regional Invasive Species Management (PRISM) in NYS. The program's founding partners – as defined in memorandum of understanding – are TNC, NYSDEC, NYS Department of Transportation (DOT) and NYS Adirondack Park Agency (APA). The program is housed in Keene Valley under the Adirondack Chapter of TNC.

APIPP has been actively engaged in invasive species prevention, surveillance and management activities throughout the Adirondack region since its inception but has expanded its programmatic scope significantly since first receiving dedicated state funding in 2008. Over thirty partner organizations and hundreds of volunteers now assist APIPP in its mission *to protect the Adirondack region from invasive species impacts*.

[1] *The U.S. Department of the Interior. 2016. Safeguarding America's lands and waters from invasive species: A national framework for early detection and rapid response, Washington D.C., 55p.*

To date, over 460 lakes have been surveyed in the PRISM with approximately 75% found to be free of aquatic invasive species (AIS). APIPP's target AIS have been mapped in just over 100 lakes and ponds, while over 350 lakes remain uninvaded. Over 6,000 infestations of APIPP's target terrestrial invasive species have been mapped in the PRISM, with over 1,500 historically managed infestations found to be free of terrestrial invasive species upon follow-up survey.

Through these extensive invasive species surveillance and management experiences, APIPP has developed effective best management practices (BMPs) for invasive species affecting the Adirondack region. The program shares these BMPs with the public through educational events, trainings and publications. Each invasive species infestation, as well as the geographic, ecological, and societal setting in which it establishes, is unique and may require the use of different methods and tools to ensure that control measures are appropriate, effective, and permitted. Invasive species management activities should always follow the principles of Integrated Pest Management (IPM) and the minimum tool approach to effectively address impacts, while minimizing risk of harm to non-target species, people, and the environment. This document is meant to serve as a resource for individuals and organizations seeking to undertake invasive species management activities in the Adirondack PRISM. Please note that the BMPs included in this document are continually adapted and improved upon over time through experience-based learning. This document will be reviewed and updated periodically to reflect the best available invasive species management information, control techniques, and technologies. If you have questions or comments regarding these BMPs, please contact APIPP.

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Invasive bush honeysuckle (*Lonicera spp.)* in flower.
Photo Credit: The Nature Conservancy (Zachary Simek)

Pre-Project Planning

Before engaging in invasive species management, it is critical to develop a management plan, budget, and establish project goals and objectives to ensure all desired outcomes are realistic, cost effective, and measurable. APIPP staff have extensive experience in invasive species management and monitoring and can offer technical assistance or guidance.

In general, we recommend evaluating potential projects using the following framework which represents APIPP's unified theory of invasive species management (Figure 2). This includes:

1. Assessing the relative threat of the species of management interest
2. Determining whether a conservation, economic, or societal asset would be put at risk if the species infestation were left unmanaged
3. Evaluating whether effective tools are available to manage both the infestation and any potential source of reintroduction
4. Whether sufficient resources are available to complete the project and expenditure will result in a high return on investment over a five to ten-year time horizon

APIPP recommends referring to and utilizing several resources and pre-project planning tools to address each question posed in this framework. These include New York State's invasive plant and animal threat ranking assessments, available BMPs, geographic information systems, conservation asset maps, economic impact studies, invasive species distribution databases, and the Invasive Plant Management Decision Analysis Tool (IPMDAT). Failing to address all components of the framework before implementation can significantly increase the likelihood for project failure or result in management being undertaken with little to no ecological, economic, or societal benefit.

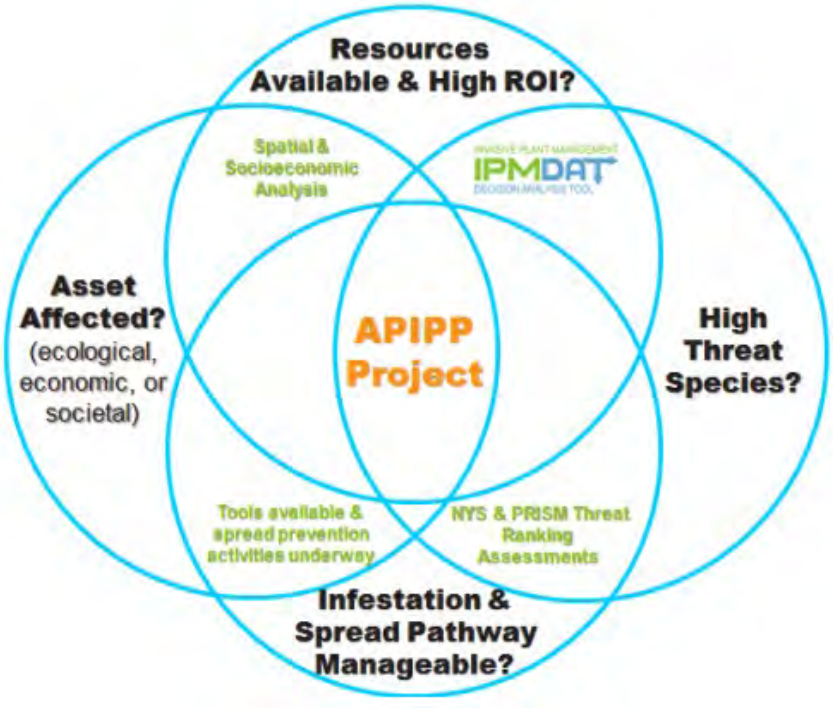


Figure 2. APIPP's unified theory of invasive species management.

Project Implementation and Monitoring

Once a viable management project has been identified and all available BMPs have been considered, implement the management strategy most appropriate for your site and the invasive species infestation of concern. Annual follow-up management over multiple, consecutive years is often required to successfully reduce or eradicate infestations. Management sites should be revisited annually, at the appropriate time of growing season, for at least five years after initial management or until no invasive species have been documented at the site for at least three consecutive years.

Progress in meeting project goals can be evaluated by documenting reductions in invasive species abundance (extent, percent cover, density, number of plants, etc.) as well as reestablishment of native species over time. Invasive species mapping and monitoring systems such as iMapInvasives and EDDMaps can assist you with documenting management activities and tracking progress over time. Large terrestrial infestations – usually greater than 2.47 acres (1 hectare) – may require sustained annual management and/or active restoration into perpetuity to maintain low invasive species abundance and promote the reestablishment of native species.

If your project was not as successful as desired, you may need to adapt your management technique or goals. For example, you may need to deploy a stronger management tool such as an herbicide should manual management efforts fail. Additionally, you may need to switch from an eradication strategy to a containment or suppression strategy should invasive species continue to persist after multiple years of management.

If you have been involved in an invasive species management project, it is important to share your results with others. APIPP is continuously seeking to improve its BMPs and we would value your input. Please contact us to share your experiences managing invasive species in the Adirondacks.

*i*MapInvasives

New York's Invasive Species Database

About NY iMapInvasives

*i*MapInvasives is New York State's on-line, all-taxa invasive species database and mapping tool. The comprehensive database can be used for:

- Documenting and sharing invasive species observation, survey, assessment and treatment data
- Collecting observations of invasive species in the field using a convenient mobile app
- The coordination of early detection and rapid response efforts though email alerts
- Data analysis and summaries in the web interface and GIS

For more information, visit: www.nyimapinvasives.org

iMapInvasives is managed by the New York Natural Heritage Program (NYNHP), which is a partnership between SUNY College of Environmental Science and Forestry and the NYS Department of Environmental Conservation, with funding from the New York State Environmental Protection Fund.

Permitting Requirements

Invasive species management activities may be subject to one or more permits from various state agencies and/or departments. The list below includes site conditions and/or special circumstances that may trigger permitting requirements from various regulatory agencies.

Please note: This is not exhaustive list. Additional permits may be required to implement your management project.

1. MANAGEMENT ACTIVITIES UNDER APA JURISDICTION

A permit from the APA may be required for:

- Activities involving wetlands subject to Agency jurisdiction
- The application of pesticides within 100 feet (30m) of such wetlands
- Cutting within the set back of a navigable body of water
- Certain forestry clear cuts
- Hand or mechanical harvesting of aquatic vegetation
- Installation of benthic barriers
- Draining or dredging of a water body
- Mechanical harvesting of AIS

Note: There may be other predicates of jurisdiction and it is best to contact the APA directly for guidance regarding specific permitting needs. Contact the APA for additional information (Appendix B).

2. MANAGEMENT ACTIVITIES UNDER NYSDEC JURISDICTION

A permit from the NYSDEC may be required for:

- Management of invasive species on NYSDEC Administered Land – such as the Forest Preserve
- Chemical control of invasive species emerging from standing water – such as *Phragmites*
- Chemical control of aquatic invasive species using pesticides applied to surface waters
- Management activities in or near wetlands outside the Adirondack Park boundary

Note: There may be other predicates of jurisdiction and it is best to contact the NYSDEC directly for guidance regarding specific permitting needs. Contact a NYSDEC regional office for additional information (Appendix B).

3. MANAGEMENT ACTIVITIES UNDER DOT, COUNTY, OR LOCAL HIGHWAY DEPARTMENT JURISDICTION

Management of invasive species within a road right-of-way may require a highway work permit. Contact your DOT regional office (Appendix B) or county/local highway superintendent for more information.

BEST MANAGEMENT PRACTICES

The following BMPs are for invasive species that are already present in the Adirondack region, or present in New York State and approaching, and have the highest likelihood of causing significant negative ecological, economic, or societal impacts. Additional BMPs will be developed and incorporated over time as new species arrive and/or additional information on impacts becomes available. For management advice on other species not referenced in this document please refer to other resources or contact APIPP.

Terrestrial Invasive Plants

The following general infestation size thresholds are provided to inform the specific management activities most appropriate for each individual plant species. For the purposes of the following terrestrial invasive plant BMPs, four size thresholds will be referenced:

1) **Early Detection Infestation** – An early detection infestation is classified as being a discrete population under 0.1 acres (0.04ha).
2) **Small Infestation** – A small infestation is classified as being a discrete population over 0.1 acres (0.04ha) but under 1 acre (0.4ha).
3) **Medium Infestation** – A medium infestation is classified as being a discrete population over 1 acre (0.4ha) but under 2.47 acres (1ha).
4) **Large Infestation** – A large infestation is classified as being a discrete population over 2.47 acres (1ha).

Note: When treating infestations larger than one acre, consider active restoration (seeding or planting) following management to facilitate the recovery of desirable, native vegetation.

Garlic mustard *(Alliaria petiolata)*

Photo Credit: David Cappaert, Bugwood.org

Terrestrial Invasive Plant BMP's

Common Name	Scientific Name	Page Number
Bush honeysuckles	*Lonicera spp.*	23
Common & glossy buckthorn	*Rhamnus cathartica*	23
Common reed grass	*Phragmites australis*	17
Garlic mustard	*Alliaria petiolata*	14
Giant hogweed	*Heracleum mantegazzianum*	14
Glossy buckthorn	*Frangula alnus*	23
Indian cup plant	*Silphium perfoliatum*	14
Japanese & common barberry	*Berberis thunbergii & B. vulgaris*	23
Japanese angelica tree	*Aralia elata*	27
Japanese honeysuckle	*Lonicera japonica*	23
Japanese hops	*Humulus japonicus*	14
Japanese snowball	*Viburnum plicatum*	23
Japanese stiltgrass	*Microstegium vimineum*	10
Japanese tree lilac	*Syringa reticulata*	27
Knapweed spp. (brown & spotted)	*Centaurea stoebe & C. jacea*	14
Knotweed spp. (Japanese, giant, & Bohemian)	*Reynoutria japonica, R. sachalinensis, and R. x bohemica*	17
Lesser celandine	*Ficaria verna*	14
Mile-a-minute	*Persicaria perfoliata*	14
Multiflora & rugosa rose	*Rosa multiflora & R. rugosa*	23
Norway maple	*Acer platanoides*	27
Asiatic bittersweet	*Celastrus orbiculatus*	23
Porcelain berry	*Ampelopsis glandulosa*	23
Purple loosestrife	*Lythrum salicaria*	14
Reed canary grass	*Phalaris arundinacea*	10
Russian & autumn olive	*Elaeagnus umbellata & E. angustifolia*	23
Scotch broom	*Cytisus scoparius*	23
Slender false brome	*Brachypodium sylvaticum*	10
Small carpetgrass	*Arthraxon hispidus*	10
Swallowwort spp. (black & pale)	*Vincetoxicum louiseae & V. rossicum*	14
Sweetclover spp. (white and yellow)	*Melilotus albus & M. officinalis*	14
Tree-of-heaven	*Ailanthus altissima*	27
Wild parsnip	*Pastinaca sativa*	14
Wineberry	*Rubus phoenicolasius*	23
Winged euonymus	*Euonymus alatus*	23
Yellow iris	*Iris pseudacorus*	17

GRASSES

Due to their similar biology and growth habits, most invasive grasses can be managed using comparable techniques. The following species can be managed using the general BMPs included in this section:

Grasses	
Japanese stiltgrass	*Microstegium vimineum*
Reed canary grass	*Phalaris arundinacea*
Slender false brome	*Brachypodium sylvaticum*
Small carpetgrass	*Arthraxon hispidus*


Japanese stiltgrass


Reed canary grass


Slender false brome


Small Carpetgrass

PLANT DESCRIPTIONS

JAPANESE STILTGRASS is an annual grass native to Asia. It prefers moist soil and can thrive in a variety of light conditions, including heavily shaded areas. Japanese stiltgrass readily invades forest understories, marshes, floodplains, wetlands, etc. where it forms dense carpets that displace native vegetation, interfere with forest regeneration, and alter soil chemistry. It grows one to three feet (0.3-1m) tall and has a small stem that resembles bamboo. The leaves are narrow and lance-shaped with a prominent silver strip that runs along the midrib on the upper surface. The inflorescence of Japanese stiltgrass is inconspicuous, appearing from late summer to early fall. It spreads primarily by human and wildlife dispersed seeds and infestations are often exacerbated in areas with high deer abundance.

REED CANARY GRASS is a tall, coarse, perennial grass native to parts of Europe, Asia, and North America. It commonly invades open canopy wetlands and riparian corridors but can also be found in drier sites. Reed canary grass can form dense infestations that displace native vegetation, degrade wildlife habitat, and alter wetland hydrology. Its leaves are tapered and grow up to 10 inches (25cm) long. The flowers are single and occur in dense clusters from May to August. New inflorescences range from green to purple and will transition to a light brown at maturity. The ligule of reed canary grass is transparent, distinguishing it from several native grass species. Spread occurs vegetatively via creeping rhizome and by seed; however, the establishment of seeds is assumed to be low.

SLENDER FALSE BROME is an annual bunch grass native to Eurasia. It is highly invasive in a wide range of habitats including wetlands, forests, and disturbed sites, where it often excludes native grasses and forbs. It is well adapted to a variety of light and soil conditions, allowing it to become the dominant species in the plant community. Mature plants reach 18+ inches (46cm) tall and have a distinctive drooping growth habit. The leaf blades are bright green and have fine hairs along the margins. The lower stem is also covered with fine white hairs. Roots have a prominent wintergreen aroma when crushed. It is primarily spread by human and wildlife dispersed seeds produced between June and September. Slender falsebrome infestations are often exacerbated in areas with high deer abundance.

SMALL CARPETGRASS is a quick growing annual grass native to Asia. It prefers well lit, moist areas and thrives in disturbed wetland and riparian areas. This quick growth coupled with its ability to reproduce quickly allows small carpetgrass to form monocultures, excluding native plants. It grows up to 18 inches (46 cm) in height. The leaves are bright green, often hairy along the edges, and clasp the stem. Flowers emerge in late summer and are characterized by a greenish to purple inflorescence with up to ten "fingers." Small carpetgrass can reproduce via prolific seed production as well as vegetatively via rooting at nodes.

Japanese stiltgrass infestation

Photo Credit: The Nature Conservancy

MANAGEMENT OPTIONS

1. Digging/Pulling

Effectiveness:
Non-mechanized digging or hand pulling is an effective method for containing, suppressing, or locally eradicating early detection infestations of invasive grasses. Mechanical management should be performed prior to seed set, typically before mid-summer.

Methods:
Slowly dig or pull each plant up by the base to ensure the entire root system is removed. Root fragments that are left behind may re-sprout into new plants. Disturbed soil should be tamped down firmly after removing plants. Soil disturbance can bring seeds to the surface and create a favorable environment for germination within the control site. Plants should be removed before seed set. Refer to the plant descriptions above for phenological information.

Disposal:
Bag all plant parts and remove from site. Solarize by placing bagged plant material in the sun for at least two-weeks and then dispose of in an approved landfill.

2. Cutting/Mowing

Effectiveness:
Cutting or mowing can be effective in containing or suppressing early detection to medium sized infestations of invasive grasses. Persistent mowing/cutting will prevent seed production/dispersal but is unlikely to result in local eradication as dormant seeds in the soil are unaffected by this technique.

Methods:
Cut or mow the invasive grass at ground level manually or with motorized equipment just before its flowering period, typically by mid-summer. Follow-up mowing/cutting may be required within a growing season and must be repeated annually. Do not mow or cut plants during seed set as this will aid in seed dispersal.

Disposal:
If possible, bag all cut plant parts and remove from site. Solarize by placing bagged plant material in the sun for at least two-weeks and dispose of in an approved landfill. Mowed or mulched material can be left to decompose on site.

3. Herbicide

Effectiveness:
Herbicide treatments can be effective in containing or locally eradicating early detection to medium-sized infestations and suppressing large infestations of invasive grasses. Invasive grasses can be effectively controlled by glyphosate-based herbicides.

Methods:
Apply glyphosate-based herbicide using one or more of the selective application techniques identified below. Treatments should be performed close to peak growth, but before seed production.

For herbicide treatments use any of the following application techniques:

a) Wiper application - sponge tip applicator with wick or cloth glove applicator.
b) Foliar spray application - commercial-grade spray bottle with adjustable nozzle, backpack sprayer with adjustable nozzle, boom/broadcast sprayer and/or spot sprayer.

Disposal:
Plants should remain undisturbed for at least two weeks following treatment. No disposal is required.

HERBACEOUS PLANTS AND VINES

Due to their similar biology and growth habits, many invasive herbaceous plants can be managed using comparable techniques. The following species can be managed using the general BMPs included in this section:

Herbaceous Plants and Vines	
Garlic mustard	*Alliaria petiolata*
Giant hogweed	*Heracleum mantegazzianum*
Indian cup plant	*Silphium perfoliatum*
Japanese hops	*Humulus japonicus*
Knapweed spp.	*Centaurea stoebe & C. jacea*
Lesser celandine	*Ficaria verna*
Mile-a-minute	*Persicaria perfoliata*
Purple loosestrife	*Lythrum salicaria*
Swallow-wort spp.	*Vincetoxicum louiseae & V. rossicum*
Sweetclover spp.	*Melilotus albus & M. officinalis*
Wild parsnip	*Pastinaca sativa*


Garlic mustard


Giant hogweed


Indian cup plant


Japanese hops


Knapweed spp.


Lesser celandine


Mile-a-minute


Purple loosestrife


Swallow-wort spp.


Sweetclover spp.


Wild parsnip

PLANT DESCRIPTIONS

GARLIC MUSTARD is a European biennial herb that typically invades partially shaded forest understories and roadsides. It exudes an allelopathic compound from its root system that can suppress the growth of surrounding vegetation, negatively impact mycorrhizal fungi and reduce forest regeneration. Its seeds germinate in early spring and develop into a basal rosette of leaves during the first year. Leaves have a distinct onion/garlic aroma when crushed. Second-year flowering plants average three feet (1m) in height with white, cross-shaped flowers blooming between late April and June. Seeds mature and disperse in late July, are spread by both humans and wildlife, and may remain viable in the soil for up to seven years. Garlic mustard infestations are often exacerbated in areas with high deer abundance.

GIANT HOGWEED is a biennial or perennial herbaceous plant native to Eurasia that can exceed 15 feet (4.6m) in height. It can form dense stands and spreads quickly in disturbed areas such as abandoned fields and roadsides. The sap of giant hogweed is highly caustic – chemicals activated by sunlight may cause serious burns and blistering to exposed skin. In its first one to three years of growth, giant hogweed exists as an increasingly larger rosette. Its basal leaves are large and deeply divided, typically with three prominent lobes. Once mature, it produces a flowering stalk with several large, white umbels that can exceed two feet in diameter. Stems are characterized by coarse white hairs and purple/dark-red spots. Plants produce a large quantity of seeds that are easily dispersed by wind, water, and on equipment.

INDIAN CUP PLANT is a large perennial native to central North America that can reach eight feet (2.4m) in height. It can form dense stands that spread quickly in wetlands and along river corridors, excluding native species. Its stems are stout and uniquely square in cross section. The leaves are opposite and are joined to form a cup around the stem. The leaves are rough in texture and have finely serrated margins. Flowers are bright yellow, two to three inches (5-8cm) wide with 16-35 rays. Plants spread locally via rhizomes and can disperse longer distances via seeds carried by water and wind.

JAPANESE HOPS are herbaceous, annual twining vines native to temperate Asia that can reach lengths of up to 35 feet (10.6m). It prefers well-lit, moist areas and typically colonizes areas such as streambanks, floodplains, roadsides, and forest edges. Japanese hops grow rapidly and is capable of smothering native plants. It can form dense matts several feet deep, that block light to the plants underneath, preventing new plants from emerging. Additionally, it is able to twine around understory trees and shrub which can cause them to break or fall over. feet. Leaves have five to seven palmately (like a hand) arranged lobes with toothed edges. Both leaves and stems have hooked hairs present. These hooked hairs on the stem can be used to distinguish this species from look-a-likes and are characterized as sharp and downward pointing. Japanese hops flowers in mid-to-late summer with short flower spikes. Flowers are green in color with five petals. Seeds can be dispersed by wind, water, wildlife, and vehicles.

KNAPWEED SPP. are bushy, tap rooted biennials native to Europe. They can form large, monotypic stands in disturbed upland habitats and are most often associated with roadsides, railbeds, utility lines, forest edges, hiking trails, and open fields. In agricultural settings, knapweed can reduce grazing opportunities and increase soil erosion. Plants are allelopathic, producing chemicals that suppress the growth of surrounding vegetation. First year plants exist as a small basal rosette of deeply divided leaves. Second year plants grow up to three feet (1m) in height with leaves alternately arranged on the stem. Mature plants will bloom from late June to August, producing numerous flower heads at the tips of terminal or ancillary stems. Flowers are generally pinkish-purple, but in rarer instances, can be white. Each flower is surrounded by green scale-like structures called bracts. Knapweeds spread through prolific seed production. Each mature plant can release over 1000 seeds that can remain dormant in the soil for up to 10 years. New rosettes may also develop from lateral roots.

LESSER CELANDINE is a short lived herbaceous perennial native to Eurasia. It can form a dense carpet of vegetation that excludes native ephemeral plants in open woods, floodplains and wet meadows. Plants senesce early in the spring, often exposing large patches of bare soil that are prone to erosion. Plants are comprised of a basal rosette of dark green, kidney shaped leaves. It flowers early in the spring, between late March and May, producing bright yellow flowers, each with 8-12 petals. Plants spread vegetatively via small underground bulbils and tuberous roots.

MILE-A-MINUTE is an herbaceous, annual climbing vine native to Asia. Once established, vines can grow up to six inches (15cm) per day. Large mats can quickly smother native vegetation and alter the quantity of light filtering through the forest canopy. In additional to its ecological impacts, mile-a-minute can disrupt recreational opportunities with its spine-covered stems. The delicate, branched stems have alternately arranged triangular leaves. Ocreae, or circular shaped leaves, can be found surrounding the stem near its nodes. Flowers are small and inconspicuous, but give rise to attractive metallic blue berries, which begin growing in July. Seeds can spread long distances via wildlife or water.

PURPLE LOOSESTRIFE is an herbaceous perennial native to Eurasia that can form large, monotypic stands that exclude native vegetation in open wetlands, drainage ditches, and along shorelines. Dense infestations can degrade waterfowl habitat, reduce furbearer populations, and negatively impact hay/forage fields. Plants average three feet (1m) in height and produce vigorous rootstock that serves as a storage organ for growth in spring and re-growth if the plant is damaged. Stems are square-shaped and produce leaves that are opposite, whorled, and lance-shaped with smooth edges. Plants produce several, vibrant magenta flower spikes between early July and September. A single mature plant can produce more than 2.5 million seeds per growing season, which are easily transported by water and human activities.

SWALLOW-WORT (BLACK & PALE) are herbaceous twining vines native to Europe that grow up to ten feet (3m). Vines typically twine and sprawl, shading out or smothering desirable vegetation. The foliage of swallow-wort is toxic to some wildlife and livestock. In forest understories, swallow-wort can impact forest regeneration. Both species have opposite, shiny leaves that are 2-4 inches (5-10cm) long. Black swallow-wort usually bears purple-black, star shaped flowers while pale swallow-wort usually bears light maroon, star shaped flowers. The flowers of black swallow-wort have petals that are about half as wide (at the base) as they are long, whereas the flowers of pale swallow-wort are much narrower at the base than their length. Both species produce long slender green seed pods around June, which bear numerous seeds that are dispersed by wind and wildlife. Seeds resemble common milkweed and are rounded and flattened with an attached tuft of silky hair.

SWEETCLOVER (WHITE AND YELLOW) are biennial invasive plants native to Europe that form large, monotypic stands in upland environments. Sweetclover prefers full sunlight and is most often associated with disturbed habitats such as roadsides, forest edges, and hiking trails. Dense infestations alter native seedling recruitment which can result in long term changes to plant communities and soil properties. First year plants do not bloom and exist as a small basal rosette of deeply divided leaves. Second year plants can reach six-feet (1.8m) in height with leaves alternately arranged on the stem. The small fragrant flowers appear in June through July and are located terminally on the branches. Flowers are creamy white or bright yellow depending on the species. Sweetclover spreads primarily by seed, which is persistent and can remain viable in the soil for up to 30 years. Plants can sprout from root fragments.

WILD PARSNIP is a biennial or perennial herbaceous plant native to Eurasia that can grow over five feet (1.5m) tall. It can form dense stands and spread quickly in disturbed areas such as abandoned fields and roadsides. The sap of wild parsnip is highly caustic – chemicals activated by sunlight may cause serious burns and blistering to exposed skin. It exists as a low, spindly rosette of leaves in the first year while the root develops. In the second year, it flowers on a tall stalk and then dies. Its leaves are pinnately compound with saw-toothed edges. Branching stems bear umbels of small yellow flowers from mid-June to early August. It spreads primarily by seeds, which are dispersed by wind, water, and on equipment.

MANAGEMENT OPTIONS

1. Digging/Pulling

Effectiveness:
Non-mechanized digging or hand pulling is an effective method for containing, suppressing, or locally eradicating early detection infestations of invasive herbaceous plants. Mechanical control is most effective when performed before seed/fruit production.

Methods:
Dig or pull up each plant by the base to ensure the entire root system is removed. Disturbed soil should be tamped down firmly after removing plants. Soil disturbance can bring existing invasive plant seeds to the surface, creating a favorable environment for germination. Plants should be removed around peak flower, but before seed set. Refer to the plant descriptions above for phenological information.

Disposal:
Bag and remove all plant parts from site. Solarize by placing bagged plant material in the sun for at least two-weeks and then dispose of in an approved landfill. Do not compost invasive plant material.

2. Cutting/Mowing

Effectiveness:
Cutting or mowing can be effective in containing or suppressing early detection to large-sized infestations of invasive herbaceous plants. Mowing or cutting must be repeated annually to reduce an infestation to desired levels as dormant seeds in the soil are unaffected by this technique.

Methods:
Cut or mow invasive herbaceous plants at ground level either manually or with motorized equipment just before their flowering period, typically by mid-summer. Follow-up mowing/cutting may be required within a growing season. Do not mow or cut plants when in seed set as this will aid in seed dispersal. In addition, do not use a weed-whacker or brush cutter to mow giant hogweed or wild parsnip. Mechanized cutting equipment can splatter the plants toxic sap leading to injury. Instead, use a sharp spade to cut the taproot or each plant approximately 6-10 inches (15-25cm) below the soil surface. If plants return, repeat the root cutting procedure.

Disposal:
If possible, bag all cut plant parts and remove from site. Solarize by placing bagged plant material in the sun for at least two-weeks and then dispose of in an approved landfill. Mowed or mulched plant material can be left to decompose on-site.

3. Herbicide

Effectiveness:
Herbicide treatments can be effective in containing or locally eradicating early detection to medium-sized infestations and suppressing large infestations of invasive herbaceous plants. Invasive herbaceous plants can be effectively controlled by glyphosate, triclopyr, or imazapyr based herbicides. Glyphosate and triclopyr will not affect subsequent plant emergence; however; the use of imazapyr may inhibit regrowth for several months or years.

Methods:
Apply glyphosate, triclopyr, or imazapyr formulations using the selective application techniques identified below. Herbicide applications should be performed close to peak flower, but before seed set. The rosettes of biennial species may be treated later in the season following senescence of native species. Consult the herbicide product label for recommended dilution rates and to ensure the target species, desired application technique, and habitat type (upland vs. wetland) are listed and approved.

For herbicide treatments use any of the following application techniques:

a) Wiper application - sponge tip applicator with wick or cloth glove applicator. This technique is most often used with glyphosate-based herbicides.
b) Foliar spray application - commercial-grade spray bottle with adjustable nozzle, backpack sprayer with adjustable nozzle, boom/broadcast sprayer and/or spot sprayer. This technique can be used with most herbicide active ingredients.
c) Stem injection application (hollow stemmed species) - stem injection tool with a short, stout needle. This technique is most often used with glyphosate-based products.

Disposal:
Plants should remain undisturbed for at least two weeks following herbicide application. No disposal is required.

4. Biocontrol (NOTE: biocontrols are only used to control purple loosestrife at this time; biocontrols are available for mile-a-minute but infestations in the region are too small to warrant use in the region; biocontrols are under evaluation for swallow-wort)

Effectiveness:
Biocontrol releases of *Galerucella calmariensis* and *G. pusilla* can be effective in suppressing medium- to large-sized infestations of purple loosestrife. Release sites should have healthy, mature loosestrife plants and assurance from the landowner(s) that no insecticide spraying will occur. Biocontrol is most effective in areas that are not permanently flooded and have at least one acre of purple loosestrife of medium to high density.

Methods:
Beetles may be purchased from commercial suppliers or collected from historic release sites and moved to new areas. The number of beetles released per site depends on the infestation size, resources available, and seasonal timing. When releasing *Galerucella* in the spring, as few as 200 adults can be sufficient to establish a population. When collecting or releasing a summer generation, a minimum release of 2,000 insects is recommended.

Galerucella should be released as soon as they are collected or received. It is not necessary to wait for clear weather but avoid heavy rain events. Selecting periods of cool weather (morning or early evening) can increase the survival and establishment of the insects. If possible, avoid open water and release *Galerucella* near the shore or on dry land. It is not necessary to disperse the insects at multiple locations within an infestation, as insects will spread naturally on their own.

Disposal:
Plants should remain undisturbed following the release of biocontrol agents. No disposal is required.

APIPP staff releasing *Galerucella* beetles to control purple loosestrife.

Photo Credit: The Nature Conservancy

CLONAL PLANTS

The following species are characterized by extensive rhizome systems and the ability to spread clonally via root and/or stem fragmentation, which presents unique management challenges. The following species can be managed using the general BMPs included in this section:

Clonal Plants	
Common reed grass	*Phragmites australis*
Knotweed species	*Reynoutria japonica, R. sachalinensis, and R. x bohemica*
Yellow iris	*Iris pseudacorus*

Common reed grass

Knotweed spp.

Yellow iris

PLANT DESCRIPTIONS

COMMON REED is a perennial grass native to Europe that can grow over 14 feet (4.3m) in height. It is capable of vigorous vegetative reproduction and often forms dense, monospecific stands that exclude native plants. Established infestations can negatively impact the structure and hydrology of wetlands soils and degrade wildlife habitat. Purple-hued seed heads develop between July and September, turning light brown at maturity. It is believed that most seeds produced in the Adirondack region are non-viable and most spread occurs through the unintentional human-mediated movement of rhizome material. *NOTE: A native linage of Phragmites is present in New York State. Please consult a professional for identification guidance before beginning management.*

KNOTWEED SPECIES are herbaceous perennial shrubs native to Eastern Asia that can exceed ten feet (3m) in height. They spread rapidly to form large, dense thickets that exclude native vegetation near water sources, in low-lying areas, waste areas, and utility rights-of-way. Dense infestations along riparian corridors can increase erosion and impede recreational opportunities. Knotweeds can tolerate a variety of adverse conditions including full shade, high temperatures, high salinity, and drought. There are multiple species of invasive knotweed, including Japanese, giant and bohemian. All are closely related in biology and appearance and can be managed using comparable techniques. Knotweed species have broad, heart-shaped leaves that are pointed at the tip and alternately arranged on the stem. Their stems are green and hollow with prominent raised ridges/nodes, giving the plant a bamboo like appearance. Large clusters of small white flowers appear on the branches in August and September. Knotweed spreads via seed and by vegetative expansion through stout, aggressive rhizomes.

YELLOW IRIS is a robust, clumping perennial native to Europe, Asia and parts of Africa. It can form dense monotypic stands that replace and crowd out native plants. It's dense network of rhizomes can alter soil properties and damage or clog underground water/sewer pipes. At maturity, plants can reach five feet (1.5m) with stiff, sword-like leaves. Bright yellow, three petaled flowers are present from mid-June to early July. It can be distinguished from its native lookalike (blue flag iris) by its rhizomes. The interior of yellow iris rhizomes are orange to pink, while the interior of native iris rhizomes are white. Yellow iris spreads via water dispersed seed, and fragmentation and/or expansion of its extensive rhizome system.

MANAGEMENT OPTIONS

1. Digging/Pulling

Effectiveness:
Non-mechanized digging or pulling can be effective in containing, suppressing, or locally eradicating early detection infestations of clonal species.

Methods:
Dig or pull up the entire plant including all roots and runners using a digging tool. Extreme care must be taken to remove the entire root system, as new plants can sprout from residual fragments. Small plants may be hand-pulled depending on soil conditions and root development. Disturbed soil should be tamped down firmly after removing plants.

Disposal:
Bag and remove all plant parts from site. Solarize by placing bagged plant material in the sun for at least two-weeks and then dispose of in an approved landfill. Do not compost invasive plant material.

2. Herbicide

Effectiveness:
Herbicide treatments can be effective in containing, or locally eradicating early detection to medium-sized infestations and suppressing large infestations of clonal species. Apply glyphosate, triclopyr, imazapyr, and/or imazamox based herbicides using the selective application techniques described below. Glyphosate will not affect subsequent plant emergence; however, the use of imazapyr or imazamox may inhibit regrowth for several months or years.

Methods:
Apply glyphosate, triclopyr, imazapyr, and/or imazamox formulations using the selective application techniques identified below. Herbicide applications should be performed near peak growth, typically in August or September. Consult the herbicide product label for recommended dilution rates and to ensure the target species, desired application technique, and habitat type (upland vs. wetland) are listed and approved.

For herbicide treatments use any of the following application techniques:

a) Foliar spray application - commercial-grade spray bottle with adjustable nozzle, backpack sprayer with adjustable nozzle, boom/broadcast sprayer and/or spot sprayer. This technique can be used with most herbicide active ingredients.
b) Clip and drip or stem injection application:
    - For *common reed grass* - cut the stem near the base and fill its hollow cavity with 2-5ml of glyphosate-based herbicide. Most herbicide product labels recommend a 50% v/v solution.
    - For *knotweed spp.* – using a specialized stem injection system, deliver 2-5ml of undiluted glyphosate-based herbicide directly into the plants hollow stem. Injections are typically made between the 2nd and 3rd node from the soil surface.
    - For *yellow iris* – cut a flowering stalk and inject the plants fleshy pith with 0.5-1ml of undiluted glyphosate-based herbicide.

Disposal:
Plants should remain undisturbed for at least two weeks following herbicide application. No disposal is required.

3. Excavation (mechanized)

Effectiveness:
Excavation can be effective in suppressing, containing, or locally eradicating early detection to small-sized infestations of clonal species. Associated costs and disturbance can be limiting factors for this control method.

Methods:
Excavate plants below depth of rhizome - typically at least four feet (1.2 m) - including a buffer area of at least five feet (1.5m) around visible plants to account for underground roots and rhizomes.

Note: Excavation within 100 feet (30m) of a waterbody can cause erosion and/or bank destabilization and may be subject to regulation. Contact the Adirondack Park Agency or NYSDEC (Appendix B) before proceeding.

Disposal:
Contaminated soil and plant material should be buried at least five feet (1.5m) deep in a disposal pit. The disposal site should be monitored annually for at least five years to ensure no new plants emerge.

Excavated material may also be spread on a contained, impervious surface to dry out for at least two years. Spread the material in an even, thin layer – approximately 1 foot (30cm) thick – to facilitate even heating. If necessary, treat emerging plants with herbicide.

Knotweed spp. *(Reynoutria spp.) in flower.*
Photo Credit: The Nature Conservancy (Zachary Simek)

WOODY VINES AND SHRUBS

Due to their similar biology and growth habit, many invasive woody vines and shrubs can be managed using comparable techniques. The following species can be managed using the general BMPs included in this section:

Woody Vines and Shrubs	
Bush honeysuckles	*Lonicera spp.*
Common and glossy buckthorn	*Rhamnus cathartica & Frangula alnus*
Japanese and common barberry	*Berberis thunbergii & B. vulgaris*
Japanese honeysuckle	*Lonicera japonica*
Japanese snowball	*Viburnum plicatum*
Multiflora and rugosa rose	*Rosa multiflora & Rosa rugosa*
Asiatic bittersweet	*Celastrus orbiculatus*
Porcelain berry	*Ampelopsis glandulosa*
Russian and autumn olive	*Elaeagnus umbellate & E. angustifolia*
Scotch broom	*Cytisus scoparius*
Wineberry	*Rubus phoenicolasius*
Winged euonymus	*Euonymus alatus*


Bush honeysuckle spp.


Buckthorn spp.


Barberry spp.


Japanese honeysuckle


Japanese snowball


Rose spp.


Oriental bittersweet


Porcelain berry


Olive spp.


Scotch broom


Winged euonymus


Wineberry

PLANT DESCRIPTIONS

BUSH HONEYSUCKLES (Morrow's, Bell's, Amur, and Tatarian) are multi-stemmed, deciduous shrubs native to Asia that grow up to 25 feet (7.6m) in height. They can form dense stands, even in shaded conditions, that exclude native plant species. Areas invaded by bush honeysuckles are known to have higher populations of ticks and greater incidences of tick related illness. Bush honeysuckles have simple leaves with smooth margins that are arranged alternately on the stem. Their flowers bloom in spring, typically around May, and are white, pink, or yellow. The fruits of bush honeysuckle are red, orange, or rarely yellow fleshy berries. Exotic honeysuckles can be distinguished from native varieties by their hollow stems. All species are spread by bird and animal dispersed seed.

COMMON BUCKTHORN is a deciduous shrub native to most of Europe and western Asia that can reach heights of 25 feet (7.6m). It can be found along forest edges, understories, and rights-of-way where it outcompetes native vegetation. Changes to the plant community composition result in altered litter decomposition and soil nutrient cycling. The main stem of common buckthorn can grow up to 10 inches (25cm) in diameter but is more commonly 1-3 inches (2.5-7cm). Leaves are dark-green and oval with toothed margins and 3-5 pairs of distinct arching veins. It can be distinguished from other buckthorns by its sharp, thorn tipped branches. Small, round, black berries ripen in the fall and are readily consumed by birds and other wildlife – serving as the primary spread mechanism.

GLOSSY BUCKTHORN is a deciduous shrub native to Eurasia that can reach 10-25 feet in height (3-7.6m). It grows in a wide variety of sites, including disturbed and nutrient poor habitats such as rights-of-way, forest edge, and wetlands. It is particularity invasive in wetlands where it outcompetes native vegetation and alters community composition through allelopathy. Bark is gray or brown with conspicuous white lenticels. Leaves are dark green with a shiny upper surface and 8-9 pairs of distinct arching veins. Pale yellow flowers grow from the leaf axils, turning to dark red or purple berries. Seeds are spread by birds and moving water, where they can remain buoyant for up to two weeks.

JAPANESE AND COMMON BARBERRY are spiny deciduous shrubs that can exceed ten feet (3m) in height. Japanese barberry is native to east Asia, while common barberry occupies central and southern Europe and west Asia. Their dense, thorny habit can exclude native species and impede recreational activities. Areas invaded by barberry are known to have higher populations of ticks and greater incidences of tick related illness. Leaves of Japanese barberry are small and oval with smooth margins, while common barberry has toothed margins. Japanese barberry has two common color morphs, a dark-green and deep-purple variety, while common barberry is typically only green. Japanese barberry has a single spine at each node where the leaves meet the stem, while common barberry has three spines. Flowers are very small, white to yellow in color, and bloom in April or May. Fruits are small, oval, bright-red berries less than 0.5 inches (1cm) long. The inner roots and stem of barberry are vibrant yellow in color. Both species are spread readily by bird dispersed seed. Barberry infestations are often exacerbated in areas with high deer abundance.

JAPANESE HONEYSUCKLE is a perennial trailing or climbing woody vine native to east Asia. It is most common at disturbed, open sites such as forest edges and rights-of-way. Its dense growth habit excludes native species, while its climbing stems can smother or topple host plants. The foliage and fruit of Japanese honeysuckle provide little value for native wildlife. Leaves are oval and approximately 2-4 inches (5-10cm) long. Fragrant white flowers are produced in late April through July. Fruits are small black berries that are produced September through November. Seeds are spread primarily by birds and other wildlife.

JAPANESE SNOWBALL is a perennial shrub native to temperate Asia that can reach heights of 15 feet (4.5m). It can grow in full sun to partial shade and can be found invading both disturbed habitats such as roadsides, and natural areas such as riparian areas, forest edges and interiors, and shrublands. Dense thickets crowd and shade out native vegetation and can also increase sedimentation rates along waterways. Leaves are simple, opposite, and oval shaped with serrated edges. There are distinct veins on the top of the leaves that run from the midride to the edge. Leaves turn a deep reddish-purple color in the fall. Flowers occur as white clusters in mid-spring with small fruits ripening from red to black as summer progresses. Japanese snowball is utilized as an ornamental species and can escape cultivation via bird and animal dispersed seeds.

MULTIFLORA AND RUGOSA ROSE are thorny, perennial shrubs native to east Asia that can grow up to 15 feet (4.6m). Their dense, thorny habit can exclude native species and impede recreational activities. Stems are long, flexible, green or reddish in color, and covered with numerous stiff, recurved thorns. Leaves are alternate and compound. Multiflora rose often has 5-11 one-inch (2.5cm) leaflets, while rugosa rose has 7-9 (rarely 5). The leaf margins are toothed for both species. Invasive rose species bloom in late spring or early summer, producing numerous clusters of showy white or pink flowers. The flowers are small - 1 inch (2.5cm) wide - with five petals. In summer, flowers develop into small, hard red fruits approximately 1/4 inch (<1cm) in size. Both species spread through bird dispersed seed.

ASIATIC BITTERSWEET is a rapidly spreading deciduous vine native to Asia. It twines around and drapes itself over other trees and shrubs in successional fields and along forest edges, often completely covering the supporting vegetation. Its characteristically bright orange roots can alter soil pH and nutrient levels, affecting plant community composition. Stems are round, light to dark brown, usually with noticeable lenticels. Leaves are round, glossy on the upper surface, and alternately arranged. Small greenish flowers occur in clusters in the leaf axils. Fruits are green to yellow berries that begin developing around July and transition to red-orange in late summer. This species may be distinguished from the native American bittersweet (*Celastrus scandens)* by the location of its fruit. Asiatic bittersweet has small clusters in the leaf axils while *C. scandens* has clusters only at its branch tips. It can be spread long distances via bird dispersed seeds.

PORCELAIN BERRY is a woody, perennial climbing vine native to Asia. If occurs in open, edge habitats where mature vines can reach 20 feet (6m) into the canopy, blocking light and smothering native plants below. Heavy infestations can suppress the regeneration of native tree seedlings and degrade wildlife habitat. Leaves are alternate and dark green with 3-5 lobes. Flowers are small, greenish white, and appear from May through August. Vines begin to produce bright blue or purple, speckled berries in late-summer. Berries are readily spread long distances by birds.

RUSSIAN AND AUTUMN OLIVE are deciduous shrubs native to parts of Asia and Russia, that can reach 20 to 35 feet (6-10m) in height. They prefer disturbed sites such as forest edges or rights-of-way, where they form dense stands that exclude native plants. Both species have nitrogen fixing capabilities that provide a large advantage over native species. The leaves of autumn olive are oval and alternately arranged on the stem, with a green upper surface and silver underside. The leaves of Russian olive are more elongate, resembling a willow, and are silver on both sides. Twigs of both species are gray and often armed with sharp thorns. Flowers have four petals, are fragrant, white to yellow, and appear in late spring. The fruit of both species is a small, round berry. Autumn olive berries are typically red, while Russian olive berries are yellow-orange. Both species prefer disturbed sites, where they establish and spread via animal dispersed seed.

SCOTCH BROOM is a perennial shrub native to Europe that grows up to 10 feet (3m). It can fix nitrogen, allowing it to become established in poor sites where it may form dense thickets that decrease the richness and diversity of native plants. Established infestations can alter soil properties. Leaves are small, alternate, and compound with three leaflets. Stems are a prominent green and five-sided. Shrubs bloom early in the season from late May to June, producing small bright-yellow flowers along the length of the stem. Flowers give rise to fuzzy, flat seed pods that can be up to 1.5 inches (4cm) long. When seed pods are ripe, they split and eject seeds up to 20 feet (6m) where they may remain viable for up to 60 years in the soil.

WINEBERRY is a perennial shrub in the rose family native to parts of east Asia. It prefers moist soil and full to partial sunlight, and can readily invade forest edges, fields, forest understories, and wetland edges. Dense infestations exclude native vegetation and can impact recreational use. Leaves are light-green on top and white below, alternate, and compound with three heart-shaped leaflets. Branches are long, arching, and covered with reddish-purple spines. Small greenish-white flowers appear in late spring to early summer, giving rise to edible red raspberry-like fruits in mid-summer. Plants can spread long distances via animal and bird dispersed seed, but also locally through vegetative expansion.

WINGED EUONYMUS also known as burning bush is a deciduous shrub native to central and east Asia that can grow up to 20 feet (6m) tall and wide. Shrubs are adaptable to a variety of soil and light conditions, and can be found in forested wetlands, forest understories, riparian corridors, and rights-of-way. Dense stands exclude native species and can increase the populations of ticks, leading to greater incidences of tick related illness. Leaves are simple, opposite, and 1-3 inches (2.5-8cm) long with smooth edges. Green during the summer, foliage transitions to a vibrant red in the fall. Stems are green to brown in color with four prominent corky wings. Plants bloom in May or early June, producing small green flowers. Fruits mature in later summer as small, oval, bright red berries that are spread by birds.

Scotch broom (*Cytisus scoparius) in flower.*

Photo Credit: Eric Coombs, Oregon Department of Agriculture, Bugwood.org

MANAGEMENT OPTIONS

1. Digging/Pulling

Effectiveness:
Non-mechanized digging or pulling can be effective in containing, suppressing, or locally eradicating early detection infestations of invasive woody plants. Mechanical control is most effective when performed before seed/fruit production.

Methods:
Dig or pull up each stem by the base to ensure the entire root system is removed. Use a digging or leverage tool such as The Uprooter, Weed Wrench, or Honeysuckle Popper for larger individuals. Disturbed soil should be tamped down firmly after removing plants. Soil disturbance can bring existing invasive plant seeds to the surface, creating a favorable environment for germination. Plants should be removed around peak flower, but before seed set. Refer to the plant descriptions above for phenological information.

Disposal:
Woody debris can be mulched/chipped and left on-site or burned if allowed under local laws and regulations. Non-fruit bearing plants can be propped against or suspended from nearby tree trunks/branches with their roots exposed to decompose. They can also be arranged into brush piles for wildlife habitat.

2. Cutting/Mowing

Effectiveness:
Cutting or mowing/mulching can be effective in containing or suppressing early detection to large-sized infestations of invasive woody plants. Mowing or cutting/mulching must be repeated annually to reduce an infestation to desired levels as dormant seeds in the soil are unaffected by this technique. Do not mow or cut plants when in seed set as this will aid in seed dispersal.

Methods:
Cut or mow/mulch invasive woody vines and shrubs at ground level either manually or with motorized equipment just before seed production, typically by mid-summer. Follow-up mowing/cutting may be required within a growing season and must be repeated annually.

Some shrubs respond positively to cutting and may release numerous root suckers; follow up treatment with herbicide may be necessary to minimize regrowth.

Disposal:
Woody debris can be mulched/chipped and left on-site or burned if allowed under local laws and regulations.

3. Herbicide

Effectiveness:
Herbicide treatments can be effective in containing or locally eradicating early detection to medium-sized infestations and suppressing large infestations of invasive woody plants. Invasive woody plants can be effectively controlled by glyphosate, triclopyr, or imazapyr based herbicides. Glyphosate and triclopyr will not affect subsequent plant emergence; however; the use of imazapyr may inhibit regrowth for several months or years. Consult the herbicide product label for recommended dilution rates and to ensure the target species and desired application technique are listed and approved.

Methods:
Apply glyphosate, triclopyr, or imazapyr formulations using the selective application techniques identified below. Foliar applications should be performed close to peak flower, but before seed set. Cut stump and basal bark applications can be performed in the spring or fall for some species; consult the herbicide

product label for more information.

For herbicide treatments use any of the following application techniques:

a) Foliar spray application - commercial-grade spray bottle with adjustable nozzle, backpack sprayer with adjustable nozzle, boom/broadcast sprayer and/or spot sprayer. This technique can be used with most herbicide active ingredients.

b) Cut stump application - commercial-grade spray bottle with adjustable nozzle, backpack sprayer with adjustable nozzle, wash bottle, eye dropper, or paintbrush. This technique is primarily used with glyphosate or triclopyr based herbicides.

c) Basal bark application – commercial-grade spray bottle with adjustable nozzle, backpack sprayer with adjustable nozzle, or paintbrush. This technique is most often used with triclopyr based herbicides.

d) Hack and squirt – machete or ax with commercial grade spray bottle. This technique is most often used with glyphosate or imazapyr based herbicide.

Disposal:
Plants should remain undisturbed for at least two weeks following herbicide application. No disposal is required.

A forest understory invaded by Japanese barberry (*Berberis thunbergii).*

Photo Credit: The Nature Conservancy (Zachary Simek)

TREES

Due to their similar biology and growth habit, many invasive trees can be managed using comparable techniques. The following species can be managed using the general BMPs included in this section:

Trees	
Japanese angelica tree	*Aralia elata*
Japanese tree lilac	*Syringa reticulata*
Norway maple	*Acer platanoides*
Tree-of-heaven	*Ailanthus altissima*


Japanese angelica tree


Japanese tree lilac


Norway maple


Tree of heaven

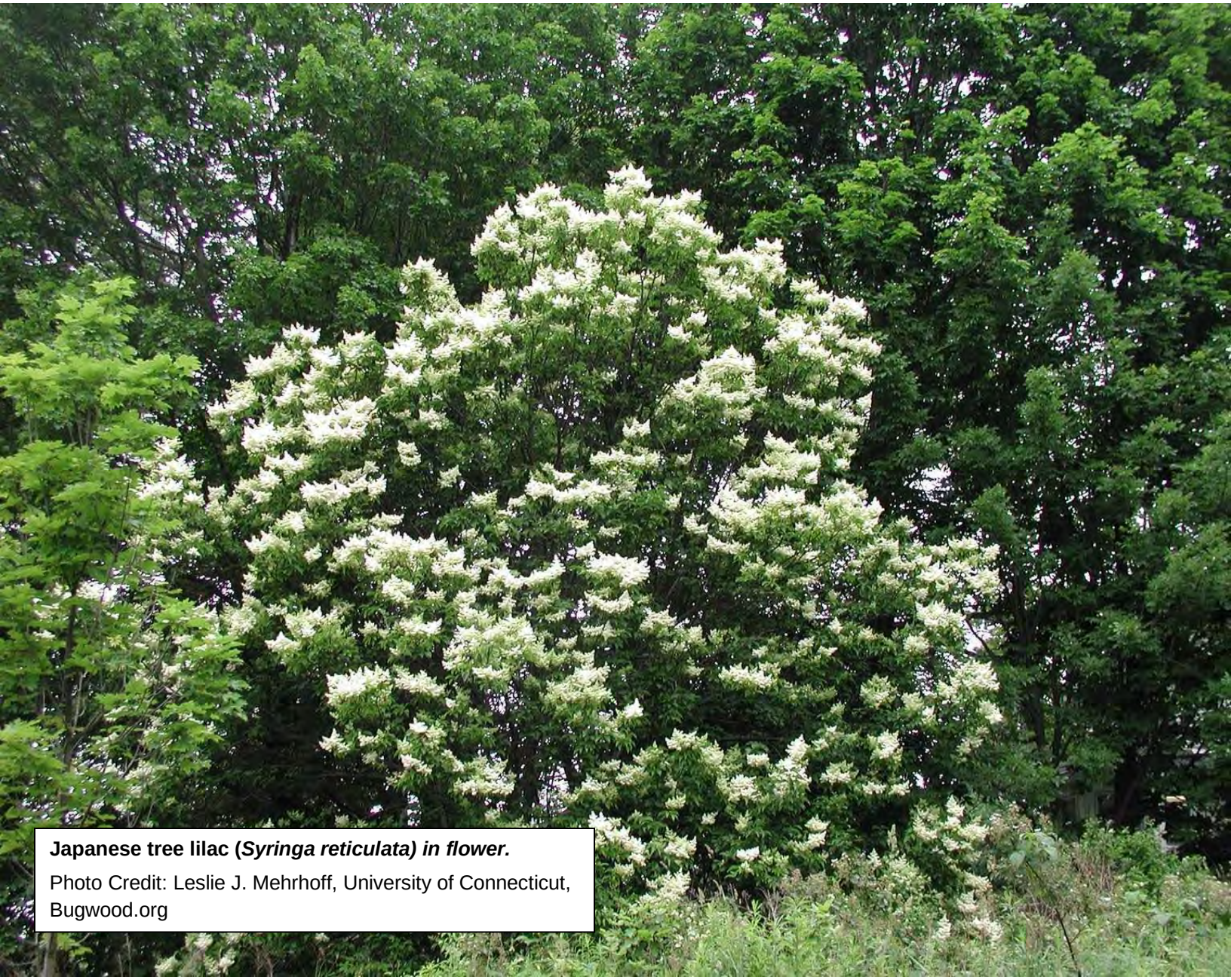
PLANT DESCRIPTIONS

JAPANESE ANGELICA TREE is a fast-growing deciduous tree native to Asia and eastern Russia. It can be found in forests, edge habitats, fields, and rights-of-way where it may form large thickets that displace native plant species and wildlife. Its thorny stem makes it of little value as forage for wildlife. Mature individuals can reach 40 feet (12m) or more under optimal conditions. Leaves are very large – up to four feet long – and compound with up to 80 oval leaflets. Clusters of white flowers appear in late summer, ripening to purplish-black round berries. This species is readily spread by bird dispersed seed.

JAPANESE TREE LILAC is a large shrub or small tree native to Asia that can reach 30 ft (10m) in height. It can tolerate a range of site conditions, and as a popular ornamental, is frequently found in yards or urban areas. It can escape cultivation and invade natural areas such riparian corridors and floodplains where it excludes native trees and shades out native plants in the understory. Oppositely arranged leaves are ovate and dark green with a rounded base. The reddish-brown bark of young trees is smooth with many horizontal lenticles (slits). Large bunches of small, fragrant white flowers bloom in early summer. These flowers ripen to green seed pods that turn brown in later summer and persist into the winter months. Spread occurs through dispersal of wind dispersed seeds and may occur via dispersal by water.

NORWAY MAPLE is a large, deciduous tree native to Europe and Asia than can exceed 65 feet (20m) in height. It produces numerous seeds that can grow in dense shade, outcompeting native understory tree species and impacting native forest regeneration. It can be distinguished from native maples by its leaves and petioles that ooze white, milky sap when cut or damaged. Leaves are dark green, with five to seven lobes. The bark is smooth and gray-brown, becoming more furrowed as the tree matures. Fruit are double-winged samaras arranged nearly 180 degrees from each other. Spread occurs locally through wind dispersed seed.

TREE-OF-HEAVEN is a fast-growing deciduous tree native to Asia that can exceed 80 feet (24m) in height. Each tree can release over 100,000 seeds and sprouts prolifically, lending to rapid population expansion. Tree of heaven excludes native vegetation, can increase maintenance requirements along rights-of-way, and is a primary host for the invasive spotted lanternfly (*Lycorma delicatula*). Leaves are compound with 10-41 smooth edged leaflets. Leaves have a rancid aroma when crushed, reminiscent of cat urine or burnt peanut butter. The fruit is a single winged samara, which forms in late summer from clusters of small yellow flowers. Spread occurs by both seeds and aggressive vegetative root sprouts.



Japanese tree lilac (*Syringa reticulata) in flower.*

Photo Credit: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

1.Digging/Pulling

Effectiveness:
Frequent non-mechanized digging or pulling can be effective in containing, suppressing, or locally eradicating early detection infestations of invasive trees ≤ 3" DBH. Well rooted, mature individuals cannot be effectively removed by this technique.

Methods:
Dig or pull each individual sapling from the soil, taking care to remove the entire root system. Mechanical management should be performed prior to fruit production in late summer. Use a digging or leverage tool such as The Uprooter, Weed Wrench, or Honeysuckle Popper for larger stems. Some species of invasive trees (ex: tree-of-heaven) may produce numerous root suckers in response to mechanical control; use herbicide to minimize re-sprouting. Disturbed soil should be tamped down firmly after removing plants. Soil disturbance can bring seeds to the surface and create a favorable environment for germination within the control site.

Disposal:
Woody debris can be mulched/chipped and left on-site or burned if allowed under local laws and regulations. Non-fruit bearing plants can be propped against or suspended from nearby tree trunks/branches with their roots up to decompose. They can also be arranged into brush piles for wildlife habitat.

2. Cutting

Effectiveness:
Cutting can be effective in containing or suppressing early detection to large-sized infestations of invasive woody trees. Cutting can be used to remove large stems to minimize or eliminate further seed production.

Methods:
Cut invasive woody trees either manually or with motorized equipment. Some invasive trees (ex: tree of heaven) respond positively to cutting and may release numerous root suckers; apply herbicide immediately to the stump after cutting to minimize re-sprouting.

Disposal:
Woody debris can be mulched/chipped and left on-site or burned if allowed under local laws and regulations.

2.Herbicide

Effectiveness:
Herbicide treatments can be effective in containing or locally eradicating early detection to medium-sized infestations and suppressing large infestations of invasive trees. Invasive trees can be effectively controlled by glyphosate, triclopyr, or imazapyr based herbicides. Glyphosate and triclopyr will not affect subsequent plant emergence; however; the use of imazapyr may inhibit regrowth for several months or years. Consult the herbicide product label for recommended dilution rates and to ensure the target species, desired application technique, and habitat type (upland vs. wetland) are listed and approved.

Methods:
Apply glyphosate, triclopyr, or imazapyr formulations using the selective application techniques identified below. Foliar applications should only be used for low-growing stems. Cut stump and basal bark applications can be performed in the spring or fall for some species; consult the herbicide product label for more information. Avoid use of imazapyr in the root zone of desirable tree species.

For herbicide treatments use any of the following application techniques:

a) Foliar spray application - commercial-grade spray bottle with adjustable nozzle, backpack sprayer with adjustable nozzle, boom/broadcast sprayer and/or spot sprayer. This technique is primarily used on small, low-growing stems and can be used with most herbicide active ingredients.

b) Cut stump application - commercial-grade spray bottle with adjustable nozzle, backpack sprayer with adjustable nozzle, wash bottle, eye dropper, or paintbrush. This technique is primarily used on large, tall stems and with glyphosate or triclopyr based herbicides. Cut stump applications are not recommended for tree-of-heaven as it responds with prolific resprouting.

c) Basal bark application – commercial-grade spray bottle with adjustable nozzle, backpack sprayer with adjustable nozzle, or paintbrush. This technique is most often used on large, tall stems with triclopyr based herbicides.

d) Hack and squirt – machete or ax with commercial grade spray bottle. This technique is most often used on large, tall stems with glyphosate or imazapyr based herbicide.

Disposal:
Plants should remain undisturbed for at least two weeks following herbicide application. No disposal is required.

Tree-of-heaven *(Ailanthus altissima)*

Photo Credit: www.treehelp.com

Terrestrial Invasive Animals

The following general infestation size thresholds are provided to inform the specific management activities most appropriate for each individual animal species. For the purposes of the following terrestrial invasive animal BMPs two size thresholds will be referenced:

1) **Early Detection Infestation** – An early detection infestation is classified as a discrete population under 10 acres (4ha).

2) **Established Infestation** – An established infestation is classified as being a discrete population that exceeds 10 acres (4ha).

Terrestrial Invasive Animal BMP's	
Common Name	**Scientific Name**
Emerald ash borer	*Agrilus planipennis*
Hemlock woolly adelgid	*Adelges tsugae*

- Effective management strategies are not available for beech leaf disease or jumping worms
- If you suspect oak wilt, please contact NYSDEC at 1-866-640-0652 or foresthealth@dec.ny.gov for more information
- There is no universal solution for spotted lanternfly, please contact APIPP to discuss your unique situation

Emerald ash borer

Hemlock woolly adelgid

HEMLOCK WOOLLY ADELGID

(Adelges tsugae)

PEST DESCRIPTION

Hemlock woolly adelgid (HWA) is an aphid-like insect native to Asia, Japan, and the pacific northwest that feeds on eastern hemlock. It is spread through wind, by movement of birds and wildlife, as well as planting of infested nursery stock. HWA feeds on hemlock twigs, producing a woolly bundle near the base of hemlock needles to protect itself and its eggs. HWA reproduces asexually in the US and produces two generations per year, allowing for rapid population growth. While this pest is impacted by cold winters, its high reproductive rate assures rapid reestablishment after cold weather events. Heavy infestations of HWA will usually result in tree mortality in 10-30 years.

MANAGEMENT OPTIONS

1. Pesticides

Effectiveness:
Systemic insecticides can be effective in suppressing, containing, or locally eradicating early detection-sized infestations. Treatment of individual infested trees, as well as a buffer area of un-infested hemlocks around the infestation, is appropriate for early detection infestations. Response time is critical; immediate treatment before the next dispersal period will greatly increase the potential for local eradication of HWA from the site and prevent continued spread. Imidacloprid and dinotefuran based insecticides can be effective in controlling HWA. Imidacloprid moves slowly through the tree, sometimes taking up to a year to reach the canopy. Older trees that may have compromised vascular systems or crown decline from adelgids may not be able to translocate imidacloprid into the crown quickly enough to survive. However, treatments with imidacloprid have been found to be effective for up to seven-years following a single application. Dinotefuran translocates into the tree canopy much more rapidly than imidacloprid (usually within two to three weeks) and can provide control of HWA during the same application season.

Methods:
Systemic insecticides should be applied in spring or fall when the soils are moist, and trees are actively growing. The spring treatment window opens when soils thaw, while fall treatments can begin in late-September and close usually around the end of October or early November when soils begin to freeze. Use imidacloprid and/or dinotefuran only by one or more of the following means:

a) **Basal bark spray**: provides effective and efficient control of woolly adelgids, with minimal off-target effects. Numerous imidacloprid products are labeled for application via basal bark spray, while only two dinotefuran products are currently approved in New York State. A tank mix of the two pesticides is frequently used to provide both immediate and long-term control. The basal bark spray technique uses a low-pressure handheld or backpack sprayer to apply pesticide product to the basal portion (~bottom 4 ft.) of each tree's trunk. Applications should be made just to the point of saturation and run-off. Basal bark spray can be used near waterways since only a limited amount of product meets the ground.

b) **Trunk injection:** is a higher-cost application method with the least off-target effects. Tools that inject imidacloprid into the tree after drilling a small diameter hole into the xylem have demonstrated effectiveness. Although injection is a time-consuming application technique, it is useful near water because the imidacloprid is contained within the tree. A marking pen or tape should be used to ensure trees are not injected more than once.

2. Biological control

Effectiveness:
Biological control using releases of *Laricobius nigrinus*, and *Leucotaraxis spp*. can be effective in suppressing established HWA infestations, and is the only viable long-term control method. Only release biocontrol agents in areas that have sufficient adelgid populations to support establishment of predators. Once an HWA infestation is well established, and preliminary biological control agents released, pesticide treatments can be supplemented to preserve high-priority hemlock trees/populations and minimize HWA spread near the perimeter of the infestation. Priorities for hemlock conservation will vary by site, but should include trees that provide slope stabilization, maintain high-quality watersheds, display individual magnificence/strong genetic traits, provide cultural value, and/or habitat for rare, threatened or endangered species.

Methods:
The release of HWA biocontrol agents in New York State requires special permitting and approvals. Please contact APIPP for more information.

EMERALD ASH BORER

(Agrilus planipennis)

PEST DESCRIPTION

Emerald ash borer (EAB) is an Asian wood-boring beetle that feeds on ash trees (*Fraxinus spp*). Adults are approximately ½ inch (1.2cm) long with a metallic green body and copper segments beneath their wings. EAB is spread long distances through infested firewood or wood packaging material, but is also an efficient self-disperser, capable of traveling up to seven miles in a single flight. Larvae feed on the inner bark of ash trees, disrupting the tree's ability to translocate nutrients. Trees infested with EAB may have a thinning crown, bark splits, heavy bark loss from woodpecker feeding, and/or D-shaped exit holes.

MANAGEMENT OPTIONS

1. Pesticides

Effectiveness:
Systemic insecticides can be effective in suppressing, containing, or locally eradicating early detection-sized infestations. They are the most effective control method for treating individual trees infested by EAB. Treatment of individual infested trees, as well as a buffer area of un-infested ash trees, is appropriate for early detection infestations. For highly valuable street/ornamental trees, prophylactic treatment can be conducted on uninfested ash trees within 10-15 miles of a known EAB infestation.

Emamectin benzoate-based insecticides can be effective in controlling EAB for up to two-years when applied as a trunk injection. Trunk injections are absorbed and distributed throughout the tree relatively quickly (1-4 weeks) and are most effective when applied while the tree is actively transpiring.

Treatments:
Emamectin benzoate should be applied when soils are moist and trees are actively growing. Optimal timing of trunk injections occurs after trees have leafed out in spring but before EAB eggs have hatched, or generally between mid-May and mid-June. Best results are usually obtained by injecting trees in the morning when soil is moist but not saturated.

2. Biological control

Effectiveness:
Biological control using *Oobius agrili*, *Tetrastichus planipennisi*, and/or *Spathius agrili* can be effective in suppressing established infestations of EAB. Only use biocontrols in areas that have sufficient EAB populations to support establishment of predators. Once an EAB infestation is well established and preliminary biological control agents released, pesticide treatments can be supplemented to preserve high- priority ash trees/populations and slow emerald ash borer spread near the perimeter of the infestation. Priorities for ash conservation will vary by site, but should include trees that provide slope stabilization, maintain high-quality watersheds, display individual magnificence/strong genetic traits, provide cultural value, and/or habitat for rare, threatened or endangered species.

Methods:
The release of EAB biocontrol in New York State requires special permitting and approvals. Please contact APIPP for more information.

Aquatic Invasive Species

The following general infestation size thresholds are provided to inform the specific management activities most appropriate for each individual species. For the purposes of the following aquatic invasive species BMPs, four size thresholds will be referenced:

1) **Early Detection Infestation** –An early detection infestation is classified as a discrete population under 0.5 acres (0.2ha) within a single waterbody.
2) **Small Infestation** –A small infestation is classified as a discrete population over 0.5 acres (0.2ha) but under 1 acre (0.4ha) within a single waterbody.
3) **Medium Infestation** –A medium infestation is classified as a discrete population over 1 acre (0.4ha) but under 3 acres (1.2ha) within a single waterbody.
4) **Large Infestation** –A large infestation is classified as a population over 3 acres (1.2ha) within a single waterbody.

Aquatic Invasive Species BMP's	
Common Name	Scientific Name
Asian clam	*Corbicula fluminea*
Curly-leaf pondweed	*Potamogeton crispus*
Eurasian watermilfoil	*Myriophyllum spicatum*
European frog-bit	*Hydrocharis morsus-ranae*
Fanwort	*Cabomba caroliniana*
Hydrilla	*Hydrilla verticillata*
Quagga mussels	*Dreissena rostriformis bugensis*
Variable-leaf milfoil	*Myriophyllum heterophyllum*
Water chestnut	*Trapa natans*
Zebra mussels	*Dreissena polymorpha*


Asian Clam


Curly-leaf pondweed

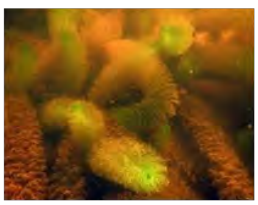

Eurasian watermilfoil


European frog-bit


Fanwort


Hydrilla


Quagga mussels


Variable-leaf milfoil


Water chestnut


Zebra mussels

ORGANISM DESCRIPTIONS

ASIAN CLAM is a freshwater bivalve mollusk native to Asia. It is hardy and can survive in many aquatic habitats, but prefers warmer, shallower areas near shore. At high densities this species can displace highly vulnerable native mollusks, reduce biodiversity, alter food chains, cause algae blooms, and clog industrial and commercial water systems. The outside of the shell is yellow-green to brown with elevated, concentric rings. Adults are usually less than 1.5 inches (3.8cm) in length. It is fast growing and can self-fertilize, allowing it to spread quickly. A single adult can produce up to 100,000 juveniles per year. It is believed that tiny juvenile clams (less than 0.01 inches or 0.2mm in size) are typically carried to new locations mixed in with sediments (i.e. sediment left on a boat anchor) or attached to vegetation.

CURLY-LEAF PONDWEED is a submerged perennial native to Europe, Africa and Australia. It is tolerant of low light and low water temperature and invades a wide range of water depths. This plant starts growing under the ice in late winter, which gives it a competitive advantage over native plants in the spring. It then dies off in early to mid-summer. In the Adirondack Region die back generally occurs before many summer lake residents have arrived and surveillance activities for the presence of AIS begins. Large scale die offs may cause nutrient loading and a critical loss of oxygen in the water column. Leaves are reddish-green and oblong with finely toothed, wavy edges. It reproduces and spreads through winter buds, called turions, which resemble small, pinecones and more locally through root expansion.

EURASIAN WATERMILFOIL is a submerged perennial native to Europe and Asia. It grows in a wide variety of water depths, sediment types and hydrological conditions. Dense infestations form mats at the surface of the water that degrade habitat and reduce recreational access. The plant's feathery leaves are usually in sets of four, whorled around the stem. Each leaf is finely divided, and the leaf tips are flat. Tiny pink flowers may occur on an emergent spike during late summer. The primary spread mechanism for Eurasian watermilfoil is fragmentation of the stem, which can spread the species to new areas within a waterbody. It also spreads locally through stolon expansion.

EUROPEAN FROG-BIT is a free-floating annual native to Europe and northern Asia. It grows in slow moving waters in bays, ponds, open marshes, ditches and along protected edges of lakes and rivers. This plant has rapid vegetative spread and forms dense mats which can limit light penetration and inhibit recreational use. The leaves are leathery and heart-shaped with dark purple undersides. Three-petaled, white flowers with yellow centers bloom in the summer. It produces winter turions that sink to the sediment and begin growing in the spring. This plant also spreads locally by producing stolons which develop juvenile plants.

FANWORT is a submerged perennial native to the southeastern United States and parts of South America. It typically grows in 3-10 feet (1-3m) of water and prefers acidic lakes, ponds and quiet streams. At high densities it forms extremely dense stands, clogging water flow and impairing recreational activities. The opposite leaves are fan-like and are attached to the stem on petioles. Small white flowers bloom in late summer. Reproduction and local spread can occur through short rhizomes and seeds. In late summer the plant becomes fragile and breaks apart very easily, facilitating long distance spread within a waterbody.

HYDRILLA is a submerged perennial native to Asia. It is tolerant of a wide range of hydrological conditions. It has low light requirements and thrives in both high and low-nutrient waters. Growing up to an inch a day, this plant produces very dense mats of vegetation that shade out native vegetation and interfere with fish spawning sites. The mats also disrupt water flow, decrease dissolved oxygen in the water, and interfere with recreational use. Leaves are visibly toothed and arranged in whorls of more than four. It reproduces by seeds, tubers, plant fragments, and turions. Fragments of the roots or stems are easily spread long distances and grow into new plants with waterfowl ingestion of tubers and turions.

QUAGGA & ZEBRA MUSSELS are small, fingernail-sized freshwater mollusks native to eastern Europe. Zebra mussels inhabit water depths up to 50 feet (15m) while quagga mussels can be found up 90 feet (27m) deep. Using byssal threads, they attach to most hard surfaces, though they have been found to colonize sand, silt and other softer substrates. They also attach to the shells of native mollusks, industrial intake pipes, and recreational structures and equipment such as docks, boats and trailers. As filter feeders, they remove particles from the water, affecting the clarity, content and ultimately the food chain of aquatic ecosystems. The shells of zebra mussels are D- shaped, range in size from 1/8 to 2 inches (3-50mm) in length and are mostly white or cream-colored with jagged brown or black stripes. Quagga mussel shells tend to be slightly larger, with the hinge side more rounded, and are slightly thinner and lighter in color than zebra mussels. Quagga and zebra mussels release large numbers of offspring (up to one million per season per female) which are free-swimming in the water column for up to 30 days. They are dispersed by water currents to new locations and then settle to the bottom and attach to any hard surfaces or vegetation.

VARIABLE-LEAF MILFOIL is a submerged perennial native to the southeastern and midwestern United States, as well as Ontario and Quebec Canada. It grows in a variety of depths, sediment types and hydrological conditions, but prefers shallow bays and coves. Dense infestations form mats that degrade habitat and reduce recreational access. The feathery leaves are arranged in whorls of 4-6 on the stem, but some leaves can also be alternating. Dense leaf arrangement gives this plant a bottle brush appearance under water. Stems are thick and reddish-brown. In mid to late summer, blade-like serrated leaves with small reddish-pink flowers form an erect spike that emerges from the water. The primary spread mechanism for variable-leaf watermilfoil is fragmentation of the stem, which can spread the species to new areas within a waterbody. It also spreads locally through stolon expansion.

WATER CHESTNUT is a floating annual native to Europe and Asia. It grows in quiet, high nutrient waters with soft substrate and prefers neutral to alkaline acidity. This plant is fast-growing and creates large, impenetrable mats that alter water quality and clarity, shade out native plants, and inhibit recreational use. Each plant produces a floating rosette(s) comprised of glossy, triangular, toothed leaves. Floating leaf stalks have visible bladders. Four-petaled white flowers bloom in July. Distinctive nutlets with four sharp spines mature in late summer. The nutlets or rosettes can float long distances on currents or may be spread by clinging to wildlife, plants or watercraft/equipment.

European frog-bit *(Hydrocharis morsus-ranae).*

Photo Credit: The Nature Conservancy (Meghan Johnstone)

HAND HARVESTING & DIVER ASSISTED SUCTION HARVESTING (DASH)

Hand harvesting involves the removal of aquatic invasive plants from the benthos or surface by scuba divers. Plants and their associated root mass are carefully removed and placed in a fine mesh bag for disposal. DASH utilizes a suction hose system to transport plant material to the surface in place of mesh bags. Both methods require topwater support staff to monitor and collect floating plant fragments.

Effectiveness:
Hand harvesting and/or DASH can be effective for locally eradicating early detection to small-sized infestations as well as containing or suppressing medium- to large-sized infestations of Eurasian watermilfoil, variable-leaf watermilfoil, parrot-feather, fanwort, curly-leaf pondweed, Brazilian elodea, hydrilla, water chestnut, European frog-bit, and yellow floating heart. Hand harvesting can also be used to reduce user impacts for very small infestations of Asian clams, quagga mussels, and zebra mussels. DASH should not be used to manage Asian clams, quagga mussels or zebra mussels as small organisms cannot be collected effectively and will be discharged back into the waterbody. It is important to consider the biology of the species when scheduling harvesting. Harvesting should be conducted prior to the production of offspring, seeds, nutlets, tubers and/or turions which typically form in late summer.

Methods:
Gently hand-pull all plants from the sediment by the roots. Plants should be pulled slowly to minimize fragmentation. Special attention should be given to ensure that the root ball, if present, is removed and that all plant fragments which may be produced during the harvesting operation are collected. For floating plants, harvesting can be conducted from a boat or by wading in the shallows. For submerged plants, trained SCUBA divers should be deployed. If using DASH, hand-pull each plant and then use the suction hose to transport it to the surface. The suction nozzle should never be used to directly remove vegetation from bottom sediments. If possible, return to the project area multiple times each growing season to remove plants that were missed or emerged from the seed bank. Aquatic invasive mollusks can be hand-collected by snorkelers or SCUBA divers. Quagga and zebra mussels attach to surfaces using byssal threads which can easily be dislodged using a scrapping tool such as a paint scraper, screwdriver, chisel or dull knife. Particular care must be taken when collecting zebra and quagga mussels as sharp shells can produce cuts which may be prone to infection. Collect all dislodged invasive mollusks and do not allow them to fall to the bottom of the lake.

Disposal:
Bag all biomass and remove from the management site. Aquatic invasive mollusks should be killed by freezing them for at least 24 hours or allowing them to dry in the sun for at least a week before disposal in an approved landfill. Aquatic plants can be composted in an upland location or disposed of in an approved landfill. If transporting harvested material offsite is not feasible due to volume and/or distance, harvested plant materials may be scattered on adjacent upland areas at least 50 horizontal feet from the shoreline and in a manner that will not eliminate or impede growth of native vegetation. For state lands, all biomass material should be removed from the area and properly disposed of off-site.

BENTHIC BARRIERS

Benthic barriers or mats are made of plastic, fiberglass, nylon, or other materials and are placed over submerged aquatic invasive plant beds to block sunlight (preventing photosynthesis and plant growth) or over aquatic invasive mollusk populations to suffocate them (reducing/eliminating available dissolved oxygen).

Effectiveness:
Benthic barriers can be effective in suppressing, containing or locally eradicating early detection to medium-sized infestations of Eurasian watermilfoil, variable-leaf watermilfoil, and curly-leaf pondweed, though large scale deployment of benthic barriers can quickly become cost prohibitive. The use of benthic barriers to control zebra mussels, quagga mussels, or Asian clams is limited to controlling infestations in select areas of concern (i.e. public beaches, marinas, etc.); it is not an effective method for managing large areas of infestation. Heavy plant growth can impede installation of barriers; making barrier installation during low growth periods (usually in early spring after ice-out) the preferred option. Benthic barriers are unselective and will impact all species of flora and fauna under the matted area. Benthic barriers that get dislodged by wave or propeller action have caused impairments to the boating public. All benthic barriers should eventually be removed and the treatment area managed using other techniques to maintain low levels of AIS.

Methods:
For shallow infestations, barriers can be installed by wading. For deeper infestations, barriers should be installed by trained SCUBA divers. Overlap each barrier by four to six inches to prevent vegetation from escaping through seams. Larger overlaps may be necessary to deplete oxygen levels for invasive mollusk control. Barriers should be securely fastened to the benthos with stakes or anchors. Barriers must be designed to allow venting of gases which are generated beneath the barrier.

Disposal:
Benthic barriers will kill the target invasive species onsite. Offsite disposal of invasive species material is not required.

Benthic barriers are deployed to control aquatic invasive species.
Photo Credit: Jason Whalen (Flickr)

MECHANICAL HARVESTING

Mechanical harvesting utilizes a specialized watercraft to cut and collect floating or submerged aquatic invasive plant material from a waterbody. Plants are collected and conveyed onto the harvester for disposal on land.

Effectiveness:
Mechanical harvesting can be effective in suppressing large-sized infestations of Eurasian watermilfoil, variable-leaf watermilfoil, hydrilla, European frog-bit, and water chestnut. Mechanical harvesting is generally unselective, as all vegetation within the path of the harvester will be cut and removed. Additionally, fragmentation of aquatic invasive plant material resulting from harvesting operations can facilitate the spread of species that auto-fragment. This technique is most commonly used to suppress large, dense infestations and remove plant biomass to reduce lake user impacts and must be repeated annually and in some cases multiple times annually

Methods:
Navigate the mechanical harvester through large floating or submerged, near-surface aquatic invasive plant infestations to cut and collect all accessible plant material. Multiple harvests may be required each season to maintain open navigation channels, suppress infestations to desired levels, or reduce lake user impacts. When managing aquatic invasive plants, harvesting should be completed before plants produce seed or vegetative propagules. Reference the organism descriptions above for species specific phenology information.

Disposal:
Collect all harvested plant material onboard and remove from the management site. Aquatic plant material can be composted in an upland location or disposed of in an approved landfill. Cover all harvested material for transport.

A mechanical harvester removes aquatic invasive plants from Sodus Bay.

Photo Credit: New York Sea Grant (Mary Austerman)

CHEMICAL MANAGEMENT

Chemical management includes the application of pesticides, including herbicides, to the water to reduce invasive plant and animal populations. Chemical management needs to be specific to the target species, waterbody conditions, and time of application. As such, it should be part of an integrated pest management plan that is coordinated with local experts and agencies. In New York, this management technique almost always requires permitting.

Effectiveness:
Chemical management can be effective in suppressing or containing large-sized infestations of aquatic invasive species. Chemical management for aquatic invasive species management has a long history of use across the United States, but this technique has been used infrequently in the Adirondacks. Chemical management using herbicides has been used for plant species like curly-leaf pondweed, hydrilla, Eurasian watermilfoil, European frog-bit, variable-leaf milfoil, water chestnut and others. Chemical management has also been used for control of quagga and zebra mussels using oxidizing agents, anti-fouling agents, and biopesticides. Typically, the goal of chemical management is to reduce the invasive species population over a set area to a level that allows for cost-effective, long-term management of the species. Most of the time, chemical management does not result in complete eradication.

Methods:
Chemical management requires working with a licensed professional to apply the pesticide in accordance with a product's label. There are many different types of pesticides and each has its own specifications and requirements. The two major classes of pesticides are contact and systemic. Contact pesticides damage or kill organisms they are designed for when they come in physical contact with the organism (for example, Aquathol K). Systemic pesticides are taken up internally by the organism that they are designed for and kill the organism (for example, ProcellaCor). The pesticides are usually applied directly to the water, in a set location, at a specific time to ensure that they are most effective and have the lowest amount of non-target impacts. The licensed professional will know the correct time to conduct chemical treatment and will ensure that registered pesticides are applied in accordance with the label and the manufacturer's recommendations.

Disposal:
Chemical management will kill the target species onsite. Since the target species dies, this generally makes offsite disposal of the invasive species unnecessary or impractical (for example, when treating Eurasian watermilfoil with pesticides, the plant will breakdown and decompose). In some cases, however, removal of the invasive species may be necessary and should be part of the management plan (for example, when treating zebra mussels in pipes, removing the remains could be part of the management plan).

Appendix A: Pesticide Safety Tips

Review and abide by the following pesticide safety tips to ensure your invasive species management project is safely implemented and does not have unintended impacts to the environment or human health. This is not an exhaustive list; always read and consult the pesticide product label before use.

1. **Safety First.** Always take appropriate safety precautions; wear suitable clothing and personal protective equipment and follow all safety instructions on the pesticide label. Use a biodegradable tracer dye in your solution to identify accidental exposure or spills and to keep track of where you have already applied product.

2. **Use the Minimal Tool Approach.** Pesticide application is only one tool in the management toolbox. Evaluate all available control options before resorting to chemical means. Treatment actions should eliminate invasive species while aiming to maintain desirable native species.

3. **Be Mindful of Environmental Conditions.** Do not spray during windy conditions as spray may drift and affect other non-target plants or enter water. Do not apply if rain is in the near-term forecast, as herbicide may be washed away before it can act. Most herbicide applications should end at least two weeks before the first hard killing frost to allow sufficient time for the product to take effect. Unless approved by the product label, do not apply after the first hard killing frost as plants will no longer actively absorb herbicide into the roots.

4. **Be Patient.** Systemic herbicide such as glyphosate, imazapyr, triclopyr, imazamox, may require up to two weeks to take effect, while systemic insecticides like imidacloprid may require up to one-year. Do not waste pesticide, money or effort by spraying more than once during a growing season.

5. **Be Selective.** Glyphosate, imazapyr, and imazamox based herbicides are non-selective (kills both monocots and dicots) and will impact all types of vegetation. Triclopyr formulations are selective and will only affect broadleaf weeds, leaving grasses and conifers unaffected. Use of selective application equipment, such as stem injection systems, can also minimize off target impacts.

6. **Know Your Limits.** Homeowners may only apply general use pesticide products to their own property. Restricted use products or applications to other properties requires commercial pesticide certification/licensing.

7. **Exercise Caution When Using Pesticides Near Water.** General use pesticides that are available to homeowners are *NOT* approved for use in or near water. Aquatic applications must be performed by a certified applicator.

8. **Research Permit Requirements.** Pesticide applications – even on private properties – may be subject to one or more permits. Contact APIPP for more information.

Appendix B: Permit Inquiry Contact Information

1) Adirondack Park Agency

a. **Jurisdictional Inquiry Office**
(518) 891-4050

2) Department of Environmental Conservation

a. **Region 5 Regional Permit Administrator**
(518) 897-1234 – serves Clinton, Essex, Franklin, and Hamilton counties
(518) 623-1282 – serves Fulton, Saratoga, Warren, and Washington counties

b. **Region 6 Regional Permit Administrator**
(315) 785-2245 – serves Lewis and St. Lawrence Counties
(315) 793-2554 – serves Herkimer and Oneida Counties

3) New York State Department of Transportation

a. (518) 563-2020 – Clinton County
b. (518) 873-2170 – Essex County
c. (518) 483-0770 – Franklin County
d. (518) 853-3441 – Fulton County
e. (518) 648-5551 – Hamilton County
f. (315) 866-1123 – Herkimer County
g. (315) 376-3523 – Lewis County
h. (315) 732-8032 – Oneida County
i. (315) 265-2320 – St. Lawrence County
j. (518) 584-3790 – Saratoga County
k. (518) 623-3511 – Warren County
l. (518) 747-4724 – Washington County

4) County/Local Highway Departments

a. Contact your county of local highway superintendent for more information.