Best Management Practices for Priority Invasive Plants in the Lower Hudson Valley

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LOWER HUDSON PRISM

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There is a "knowing-doing gap" in invasive species control, where research into best management practices often does not inform on-the-ground practices of land managers.[1] We hope these factsheets will help address this gap in the Lower Hudson Valley. By interpreting the scientific literature and experiences of professionals in the field, we have compiled accessible and accurate information for landowners, land managers, gardeners, farmers, foresters, and anyone else with a connection to the land and an interest in managing for biodiversity by controlling invasive plants. For the factsheets, we chose a subset of invasive plants that are both significant problems in our region, and that had enough peer-reviewed literature and/or first-hand experience of practitioners in the region to come up with evidence-supported management recommendations. We caution that many of the studies cited in the factsheets were restricted in space and time, and may or may not be representative of situations in the LH PRISM region. For some species where only a few management methods had been tested, we recommended "trying" a method that had worked with another species. Our factsheets cover:

Norway maple (*Acer platanoides*)
Tree-of-heaven (*Ailanthus altissima*)
Garlic mustard (*Alliaria petiolata*)
Japanese barberry (*Berberis thunbergii*)
Oriental bittersweet (*Celastrus orbiculatus*)
Black swallowwort (*Cynanchum louiseae*)
Smooth buckthorn (*Frangula alnus*)
Bell's honeysuckle (*Lonicera × bella*)
Purple loosestrife (*Lythrum salicaria*)
Stiltgrass (*Microstegium vimineum*)
Mile-a-minute (*Persicaria perfoliata*)
Common reed (*Phragmites australis*)
Knotweed (*Polygonum cuspidatum* and *P. × bohemica*)
Multiflora rose (*Rosa multiflora*)
Water-chestnut (*Trapa natans*)

Why, whether, and when to control invasive species

When do nonnative, invasive plants threaten native species? In some cases, they directly threaten native plants through competition for space or resources, or threaten native plants

and animals indirectly by changing soil chemistry, soil microbiota, nutrient cycling, vegetation structure, or plant community composition of a native habitat. In other cases, the invaded area is a highly disturbed one such as a roadside ditch or pile of fill, and the invasive species may fill a useful niche by growing where many native plants cannot and providing shelter or resources to native animals. Certain invasive plants, e.g., the nonnative subspecies of common reed,[2] provide valuable ecosystem services—including sediment stabilization in tidal marshes, carbon sequestration, and water quality maintenance—while either degrading or enhancing habitat for certain native species of conservation concern. A highly altered environment may not be able to support native or "high quality" species unless significant changes are made, for example, to soil structure, soil microbial or fungal communities, water or nutrient availability, or canopy closure. The closer a habitat or community resembles a native, undisturbed example, the better chance of a successful outcome for invasive species removal.

Complicating this picture is the fact that many of our forests, wetlands, and other natural communities that are protected from obvious disturbances such as logging or filling are nevertheless suffering from many less obvious disturbances. These include overabundant white-tailed deer, invasions of nonnative earthworms, insect pests that do widespread damage to forest trees, inputs of a variety of pollutants (including atmospheric deposition of nitrogen), and a shifting climate. The lack or disruption of natural disturbance regimes such as fire or flooding is also a source of stress on natural communities. Finally, it is becoming clear that past disturbance—such as plowing or other agricultural activity tens, hundreds, or even thousands of years ago—has continuing effects on soil properties, nutrient cycling, and plant community composition.[3] The presence or abundance of nonnative plants is often predicted by one or more of these factors, and (just as with the more obviously disturbed land) removal of the plants may be unlikely to change the conditions that facilitated their growth.[4]

Nevertheless, there is strong evidence that many invasive plants, just by their presence or abundance, dramatically shift soil nutrient composition, microbiota, nutrient cycling rates, and other processes, making their immediate environment friendlier to themselves and often to other invasive plants.[5] In some cases their removal reverses these effects. Moreover, some of the disturbance factors contributing to the success of invasives (and the decline of natural communities) can be addressed: deer abundance can be controlled; nutrient and chemical inputs from lawn and garden fertilizers, home septic systems, pest control, and livestock can be reduced; landowners can determine where and how often mowing, tree harvesting, and other disturbances will happen. Planting native woody or herbaceous plants in invaded areas can also help by providing competitors for the invasive plants, aiding forest regeneration, and possibly restoring soil properties and plant and animal communities.

The effects of nonnative, invasive plants vary not only by species, but also by situation. Ecological relationships—including the negative or positive impacts of a plant—may vary

from one place to another within the region. Under some conditions, a given species will form a spreading patch so dense it becomes almost a monoculture, with obvious negative effects for the displaced native flora and fauna. In some cases a population of a rare plant or animal is known to be threatened by the encroachment of an invasive plant. The opposite case can also be true, where an invasive species provides critical habitat for a species of conservation concern (for example, Asian bush honeysuckles are an important component of shrublands that support New England cottontail). The vast majority of cases are less clear-cut, with invasive plants at low to moderate densities, or in discrete patches, and providing some value to other organisms in the form of cover or food, but perhaps reducing habitat quality for an unknown number of other organisms. In some cases there is no obvious effect or even a positive effect (for example, protection of a rare plant from herbivory provided by the co-occurence of invasives).[6] Decisions about whether or not to manage an invasion can only be based on imperfect knowledge—which at least is summarized in the following factsheets—and available resources.

Why focus on non-chemical control?

In invasive species management, as in agricultural weed management, chemical control is the dominant method. It is almost always more labor-efficient (hence cost-efficient) than manual or mechanical control, and often more successful, at least in the short term. Despite this obvious benefit, the environmental costs of herbicide use—discussed below—are considerable. For this reason we have focused on non-chemical management practices, which are ultimately more sustainable for human health, environmental health, and biodiversity protection. Furthermore, landowners can use non-chemical techniques without the services of a state-licensed pest control operator. (It should be remembered, however, that even non-chemical techniques may require a permit if implemented in a wetland, stream channel, or near New York City water supply reservoirs and the streams that feed them.)

There are many active ingredients in commonly used herbicides, and in commercial formulations these are mixed with other chemicals (such as surfactants) to increase their efficacy, resulting in numerous and often proprietary mixtures. Research into environmental safety of these products is often insufficient and predominantly industry-funded. Nevertheless, enough independent, peer-reviewed research has been published that some of the potential negative effects of herbicide use are becoming apparent. Glyphosate-based herbicide is the most commonly used type in the US and globally,[7] and it also has been the subject of the most research into nontarget effects (effects on organisms other than the target weed). Although glyphosate is widely reported to break down quickly in the environment, in soil tests dissipation time varied from 1 to 197 days (mean = 32 days). The breakdown product aminomethylphosphonic acid (AMPA), approximately equivalent in toxicity to glyphosate in several animals tested, dissipated in 76-240 days (mean = 76 days). In non-flowing water, it took 7-14 days for glyphosate to reach 50% of the applied concentration.[8]

Glyphosate and/or AMPA were found in 57% of over 3,700 soil and water samples taken across the US,[7] and both are also found in crops, processed foods, and livestock feed.[9] We do not yet know all the effects of pervasive low-level exposure to these chemicals on humans and other organisms, but many have been demonstrated. Glyphosate exposure at environmentally relevant concentrations can cause liver and kidney damage in rats. As an endocrine-disrupting chemical, it has been shown to alter hormonal systems (including sexual development) and gene expression patterns in various vertebrates, and alter embryonic development, causing malformations in amphibians, chickens, and pigs. It is probably carcinogenic to humans, according to the World Health Organization. Its antibiotic effects can harm the intestinal flora of vertebrates, and promote the development of new strains of antibiotic-resistant bacteria.[9] Even "inert" ingredients in herbicide formulations are proving to be toxic (the surfactant mix including POEA in Roundup® is much more toxic to amphibians, fish, and aquatic invertebrates than pure glyphosate).[10] Herbicides can easily reach nontarget habitats and organisms due to drift, runoff, and mistakes in application. Techniques of application such as "clip and drip" and injection reduce but do not eliminate the risk of nontarget effects. Control of tree-of-heaven by injection of imazapyr resulted in significant mortality of other woody species within a 3-m radius.[11]

Belief in the efficacy of herbicides may lead individuals to be less likely to perform follow-up treatment or monitoring, although in most cases successful eradication of a patch takes several years with herbicides, just as with mechanical methods. Overuse of herbicides demonstrably leads to the evolution of herbicide-resistant weeds. Also, herbicides are predicted to decline in efficacy with increasing atmospheric carbon dioxide and/or temperature.[12]

Setting management goals and making a management plan

Control of invasive plants using manual, mechanical, and cultural control methods is labor-intensive and depends on a long-term commitment to manage the invader, restore native vegetation, and monitor thereafter to prevent recurrence. Because of the effort involved, setting appropriate goals is extremely important. A good first step is to determine the habitats most worthy of management—from a biodiversity perspective—on your property, including any large, high quality, rare, or uncommon habitats. These can include natural communities such as forests and wetlands, but also some types of agricultural land, abandoned fields, or other human-modified habitats with high value for some species of conservation concern. For instance, a rocky ledge or a small patch of mature forest may support rare plants; a large hayfield can provide nesting habitat for grassland-adapted birds; a wetland or pond surrounded by unmanaged habitat can be important for amphibians. The "Biodiversity Assessment Manual for the Hudson River Estuary Corridor" by E. Kiviat and G. Stevens (available from Hudsonia) and the "Biodiversity Assessment Handbook for New York City" by E. Kiviat and E.A. Johnson (available on the American Museum of Natural History website, http://www.amnh.org/) define common and rare habitats in our region and explain

their potential conservation values. Many other useful resources are listed on the New York State Department of Environmental Conservation (NYS DEC) Hudson River Estuary Program's "Conservation and Land Use Program for the Hudson River Estuary Watershed" web page, http://www.dec.ny.gov/lands/5094.html. It also helps to think about land use and aesthetic goals, which may be informed by what you have learned about the habitats on your land and the species they may support.

Next, assess what invasive plants are present, their locations, and the approximate extent and density of each occurrence. This may require a year of acquainting yourself with the land in all the seasons, since different species are easier to spot at different times. Field guides, knowledgeable friends and neighbors, extension agents, wildflower clubs, and, of course, LH PRISM members may be good resources at this stage.

Reading the factsheet for each species should help you determine which habitats it may threaten, whether it is a problem now, and whether it may become one if left unchecked. For instance, some invasive shrubs provide good bird habitat in an oldfield, but have negative effects at high densities in a forest understory. Some species fail to produce seeds or eventually die under a dense canopy, but seed production at the sunny forest edge perpetuates the population. If a diverse mix of native plants coexists within the invasion, perhaps active management is not needed. In forests, pay particular attention to woody plant regeneration. Often, actions such as limiting access of white-tailed deer, replanting native woody plants, or limiting soil and canopy disturbance will do more to enhance habitat for native species and discourage invasives than direct removal of the offending plants.

Once the problem areas and species are identified, set realistic goals. These should take into account the time, labor, and budget at your disposal, with the expectation that management will need to happen for several or many years. They should also reflect the chance of success of restoring a native habitat. In many cases, total removal of an invasive is not reasonable with any method. Some reasonable goals include complete removal of a weed that is just becoming established, keeping a large patch from spreading, preventing seed production, or reducing density. Identify the best timing for management actions, and set up a schedule across years. Timing can be crucial. For example, cutting or girdling in different seasons can affect mortality or the number of root sprouts. If timed right, most species can be annually cut or pulled to almost eliminate reproduction by seed. The factsheets should also help you avoid worsening the problem. For example, cutting some perennial species once a year, or even three times a year, will only make them grow more vigorously. Most importantly, include restoration (if necessary) and monitoring as part of the plan. Much work removing invasive plants has been wasted because a lack of follow-up actions resulted in the recovery of the targeted species or the invasion of other weeds.

Some useful tools

- Hand cutting tools like pruning saws, pruners, and loppers
- Digging tools like garden fork, spade, and grubbing hoe
- Pulling tools like "Puller Bear" (www.pullerbear.com) or "Uprooter" (www.theuprooter.com) – both comparable to the discontinued "Weed Wrench"
- Drawknife for girdling (6" blade, Columbus McKinnon, www.cmworks.com)
- Propane torch, such as "Weed Dragon" 400,000 BTU backpack torch kit (www.flameengineering.com)
- Heavy black plastic sheeting for smothering
- Black plastic bags and zipties, or equivalent commercial product like "Buckthorn Baggies" (www.buckthornbaggie.com)
- Rigid plastic sheeting (e.g., www.deeproot.com) or metal sheet piling for root barriers
- Chainsaw
- Weed eater (string trimmer) or scythe (e.g., www.themaruggcompany.com/) for herbaceous plants
- Brush cutter (hand-held, with circular blade) for robust herbaceous and woody plants (for explanation and reviews, see www.brushcuttercentral.com/)
- Sickle-bar or brush hog (rotary cutter) mower

Of course these tools should be used with proper precautions to prevent serious injury to persons or valued plants. Mentions of specific brands or products are meant to serve as illustrations or examples, not endorsements.

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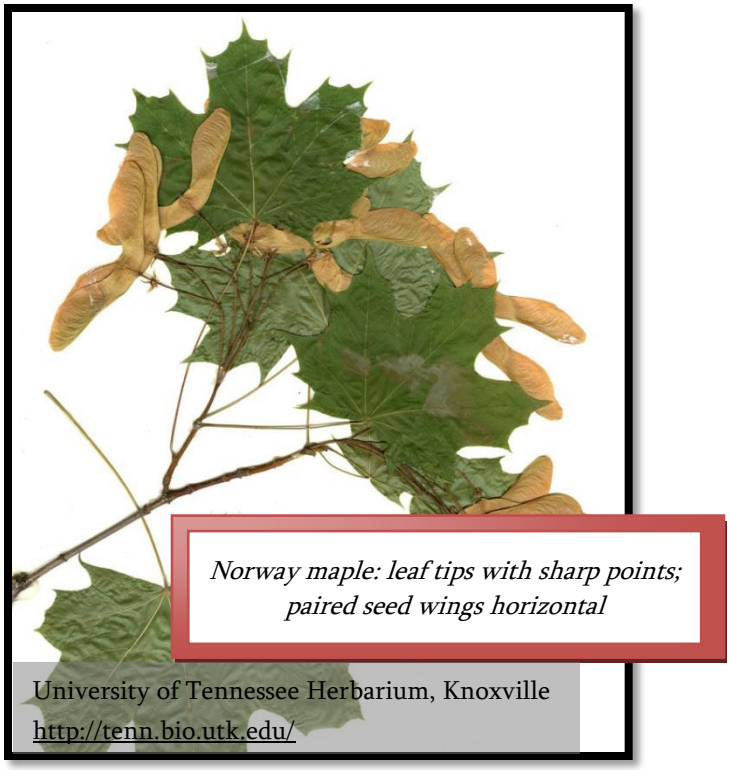
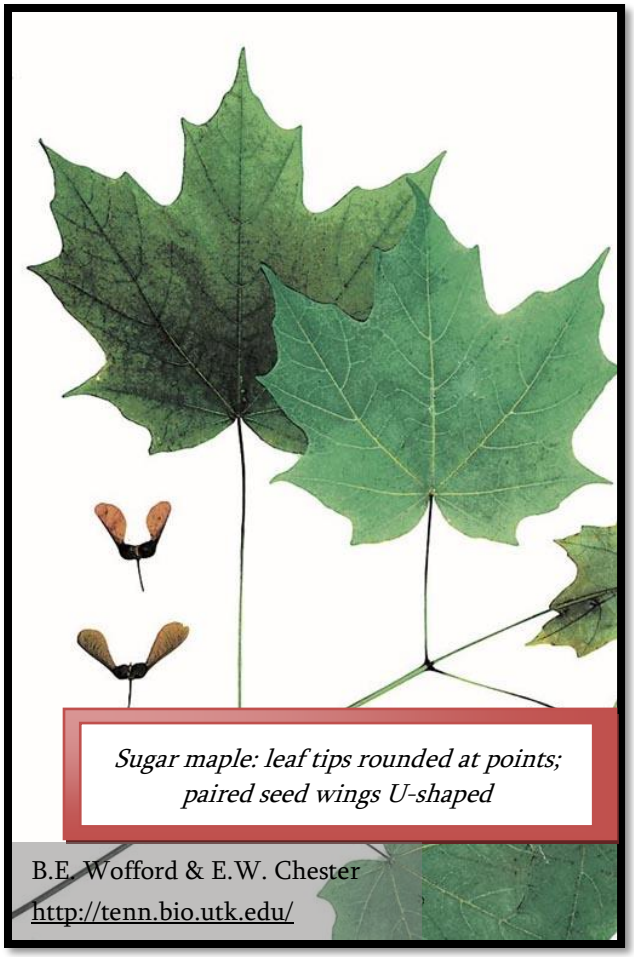
NORWAY MAPLE *(Acer platanoides)*

Regulated Invasive Species in New York (*6 NYCRR § 575.3(d)(2)(lx)*)



Norway maple: leaf tips with sharp points; paired seed wings horizontal

University of Tennessee Herbarium, Knoxville
http://tenn.bio.utk.edu/



Sugar maple: leaf tips rounded at points; paired seed wings U-shaped

B.E. Wofford & E.W. Chester
http://tenn.bio.utk.edu/

A tree that grows to 30 m with vertically-furrowed tight bark and leaves that resemble the native sugar maple (*Acer saccharum*).

Native to Europe and western Asia, Norway maple was introduced to North America in the mid- to late 1700s and continues to be planted as a street tree across the US. It has escaped and become invasive in many parts of the East, Midwest, and Pacific Northwest regions.

Similar species: Sugar maple has similar leaves. In summer, these trees can be distinguished by breaking a leaf stem: Norway maple has white sap; sugar maple sap is clear. In winter, leaf buds are the best character: Norway maple end buds are purplish or green, with rounded tips and 2-3 pairs of bud scales; and sugar maple buds are brown, pointed, and have more numerous scales.

Where found: Norway maple grows best in forests with moist, deep, fertile soils. It is less successful in sites with dry or saturated, acidic, or low-nitrogen soils.[1] It can successfully regenerate in a deeply-shaded forest understory, even in intact (relatively undisturbed) forest, and seems to have ecological requirements very similar to those of sugar maple.[2] Soil disturbance promotes seed germination, and canopy gaps allow seedlings to quickly grow into mature trees. The main limits on

abundance of Norway maple are the distance to a seed source and its slow growth in shaded understories.[2,3] Roads are common corridors of dispersal.[4]

Threats/benefits: Because generation times are long (30-40 years), Norway maple has spread relatively slowly so far. However, once established, Norway maple is a strong competitor in the forest understory, and can displace native shade-tolerant species such as sugar maple.[3] Richness of understory plants is greatly reduced under Norway maple trees compared to native trees, replaced with dense Norway maple seedlings and saplings.[5] Both saplings and mature trees negatively affect the growth of native tree saplings.[6] Norway maple also increases nutrient availability and the rate of nutrient cycling in soils (especially on richer soils), which could possibly increase its competitive advantage and also favor some native trees over others.[7] Overall, Norway maple appears to be a slow-moving but significant threat to the canopy and understory composition of mesic forests.[2] Street or yard trees are only problematic because they produce seeds that allow the species to colonize forests.

Reproduction: Norway maple blooms in spring; its flowers are insect-pollinated and susceptible to late frost. The seeds mature in late summer and are wind-dispersed. Seeds have high germination rates compared to native trees, even under deep shade. Seedlings grow very slowly in low-light conditions but can persist at a small size for many years, forming a "seedling bank."[3] When a treefall gap or other disturbance increases light, seedlings can grow quickly, reaching the canopy in about half the time it would take native co-occurring trees.[8]

Management Goals:

- Prevent or limit seed production by targeting mature trees.
- Prevent saplings from growing to maturity.
- Avoid soil disturbance, which promotes seed germination.

Management Methods:

- Saplings and mature trees may be either cut or girdled, but they usually resprout from the stump.[9] We recommend trying a type of girdling that has been used with success on tree-of-heaven (*Ailanthus altissima*): In winter or early spring, partially girdle adult trees, by using a drawknife to remove approximately 12" of bark around the whole tree (but not the cambium underneath). This will kill the trees slowly, resulting in fewer stump sprouts.[10] Decrowning (removing all branches from) a mature tree may also have this effect.[11] Kill any sprouts at the end of the growing season, and annually thereafter.
- For small trees, try the "cut and cover" method to prevent stump sprouts: cut several inches above ground level and cover the stump with something that completely blocks light for 1-2 years (e.g., a coffee can, or a heavy-duty black plastic bag zip-tied to the base of the stump).[12]

Norway maple

- Light gaps left by cut or girdled canopy trees may result in rapid growth of Norway maple seedlings or colonization by other invasive species.[9] Monitor these gaps carefully and remove invasive species and/or plant native species to compete.
- Once seed sources are removed, seedlings may either be monitored every few years to remove saplings, or hand-pulled annually until the seed bank is depleted. Soil disturbance from hand-pulling results in an increase in new Norway maple seedling density the following year,[9] but the seed bank is short-lived.

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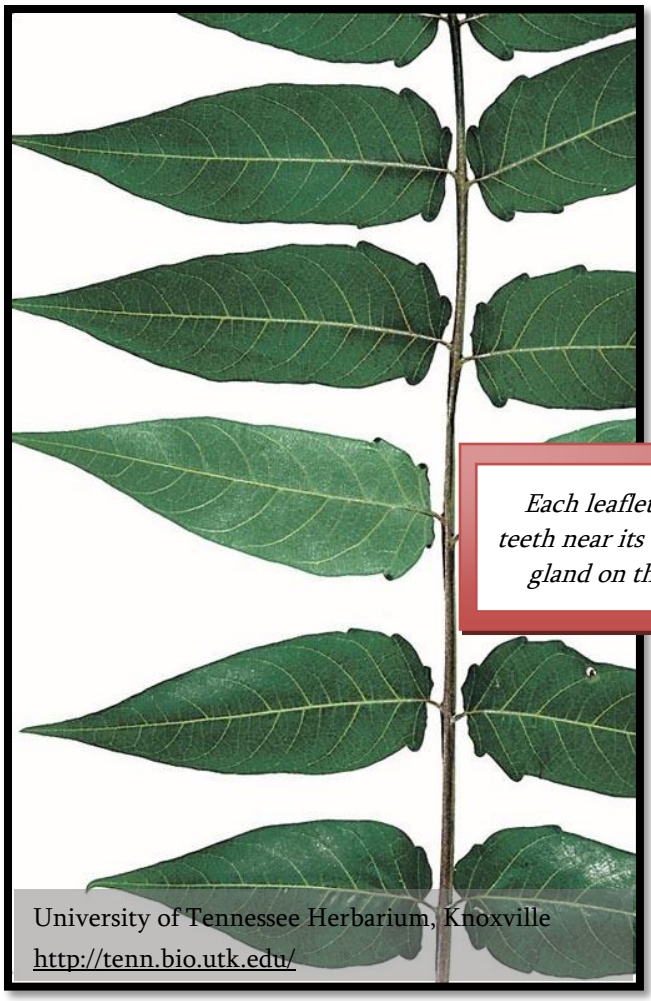
Fact sheet prepared by Kristen Bell Travis (Hudsonia) with assistance from Erik Kiviat, Gretchen Stevens, and Chris Graham (Hudsonia) and other Lower Hudson PRISM members, 2016.

TREE-OF-HEAVEN *(Ailanthus altissima)*


University of Tennessee Herbarium, Knoxville
http://tenn.bio.utk.edu/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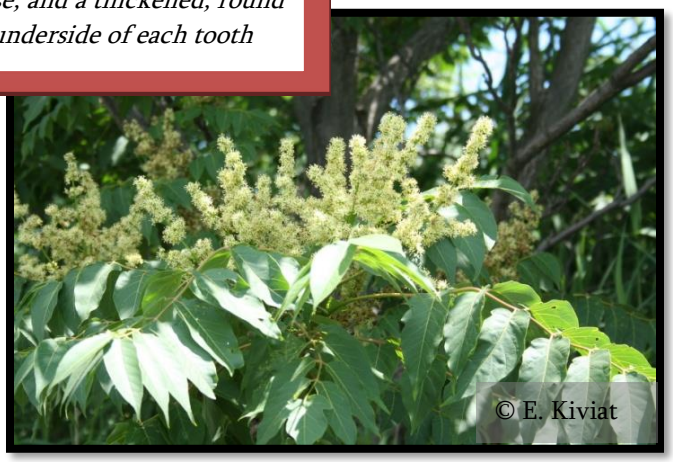
Bark of a medium-sized tree

Each leaflet has one or a few rounded teeth near its base, and a thickened, round gland on the underside of each tooth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A fast-growing tree to 20 m with large, compound leaves composed of 10-40 leaflets. Leaves and stems have a strong, unpleasant odor (likened to stale peanut butter) when crushed. In summer and fall, large drooping clusters of winged seeds are visible.

Native to central China and Taiwan, tree-of-heaven is now invasive around the world. In the US, it became widely available to gardeners in the 1820s and is now most abundant in the East, Upper Midwest, Pacific Northwest, and California.

Similar species: Several sumac (*Rhus*) species are most similar to tree-of-heaven. It can be distinguished from sumac as well as other trees with compound leaves by the presence of glands near the base of each leaflet. Also, tree-of-heaven has clear sap, while that of sumac is milky and sticky. Ashes (*Fraxinus*) have opposite leaves, and walnut and butternut (*Juglans*) leaflets are evenly toothed along the margins. Tree-of-heaven has a unique odor when bruised.

Tree-of-heaven

Where found: Tree-of-heaven is shade-intolerant, and usually found in open areas with disturbed, mineral soils.[1] It can grow in a wide range of soil types and conditions, and is tolerant of drought and most industrial pollutants. Tree-of-heaven also grows in dry-end wetlands, including estuaries.[2] Most common in urban areas and along roadsides, tree-of-heaven is also becoming an increasingly common component of young deciduous forests and forests with past disturbance (such as logging). It is most invasive in eastern deciduous forests.[1] Tree-of-heaven may become established in the forest interior by seed germination in canopy gaps. Mature trees produce numerous root sprouts (up to 27 m away from the trunk) that can persist for decades in the understory waiting for a gap to open, behaving much like the seedlings of shade-tolerant native forest trees.[3,4] Current forest disturbances such as oak defoliation, hemlock die-off, pipeline construction, and increased flooding from severe storms are all contributing to the spread of this species.[4]

Threats/benefits: Tree-of-heaven grows much faster than native trees in eastern forests, and its leaf litter has a higher nutrient content. Nutrient cycling is accelerated under its canopy, and this has the potential to alter forest composition: faster nutrient cycling benefits nonnative trees and certain native trees over others.[5] It also produces allelopathic chemicals in its roots and leaves that are toxic to other plants, microbes, and rodents.[1] Red oak, sugar maple, and red maple seedling growth was inhibited in its presence, and stimulated when the toxins were neutralized.[6,7] Native plant richness was lower under tree-of-heaven than under native trees in a European forest.[8] In urban areas, its root system can damage water facilities, archaeological sites, and walls and foundations of buildings.[1] In humans, exposure to the sap of tree-of-heaven can cause a severe rash[9] and potentially myocarditis (inflammation of the heart) and other symptoms.[10]

Tree-of-heaven has several economic uses: it is a source of chemicals with potentially important medical and agricultural (as an organic herbicide) uses; its wood can be used for wood products, firewood, or pulpwood for paper; and it can be planted as a shelterbelt to increase agricultural production in harsh, dry areas. Tree-of-heaven can also be useful for erosion prevention and reclamation on degraded lands such as landfills, mine spoils, and salinized soils.[11] Its potential to spread by seed into natural areas may outweigh the benefits of such uses in most situations. White-tailed deer (leaves), eastern cottontail (bark), northern cardinal (seeds), and insects (leaves) eat tree-of-heaven.[12] Tree-of-heaven supports macrofungi (including oyster mushrooms), and edible species can be cultivated as part of its control.[13]

Reproduction: Tree-of-heaven flowers in the spring and winged seeds develop in late summer-fall; seed production is prolific. Even very young, small trees may flower and produce seed. Seeds are dispersed by wind, water, and sometimes by rodents or birds, from fall through the following spring. Germination rates are high, but the seeds are short-lived in the seed bank (1-2 years). Tree-of heaven has an impressive ability to reproduce by vegetative sprouting from roots, root crown, and trunk. Root sprouts can produce new trees up to 27 m from the main trunk. Extensive root-

sprouting may occur even in the absence of damage to the main trunk, but is much greater after top growth is cut or damaged.[1]

Management Goals:

- Remove trees in a way that minimizes root sprouting; kill root sprouts annually until root is dead.
- Remove seedlings until seed bank is depleted.
- Monitor annually to prevent re-establishment, especially if there are seed sources nearby.

Management Methods:

- Kill sapling-sized stems (over 1 m tall) and mature trees over the course of one or two years; a slower death results in fewer resprouts. Do not cut trunks/stems without further treatment: this results in abundant resprouting and is worse than doing nothing.[14] Even two cuttings per year for four years did not have any effect on biomass or stem density, only stem height (in the Mediterranean).[15]
- In winter or early spring, partially girdle trees and sapling-sized stems, by carefully using a drawknife to remove 12-14" of bark (but not the cambium underneath), around the whole circumference of the trunk. When this method was used in an Ohio forest, all tree crowns were dead by the end of the growing season, although most had stump sprouts. The following year, 64% had no stump sprouts, and the others had few sprouts. To speed mortality, stump sprouts can be cut (or simply broken by stomping) each year until root is dead.[13]
- A similar method, using a drawknife to partially girdle the tree each year in late summer (1/4-1/2 of circumference, 6" cut, removing all cambium) resulted in 47% mortality (no stump sprouts) after 1-2 treatments, or 34% mortality after 3-4 treatments; trees in the former group were smaller, and were probably fully girdled in 1-2 years.[16]
- After crowns and smaller stems have been killed (to prevent seed production) hand-pull new seedlings (< 60 cm tall) for one or two years until seed bank is exhausted. Spot-mulching after pulling seedlings may lessen soil disturbance and germination of tree-of-heaven and other invasive plants.[17]
- Wear protective gear (gloves, long sleeves, glasses) and avoid inhalation of particles from the tree when cutting or girdling tree-of-heaven.
- Monitor the site to prevent establishment of other invasives; in one case, removal of tree-of-heaven (with herbicide) resulted in recolonization of native herbs the following year.[14]
- Minimize soil and canopy disturbance and monitor annually to prevent re-establishment, especially if there are seed sources nearby.

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Fact sheet prepared by Kristen Bell Travis (Hudsonia) with assistance from Erik Kiviat, Gretchen Stevens, and Chris Graham (Hudsonia) and other Lower Hudson PRISM members, 2016.

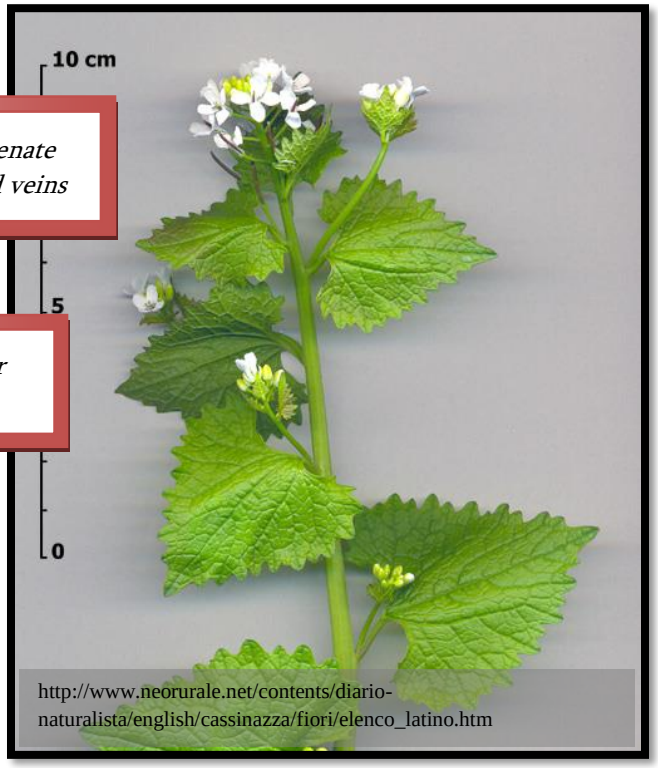
GARLIC MUSTARD *(Alliaria petiolata)*

Prohibited Invasive Species in New York *(6 NYCRR § 575.3(d)(2)(lx))*

Leaves with crenate margins, incised veins

Garlic-like odor when crushed

http://www.transformationalgardening.com/forage/master-foraging-key.html



http://www.neorurale.net/contents/diario-naturalista/english/cassinazza/fiori/elenco_latino.htm

An herbaceous plant with a biennial life cycle.

First year: Seed germinates in spring and grows into a rosette of basal leaves which stays green through winter.

Second year: Starting in spring, it bolts into a tall, flowering stalk, blooming in April-June. After seeds mature in late summer, the plant dies.

Native to Europe, garlic mustard was introduced to North America in the 1860s and is now established and invasive in the US in the Northeast, Midwest, and some parts of the South and West.

Similar species: Some other members of the mustard family have similar four-parted, white flowers (such as toothworts and cresses [*Cardamine*]), but different leaves. Basal leaves may be confused with, for example, leaves of golden ragwort (*Senecio aureus*), ground ivy (*Glechoma hederacea*), or some violets (*Viola*), but none have a garlic odor when crushed.

Where found: Garlic mustard often becomes established in moist, partly-shaded sites with disturbed soils, such as roadsides, trail edges, and stream banks. Because it tolerates a wide range of soil types, moisture regimes, and light levels, it can quickly spread into a variety of habitats, including mature forests. Conditions that lead to the highest densities include moist, nitrogen-rich,

high-pH soils; high densities of white-tailed deer and nonnative earthworms; and frequent disturbance to forest canopies and/or soils.[1,2]

Threats/benefits: Garlic mustard has been associated with declines in beneficial soil fungi (mycorrhizae) and changes in soil nutrient availability and cycling. Toxic allelopathic chemicals released from garlic mustard and dramatic reductions in mycorrhizae can change forest development and understory plant communities.[5] Garlic mustard in forests may contribute to the decline of butterflies that rely on native mustards (such as *Pieris virginiensis*, which prefers to lay eggs on garlic mustard over its native host plant even though its larvae die on garlic mustard).[6] Garlic mustard abundance is sometimes—but not always—associated with lower diversity or abundance of native plants.[1] Changes in native plant communities may also be caused by nonnative earthworms rather than nonnative plants (with nonnative plants benefitting from the soil changes brought about by the worms).[7] Deer avoid garlic mustard and augment its growth and spread by consuming native plants.[8] Strong, positive relationships have been found between the abundances of nonnative earthworms, white-tailed deer, and garlic mustard.[4]

Reproduction: Garlic mustard has a slender, white taproot, with buds at the top of the root crown and along the upper part of the taproot that will form new leaves and stems if the top part of the plant is cut. It produces numerous seeds, up to 50,000 or more per m^2, in long narrow capsules which mature by midsummer. Opening capsules can expel seeds 1-2 m from the plant; flooding, humans, or other mammals can disperse them farther.[9,1,2,10] Seeds can persist in the seed bank for up to 13 years.[11]

Management Goals:

- Prevent establishment of new populations by annual monitoring and removal.
- Eradicate small patches by preventing seed production until seed bank is depleted.
- Limit spread and reduce density of large invasions by limiting seed production.
- Re-establish a diverse assemblage of native understory plants, including tree seedlings.

Management Methods:

- Reduce or exclude deer populations. This will aid recovery of native plants, may reduce populations of nonnative earthworms,[4,8] and as a result slow population growth of garlic mustard.
- In the fall: Hand-pull the first-year rosettes when soils are moist, although pulling disturbs soil and may stimulate germination from the seed bank. Tamp soil firmly after pulling to minimize these effects. (By waiting until fall nature does most of the thinning for you – mortality is high during the first year.)[2,11]
- In the spring: To prevent seed production, cut or pull the plants after bolting but before seed maturation, preferably around the time of flowering. Cut plants at ground level, or pull

plants and tamp soil. Plants can be cut manually with a sharp trowel, pruners, sickle, scythe, or weed whip. Cut or pulled plants may still develop viable seed, so bag and remove all cut plants. Mechanical cutting with a mower, brush hog, or weed eater may be more efficient along roadsides and forest/field edges, but is much more likely to disperse viable seeds.[1,2]

- Repeat fall and spring removal until seed bank is exhausted (up to 13 years, but usually <5).
- Minimize soil and canopy disturbance: this will slow spread and lower chances of reintroduction.
- Seed or transplant native, browse-tolerant species in the forest understory, which can reduce densities of garlic mustard once established.[12] For example, bloodroot (*Sanguinaria canadensis*) planted at a density of at least 5/m^2 suppressed growth of garlic mustard.[18] If possible, estimate the number of years garlic mustard has been present. Planting native species will likely be most successful in older (less toxic) populations. If the invasion is still young, planting success may depend on removal of garlic mustard and soil inoculation.[13]
- Check soon for availability of a biocontrol option: Several weevils are candidates for biological control, and two are in the final stages of host specificity testing before release (http://www.nyisri.org/resources/biocontrol/).[10] Classical biocontrol can be a useful component of integrated weed management, but does not always work, and in some cases has adverse impacts on nontarget plants.

Special note: invasion patterns. Garlic mustard can invade a site rapidly, expanding an average of over 5 m/year in high-quality forest. Because of its biennial life cycle, density fluctuates quite a bit annually. At some invasion fronts density of garlic mustard increases rapidly, then remains established at a fluctuating but lower density, able to expand quickly with forest disturbance.[9] Densities can reach 40-200 plants/m^2 in disturbed forest.[14] However, there is also a longer-term invasion trajectory at any given site. Early in an invasion, there are high concentrations of toxic allelochemicals in garlic mustard plants and rapid population growth. Starting within a decade after invasion, there is a gradual decline in plant toxicity and slower population growth of garlic mustard. Native woody plant cover declines early in the invasion and then starts to increase after about 25 years.[15] Established populations are likely to stabilize (perhaps with a cyclical pattern) or eventually decline. Although it seems probable that garlic mustard populations will eventually self-regulate, aggressive management may still be necessary to prevent or mitigate long-lasting harm to native forest species.[16,17]

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Fact sheet prepared by Kristen Bell Travis (Hudsonia) with assistance from Erik Kiviat, Gretchen Stevens, and Chris Graham (Hudsonia) and other Lower Hudson PRISM members, 2016.

JAPANESE BARBERRY *(Berberis thunbergii)*

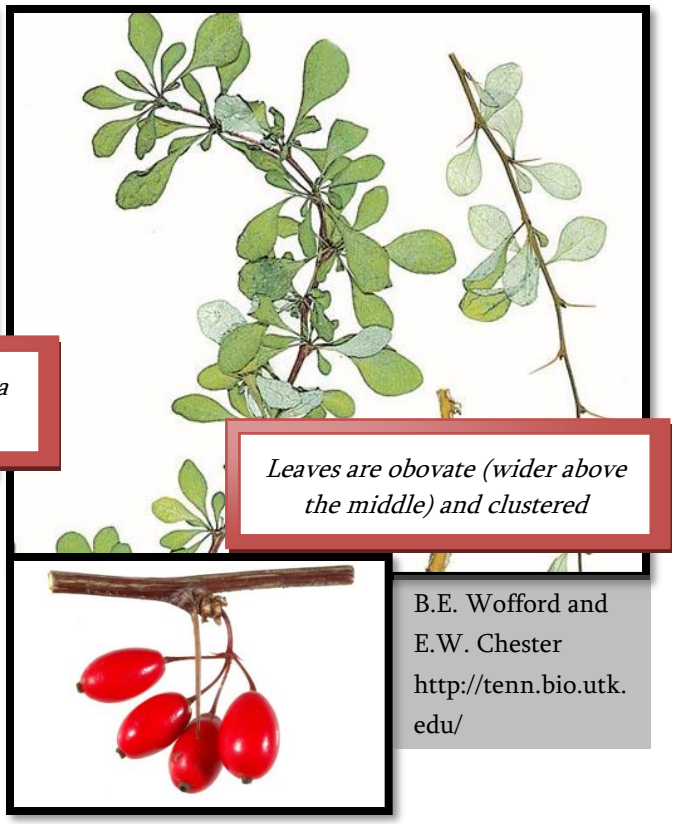
Prohibited Invasive Species in New York (*6 NYCRR § 575.3(d)(2)(lx)*)

© E. Kiviat

Dense barberry understory in a NY forest

A thorny shrub, usually less than 1.5 m tall (but sometimes to 3 m). Leaves have smooth margins and occur in clusters on alternate branch nodes, often with a single spine.

Japanese barberry flowers in early spring, and fruits ripen to red in early fall. Fruits are fleshy, with a single seed, and often persist well into winter.



Leaves are obovate (wider above the middle) and clustered

B.E. Wofford and E.W. Chester http://tenn.bio.utk.edu/

Japanese barberry was introduced to the North America from Japan in the 19th century. It has a widespread distribution in the US (most of the Northeast and Midwest, and parts of the Southeast and West) because it has been planted as an ornamental for over 100 years.

Similar species: Common barberry (*Berberis vulgaris*), seen much less frequently, is also nonnative. It has serrate leaves and three-branched spines.

Where found: Japanese barberry tolerates a wide variety of soil and light conditions and can be found in disturbed areas, oldfields, forest edges, deciduous and coniferous forest interiors, and swamps.[1] It occurs more often (and has higher productivity) in soils with high nitrogen availability.[2] Germination requires adequate light and moisture, but once established barberry can persist under a dense canopy (<1% sunlight) and in all but the driest sites.[1,3] Barberry has been described as a "long-term abandonment specialist" because its occurrence is strongly associated with pasture or cropland that returned to forest many decades ago.[3] White-tailed deer seem to find Japanese barberry distasteful and their preferential browsing of other plants may reduce woody competition for

barberry.[4] Overabundant deer can increase the abundance, growth rate, and height of barberry shrubs.[5,6,7] High densities of nonnative earthworms may also predict its presence and increase its cover[8] and growth rate.[6] In a recently invaded hemlock forest, canopy disturbance was the best predictor of barberry invasion.[9]

Threats/benefits:

Japanese barberry leafs out early in the spring—up to a month before full canopy leaf-out in forests—and drops its leaves late in the fall, allowing a much longer growing season than for most of its native competitors.[1] Presence of barberry is associated with greater nonnative earthworm biomass, reduced leaf litter volume, and higher available nitrogen.[8,10] Higher available nitrogen benefits barberry (as well as many other invasive plants), which may increase in density, making yet more nitrogen available through its nutrient-rich leaf litter. The addition of even a small amount of barberry leaf litter shifts the soil microbial community and speeds litter decomposition.[11] Although reductions in native plant richness and cover are sometimes attributed to barberry, nonnative earthworm biomass may be a better predictor of native plant richness in the understory and the seed bank.[8,12] In a Pennsylvania forest, modest densities of barberry were not associated with any differences in soil pH, carbon, or nitrogen, or reductions in richness or evenness of native plants.[13] Veeries (and perhaps other understory nesting birds) preferentially nest in dense thickets of barberry and other invasive shrubs, without reductions in nest success compared to nests in native vegetation.[14] Barberry and other nonnative shrubs can provide important habitat for New England cottontail (a Special Concern species in NY) in shrublands and young forests.[15] However, dense thickets of barberry in the forest understory change the microclimate of the forest floor, resulting in nine times more Lyme disease-infected black-legged ticks than areas without barberry; removal of barberry reduces this number by 60%.[16]

Reproduction:

Japanese barberry produces prolific fruits under a full range of light and soil conditions. Birds—especially galliform birds such as ruffed grouse and wild turkey—are primary dispersers of the relatively low-quality fruit, which is consumed late in the season. Most seedlings are found within 1 m of fruiting shrubs, but occasional individuals occur up to 80 m distant or further.[1] Shrubs can also spread by sprouting from the root crown, rhizomes, or branch-tips that touch the ground. The seed bank is fairly short-lived, with germination of 89% (year 1), 10% (year 2), and 1% (year 3) in one experiment.[17]

Management Goals:

- Eradicate small or light infestations early.
- For large or dense patches, reduce density and prevent fruiting.
- Re-establish a diverse assemblage of native understory plants, including shrubs and tree seedlings.
- If occurrence is part of a large oldfield or shrubland potentially important to New England cottontail (only east of the Hudson River) or declining grassland- or shrubland-nesting birds such as yellow-breasted chat, golden-winged warbler, field sparrow, or northern harrier,

discuss management with NYS DEC or appropriate conservation organizations (removal might not be desirable).

Management Methods:

- Reduce or exclude deer populations. This will aid recovery of native plants, may reduce populations of nonnative earthworms, and as a result slow the growth and spread of Japanese barberry.
- Limit soil disturbance and canopy disturbance: this will slow spread and lower chances of reintroduction.
- For seedlings and smaller shrubs, hand-pull with thick gloves. Hang pulled shrubs in trees or pile, roots up, to prevent re-rooting. If fruits are present, plants should be bagged and landfilled. Pulling out shrubs by the roots results in mortality 70-80% of the time.[18]
- In early spring, cut stems near ground level with a brush cutter. After stems resprout, follow this with directed flame treatment (when forest floor is damp or wet, use a 100K or 400K BTU propane torch to apply a direct flame for 3-40 seconds, until individual stems become carbonized and begin to glow). Two flame treatments (in summer and fall) with the 100K torch, or one treatment (summer) with the 400K torch may result in about 80% mortality).[19,20] This two-step process also minimizes soil disturbance and the chance of other invasive plants establishing.
- Annual cutting in summer will minimize or eliminate fruit production, but is unlikely to kill plants. Avoid winter cutting – this leads to vigorous resprouting.
- Monitor for and remove seedlings for 2-3 years following removal of fruiting shrubs.
- After reductions in deer and Japanese barberry density, seed or transplant native shrubs (to replace understory-nesting bird habitat), trees, and herbs in the forest understory.

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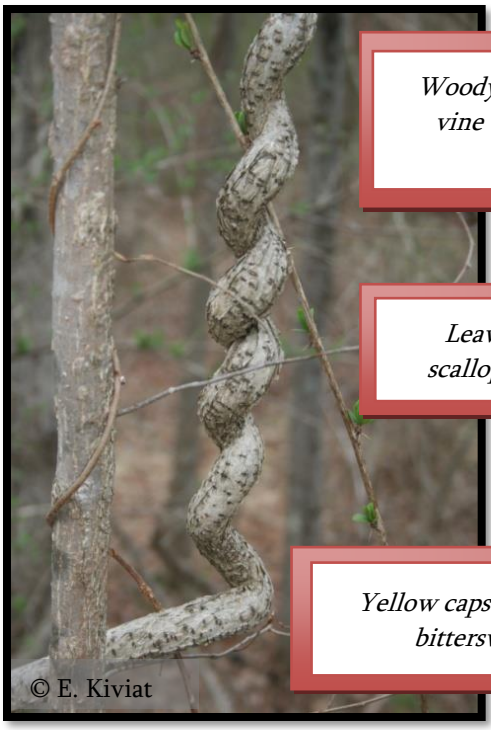
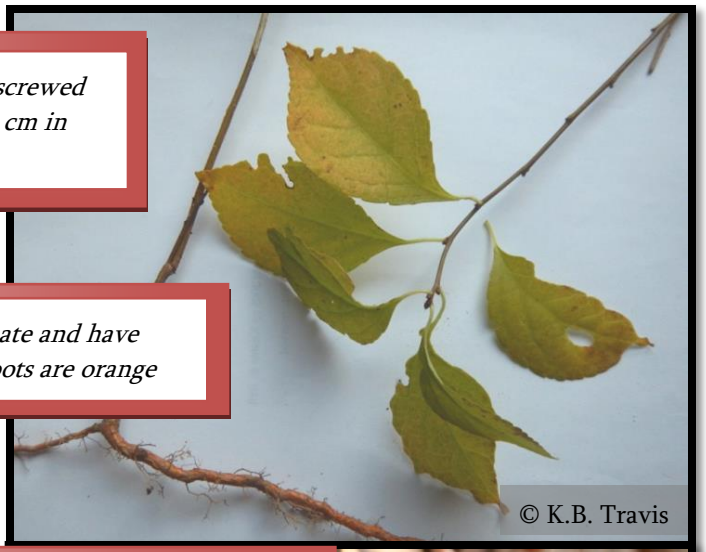
Fact sheet prepared by Kristen Bell Travis (Hudsonia) with assistance from Erik Kiviat, Gretchen Stevens, and Chris Graham (Hudsonia) and other Lower Hudson PRISM members, 2016.

ORIENTAL BITTERSWEET *(Celastrus orbiculatus)*

Prohibited Invasive Species in New York *(6 NYCRR § 575.3(d)(2)(lx))*



Woody, often corkscrewed vine can reach 10 cm in diameter



Leaves are alternate and have scalloped edges; roots are orange

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Yellow capsule encloses a red fruit (in American bittersweet the capsule can be orange)

© E. Kiviat

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A perennial, woody vine to 20 m that can ascend to the tops of canopy trees or sprawl horizontally across fields. Leaves are alternate and rounded, scalloped along the edges and often with pointed tips. Red berries and yellow leaves in fall are eye-catching.

Oriental bittersweet is native to temperate east Asia, and it was introduced to the US in the mid-1800s for ornamental use. It is widespread in the Northeast and common but sporadic throughout the South and Midwest.

Similar species: The native American bittersweet (*Celastrus scandens*) is a species of conservation concern, so care must be taken to correctly identify Oriental bittersweet. As leaves emerge in spring, Oriental bittersweet leaves are folded in half while in those of American bittersweet, each half is rolled toward the center. In addition to differences in capsule color, Oriental bittersweet generally has white pollen and 5 or more seeds per fruit; American bittersweet usually has yellow pollen and zero to one seeds per fruit. In Oriental bittersweet, clusters of flowers and fruit are borne along the twig, interspersed with leaves. In American bittersweet, clusters are at the very ends of twigs.[1,2] These two species can hybridize.[3]

Oriental bittersweet

Where found: Oriental bittersweet can be found in forests, forest edges, shrublands, meadows, fencelines, waste areas with exposed soil, and along the edges of roads and lawns. It tends to spread first along roads and from there enters forests; it is most common in mesic, eastern deciduous forest and forest edges.[4] It prefers nutrient-rich, moist, somewhat acidic soils, but tolerates a wide range of soil conditions. It does best in sunny places such as oldfields and forest edges, but can persist in the shady understory as well.[4]

Threats/benefits: Oriental bittersweet grows quickly, and large infestations occasionally form tangled thickets, blanketing other vegetation. Bittersweet can harm or discourage other plants by shading, girdling, and breakage, and when it climbs high into trees the extra weight can increase damage and blowdowns from wind, snow, and ice storms.[3] Almost 10% of large tree mortality in Connecticut River floodplain forests was caused or partially caused by bittersweet.[5] Dense patches of bittersweet interfere with forest regeneration by inhibiting growth and reproduction of native trees and shrubs; it can either enhance or depress the success of native grapevines.[4] Experiments with other woody vines determined that belowground (root) competition between the vine and the host tree resulted in reduced leaf area and reduced growth for the tree.[6] Bittersweet is negatively associated with native plant diversity, and inhibits establishment of spring ephemeral understory herbs. It can also negatively affect forest timber production, by damaging or killing trees and by reducing the ability of a harvested area to regenerate.[4] (It should be mentioned that native woody vines may also increase tree damage, and some native plants may also inhibit forest regeneration.) Addition of bittersweet leaf litter raises pH and nutrient content of soils, and these changes facilitate the growth of invasive Japanese barberry.[7] Declines in the native American bittersweet[8] are evidently due to hybridization with Oriental bittersweet: in proximity to the nonnative species, the native bittersweet produces a majority of hybrid seedlings, while the nonnative produces very few hybrids.[9] Oriental bittersweet also produces much more pollen, effectively "swamping" American bittersweet reproduction.[9]

Deer preferentially browse the leaves of Oriental bittersweet,[10] and can reduce its prevalence (along with reducing cover and richness of native plants).[11] The fruits are consumed by birds, squirrels, and rabbits, and the lipid and sugar content makes them a high-quality winter food.[4]

Reproduction: Oriental bittersweet usually has separate female (fruiting) and male (non-fruiting) plants, and reproduces prolifically by seed, by root and stem sprouts, and by resprouting of root fragments. Root sprouting is especially energetic after the vine or roots are damaged, and this vegetative reproduction can result in large patches of bittersweet.[4] Controlled burns in fire-adapted systems increase the density of bittersweet by stimulating sprouting.[12] The flowers bloom in late spring and the fruit matures in September-October. The flowers are mainly pollinated by wasps and especially bees. The seeds are dispersed by small mammals, frugivorous birds, water, and humans (widely planted as an ornamental, its berries are often used in wreaths and dried arrangements). Bird-dispersed seeds can end up far from the parent plant, in mature forests or other habitats wherever birds perch.[4] Germination rates are high, and germination can occur even in shade and

with an intact leaf litter layer. However, seeds survive less than a year in the seed bank.[13,14] Seedlings can persist with little growth for years in the forest understory, and then grow rapidly into the canopy when disturbance increases light availability.[4]

Management Goals:

- Prevent fruiting of mature vines.
- Completely remove seedlings and small vines by thorough excavation of roots and all root fragments.
- Weaken and kill larger vines and patches by repeated cutting.
- Maintain closed forest canopies wherever possible; canopy openings are likely to stimulate bittersweet growth.
- For open fields, mow regularly and frequently (or pasture goats) for several years.
- Monitor un-infested or minimally-infested areas frequently for new seedlings.

Management Methods:

- First, cut all mature vines near the base, to prevent fruiting in that year and relieve stress to the tree (belowground competition will be reduced, and risk of wind damage reduced as vines dry and start to disintegrate). Cut large vines in July-August, before fruits mature, which also reduces sprouting (compared to cutting in spring or fall)[15] and depletes stored carbohydrates.[12] Cutting the stem higher above the ground results in more sprouts.[12]
- Regular, frequent (e.g., weekly) mowing or cutting will eventually eliminate bittersweet, but less frequent mowing, such as 2-3 times per year, will only stimulate root sprouting.[3] Frequent mowing over several years may be required to deplete the carbohydrate reserves held in the roots.
- Hand-dig seedlings, removing all roots. Seedlings not in the immediate area of mature vines can be distinguished from those of American bittersweet as leaves unfold in the spring. Small infestations of Oriental bittersweet can be eliminated by cutting and excavating the roots, but this will be effective only if the roots are completely removed. A new shoot can sprout from even a small root fragment.
- To prevent re-rooting, all root material should be piled on pavement or bagged, and allowed to sit in the sun until it dies. If mature fruits are present, the vines with attached fruits along with any fallen fruit should be burned, or bagged and landfilled.
- Goats will readily consume Oriental bittersweet, and can be effective at eliminating the plant if allowed to graze throughout the growing season for several consecutive years. Goats will also eliminate other woody plants, including desirable natives, but goat grazing or regular mowing may be appropriate where the goal is to maintain an open habitat without woody plants.
- Although Oriental bittersweet is fairly shade-tolerant, an opening in the forest canopy can stimulate rapid growth. Thus, selective cutting of forest trees may encourage its spread.

- The seed bank may be repeatedly replenished by wildlife transporting seeds from nearby or fairly distant areas, so regular and frequent monitoring of treated areas (and all forest edges) is important. Scouting for new plants is best done in the fall, when bright yellow bittersweet leaves persist after most native trees have lost their leaves.[3]

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BLACK SWALLOWWORT *(Cynanchum louiseae)*

Prohibited Invasive Species in New York (*6 NYCRR § 575.3(d)(2)(lx)*)

Leslie J. Mehrhoff, University of Connecticut, bugwood.org

Perennial herb or small vine to about 2 m long. Tip of the stem is twining. Leaves are opposite, glossy and dark green, with smooth margins. Very dark purple flowers (with pubescent petals) develop into elongated seed pods which release tufted, wind-dispersed seeds (like the familiar common milkweed).

Black swallowwort is native to Europe, and it was introduced to the US in the mid-1800s as an ornamental. In the US it is primarily found in the Northeast.

Similar species: Pale swallowwort (*Cynanchum rossicum*) is extremely similar, but its flowers are a lighter color of pink to maroon, with no fine hairs on the petals. Although much less common in the lower Hudson Valley, pale swallowwort is just as invasive as black swallowwort and very similar ecologically. Many of the control methods suggested below have been tested on pale rather than black swallowwort, but the results are likely applicable to both species. Japanese honeysuckle (*Lonicera japonica*) is another non-native, invasive vine with opposite leaves—but its leaves are oval, lacking the long, pointed tips of swallowwort leaves.

Black swallowwort

Where found: Black swallowwort is most commonly found in disturbed, upland areas such as roadsides, pastures, oldfields, and orchards. It is often found on calcareous soils, but also occurs on acidic soils, and is salt-tolerant. Plants often become established in disturbed, open areas and edges, then spread into less-disturbed habitats including deciduous and mixed forests, shrublands, and occasionally wetlands. Other areas susceptible to invasion include flood-scoured river and stream banks, coastal areas, rocky outcrops, and upland edges of tidal marshes.[1]

Threats/benefits: Black swallowwort can form dense patches quickly, and each plant develops a large and almost indestructible root mass. It displaces native plants, likely through a combination of factors: swallowwort alters soil fungal communities (to its own benefit), exudes allelochemicals toxic to other plants, deeply shades the soil surface (in some cases), and efficiently acquires resources through its large root biomass.[1] Invaded oldfields show reduced arthropod diversity and reduced abundance and diversity of grassland-breeding birds. Black swallowwort is avoided by and probably toxic to most livestock. Monarchs lay eggs on swallowworts, even preferring them to common milkweed, but the larvae die. It is known to threaten at least one rare plant, the endemic Jessop's milkvetch (*Astragalus robbinsii*), along the Connecticut River.[1] The closely related pale swallowwort is known to negatively affect rare plants of sandy coastal habitats, contribute to grassland-breeding bird declines, and displace endemic flora and fauna of rare alvar communities.[2] It has also led to the abandonment of some horse pastures and land supporting perennial agriculture (e.g., Christmas tree plantations, horticultural nurseries, and orchards) due to invasions that were too expensive to control. No-till crop agriculture is also at risk, because swallowwort cannot be controlled with commonly-used crop herbicides. Both swallowworts may disrupt forest regeneration.[2]

Reproduction: Black swallowwort spreads primarily by seed. Flowering occurs in mid-May through mid-August and mature seed pods open from mid-August to mid-October. Flowers can be self- or cross-pollinated (by insects). Seeds have long hairs for wind dispersal, and they germinate in both spring (May) and fall (September-October). They can persist in the seed bank for approximately four years. Each plant forms a short rhizome and dense fibrous root system. Rhizomes do not creep, but if broken or cut into pieces they will form new plants.[1] Buds on the rhizome send up new stems if the stem is damaged. Swallowwort needs a certain amount of light to flower, but it can persist for decades in a shady place without flowering. Open sites can produce >2,000 seeds/m^2, but because about half of the seeds are polyembryonic, this could result in >4,600 seedlings.[1]

Black swallowwort

Management Goals:

- Monitor carefully to catch any invasion early.
- Eliminate small patches.
- Establish native plants after swallowwort removal.
- Keep large patches from spreading by preventing seed production.

Management Methods:

- For small patches or recently established plants, hand-dig entire root crown (before seeds mature). Digging is more effective than pulling or herbicide, but the complete root crown must be dug out to prevent resprouting.[3]
- For small to medium patches, cut and remove all top growth, then cover with a heavy tarp or heavy-duty black plastic for two years. Black plastic is damaged more easily, and plants will regrow through any holes, but this method may reduce density enough for hand-digging.[4]
- For fields, plow and plant an annual crop until seed bank is depleted (4-5 years).[3]
- Cut or mow 1-4 times per year to prevent seed production. In some cases, a single cutting timed when first fruits are formed but not fully developed (around late June) will prevent fruiting.[5] However, often two cuttings (in June and July) will not eliminate seed production[6,7] whereas four cuttings will.[7]
- Clipping or mowing four times per year does not help kill the plant, or even reduce the root mass after six years (in full sun).[7] Clipping twice per year does not decrease density in oldfield or forest habitat.[8] Cutting or mowing every week or two weeks would (presumably) eventually kill plants.
- Seed or transplant native plants where swallowwort has been dug or smothered, and monitor carefully for this or other invasive plants colonizing.[9]
- Cattle will graze swallowwort enough that it does not invade cattle pastures until they are abandoned.[1]
- A biocontrol agent, the defoliating moth *Hypena opulenta*, has been released in Canada and may be approved soon in New York. Based on studies of defoliating and clipping plants, it is unlikely that defoliation alone will reduce or kill plants in full-sun conditions.[7] In shaded forest understories, the effects of clipping or insect defoliation may be stronger.

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GLOSSY BUCKTHORN *(Frangula alnus)*

Prohibited Invasive Species in New York (*6 NYCRR § 575.3(d)(2)(lx)*

Fruits turn from red to black as they ripen

Winterberry holly for comparison: leaves with toothed margins, fruits with very short stalks; ripe fruits are bright red

Note evenly-spaced veins; leaves sometimes look wavy

A shrub or small tree to 7 m. Alternately arranged, oval leaves with smooth edges and distinct, evenly-spaced veins. Leaf buds are naked (not covered with scales), with reddish brown hairs. Fruits turn red and then purple-black. Broken twigs have an acrid smell. Leaves eventually turn yellowish in the fall and remain on the plant longer than leaves of most associated deciduous plants.

Glossy buckthorn is native to Europe, North Africa, and central Asia, and was first introduced to North America in the late 1800s. It has been widely planted as an ornamental and for improving wildlife habitat, and is now naturalized in upland and wetland habitats in much of southeastern Canada and the eastern US.

Similar species: Common buckthorn (*Rhamnus cathartica*, nonnative, invasive) and alderleaf buckthorn (*Rhamnus alnifolia*, native) are similar, but both have leaves with finely toothed edges and smooth undersides (glossy buckthorn leaves have smooth edges and sometimes have small hairs on the underside). Common buckthorn also has many leaves that are subopposite (not quite

opposite) and small thorns at the tips of some twigs, and grows as a single tree or a dense, tall thicket in oldfields, other disturbed habitats, and forest understories. Management methods described below apply to this species as well. Alderleaf buckthorn is a small shrub found in calcareous wetlands such as rich fens (where glossy buckthorn is also likely to occur). Shrubs with alternate leaves can be confusing; a key or field guide is helpful to rule out others, including winterberry holly (*Ilex verticillata*), alternate-leaved dogwood (*Cornus alternifolia*), alder (*Alnus*), shadbush (*Amelanchier*), and chokeberry (*Aronia*).

Where found: Glossy buckthorn can be found in a variety of wetland and upland habitats. It prefers wetlands, including acidic bogs, calcareous fens, sedge meadows, marshes, shrub swamps, and forested alluvial swamps, but is also found in upland old fields, shrublands, and forests including oak, conifer, mesic hardwood, and alluvial forests.[1,2] Glossy buckthorn is also associated with disturbance, and can be found along roads and in previously plowed areas.[2] Because it is most successful in drier conditions within wetlands, wetland drainage and lowered water tables benefit glossy buckthorn. Wetland invasion by this shrub may also be promoted by the cessation of regular grazing or burning, soil disturbance, or acidification of the fen surface.[1] Buckthorn seedlings establish most readily in unshaded areas with exposed soils. In deep shade, glossy buckthorn may fail to produce fruit, but can persist vegetatively for decades.[2] Nonetheless, deep shade is associated with mortality of glossy buckthorn.[3]

Threats/benefits: Glossy buckthorn grows rapidly, potentially forming dense, even-aged thickets that discourage shade-intolerant plants. For example, a sedge fen with glossy buckthorn seedlings present became a dense buckthorn shrub wetland within 20 years.[1] It leafs out before most other native woody plants in the spring and retains its leaves longer into the fall. In various forest studies, glossy buckthorn at high densities has been associated with lower tree seedling density, slower growth and higher mortality of tree saplings, and lower cover and richness of understory herbaceous and woody plants, all of which could influence forest regeneration.[2,4] Glossy buckthorn may support fewer arthropods than native woody species. It is also an alternate host for crop diseases that affect oats and alfalfa.[2]

Glossy buckthorn does not always affect native plant richness when it occurs in wetlands.[2] Nevertheless, an invasion tends to make a wetland more homogeneous—both in plant structure and composition—which may decrease habitat quality and food resources for wetland flora and fauna.[5] Its greatest potential for harm is probably in the rare, nutrient-limited wetlands it prefers such as acidic bogs and calcareous fens. Here it has the potential to displace many rare plants (such as Schweinitz's sedge [*Carex schweinitzii*] and handsome sedge [*Carex formosa*]) and their associated invertebrates (including butterflies like black dash and Dion skipper), and alter habitat quality for a few rare and uncommon vertebrates (such as bog turtle, spotted turtle, southern bog lemming, and sedge wren). Many birds consume glossy buckthorn fruit, including American robin, cedar waxwing, rose-breasted grosbeak, European starling,[2] wood duck, blue jay, and blackbirds.[1] Mice and other small rodents consume seeds.[2] However, glossy buckthorn produces anthroquinone in its

fruit, bark, and roots. Wildlife consuming the fruit metabolize anthroquinone into emodin which in high doses can cause diarrhea and at low doses constipation, both of which can lead to nutritional deficits. By displacing other fruiting plants, glossy buckthorn can reduce the quantity and diversity of other food sources important to birds. In southern Ontario, glossy and common buckthorns are larval hosts of Henry's elfin (butterfly),[2] but, to our knowledge, this association has not been documented in New York.[6]

Reproduction: Glossy buckthorn blooms May-September, and fruits ripen starting in July (a single plant may have flowers, unripe and ripe fruits present at the same time). Flowers are pollinated by insects. The fruits drop to the ground when ripe, and much of the seed germination occurs beneath the parent plant, but seeds are also dispersed by the birds and mammals that consume the fruit (for example, mice cache the seeds). Berries also float and can be water-dispersed. The germination rate is high and most seeds tend to germinate in the first year, but the seed bank can persist for at least two years.[2] When mature buckthorn stems are cut or injured, the root crown produces abundant sprouts (up to 50 or more) which often turn a single-stemmed plant into a multi-stemmed shrub or tree.[1] Sprouts can flower and fruit in their first year.[2]

Management Goals:

- Focus on occurrences in high-quality wetlands first: either remove, or keep at a low level with ongoing management. If it occurs in a rich fen, calcareous wet meadow, acidic bog, kettle shrub pool, or other rare wetland or wetland that may support rare species, consult with the NYS DEC or appropriate conservation organizations about management.
- Target mature shrubs first; then, remove seedlings until seed bank is depleted.
- Monitor disturbed ground, canopy openings, and open wetlands for new plants and remove as needed.

Management Methods:

- For large stands of glossy buckthorn, the best strategy is to remove the largest seed-producing plants first. Removing plants before the seeds mature each year can significantly deplete the soil seed bank. Repeated cutting will reduce plant vigor and eventually kill the plant,[1] but this method is probably the least efficient.
- Try the "cut and cover" method to prevent stump sprouts: cut several inches above ground level and cover the stump with something that completely blocks light for 1-2 years (e.g., a metal can, or a heavy-duty black plastic bag zip-tied to the base of the stump).[7]
- Try direct flame treatment. (A propane torch should be used only after or during rain when the ground is wet and wildfire hazard is minimal.) For stems of less than 4.5 cm (1.8 in) diameter, applying a flame torch around the stem for five seconds will reportedly kill the cambium and prevent the stems from resprouting.[1] Alternatively, cut shrubs to near ground level in spring or summer. After stems resprout, follow with directed flame treatment (use a 400K BTU propane torch to apply a direct flame for 3-40 seconds, until individual stems

become carbonized and begin to glow). This method has been successful with barberry but has not been tested for buckthorn.[8]

- Girdling in winter (removing a 2-10 cm strip of bark and cambium completely around base of stem) has been reported as either completely effective[1] or completely ineffective[9] at preventing resprouting. If stumps resprout, repeated cutting of sprouts for several years will kill the roots.
- After seed sources have been eliminated, hand-pull seedlings and small plants (or remove with a grubbing hoe or weed wrench). The removal of large plants may result in high seedling densities, but because of the short-lived seed bank, seedling removal should only be necessary for one or two years.[4]
- For open fields, regular and frequent mowing (or else pasturing goats) for several years will kill mature plants and prevent seedling establishment.[2] After first cutting large stems, properly managed low-intensity grazing of cattle (as used for bog turtle habitat management) can keep buckthorn resprouts in check in open wetlands such as fens and wet meadows.
- After removal of glossy buckthorn from a forest, replanting with desirable native woody species may help prevent invasion or re-invasion of glossy buckthorn. At one site, native woody seedling densities returned to non-invaded levels on their own by two years after removal of glossy buckthorn.[4]
- In areas not yet infested with buckthorn, early detection and removal is essential to prevent significant infestations.

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BELL'S HONEYSUCKLE *(Lonicera × bella)*

Prohibited Invasive Species in New York *(6 NYCRR § 575.3(d)(2)(lx))*

Bell's honeysuckle (*Lonicera × bella*) is a hybrid between Morrow's (*L. morrowii*) and Tatarian (*L. tatarica*) honeysuckles. This is a hybrid swarm, and individuals may be found that span the spectrum of appearance from one parent species to the other. All occur in the Northeast, along with Amur honeysuckle (*L. maackii*), another Asian species. In the lower Hudson Valley, Bell's honeysuckle is by far the most common of the shrub honeysuckles. The management methods apply to all species.

Pith is hollow (although sometimes quite small)

Leaves opposite; leaf margins entire

All the Asian shrub honeysuckles have opposite leaves, white (to yellowish or pinkish) flowers, and red (to yellow) berries. Bell's honeysuckle can reach 6 m in height.

Morrow's honeysuckle is native to Japan, and Tatarian honeysuckle to Russia. The hybrid Bell's honeysuckle was first reported in North America around 1900, and is now widely naturalized across the northern US and Canada, and into the Southeast.

Similar species: The Asian bush honeysuckles can be distinguished from the native fly honeysuckle (*L. canadensis*) and bush-honeysuckle (*Diervilla lonicera*) by having stems with hollow pith (vs. solid for native species) and leaves with smooth margins (vs. toothed or ciliate margins [look closely]). Other, less common, similar species include swamp fly honeysuckle (*L. oblongifolia*), with yellow flowers in the leaf axils; snowberry (*Symphoricarpos albus*), with hollow pith but white fruits; and coralberry (*S. orbiculatus*), with solid pith and coral to purple fruits.[1]

Where found: Bell's honeysuckle is found in a variety of habitats, most commonly in shrublands, at forest edges, and in forest understories. It thrives in disturbed sites such as oldfields, urban forests, and along roads and railroads, and can also be found in riparian and lakeshore areas and open or forested wetlands. Although the plant is quite tolerant of shade, it grows best and produces the most fruit in higher-light conditions.[2,3]

Threats/benefits: Bell's honeysuckle, similar to other non-native shrubs, has earlier leaf emergence in spring and later leaf drop in fall than native shrubs, which may help explain its ability to displace native shrubs and understory herbs. Tree seedlings are less abundant under Bell's honeysuckle shrubs in forest understories, such that substantial honeysuckle cover can impede forest regeneration.[3] Increasing honeysuckle cover also reduces the cover and richness of understory herbs.[3] However, in Wisconsin forests surveyed 50 years apart, native plant richness declined across the region but not in response to Bell's honeysuckle presence or abundance (or that of other non-native plants).[4]

Amur honeysuckle (a closely related and ecologically similar species) increases the emergence rate of the mosquito *Culex pipiens*, a vector of West Nile virus, when its leaf litter is present in the small containers and ponds where *C. pipiens* breeds (compared to native forest litter).[5] Larval amphibians reared in Amur honeysuckle extract had increased mortality (one species), behavior consistent with oxygen deprivation (two species), or no effect (two species).[6] Forest plots with high densities of Amur honeysuckle had fewer amphibian species and a shift in composition toward more common, generalist species, perhaps due in part to lower temperatures under the honeysuckle layer or its previously found effects on larvae.[7] Dense shrub honeysuckles invading forested wetlands may increase total transpiration, which could affect the hydroperiod and water levels of wetlands and streams, especially intermittent ones.[8]

Shrub honeysuckles (in oldfields, shrublands, and young forests) are an important component of New England cottontail (a Special Concern species in NY) habitat.[9] Bell's honeysuckle leaves are browsed by deer and eastern cottontail, and its berries and seeds can be an important source of winter food for birds and small rodents.[3] Shrublands dominated by shrub honeysuckles support high densities of birds during spring migration (when they have a higher abundance of insects than forest), fall migration (abundant fruits), and the breeding season.[10] Most birds gain mass during

spring migration stopovers in such habitat in Pennsylvania, indicating that honeysuckle shrublands are an important resource for migrants.[10] However, native fruiting shrubs provide much higher-quality fruit to fuel fall migration.[11] Birds nesting in both oldfield and forest understory habitat often prefer honeysuckle and other nonnative shrubs for nest placement. In habitats ranging from oldfields to mature forest, nests placed in honeysuckle experienced higher predation rates and lower reproductive success (during at least part of the nesting season), making the invasive shrubs an ecological trap.[12,13,14] Shrub honeysuckle cover increases the activity of mice and raccoons (which could help account for decreased nest success).[15] In contrast, veeries nesting in honeysuckle in a forest understory had similar success to those nesting in native shrubs.[16]

Reproduction: Bell's honeysuckle blooms in May and June, and is pollinated primarily by bees. The abundant fruits ripen from June-August. The fruit, a multi-seeded berry, is consumed by birds, small mammals, and deer, and these animals are also the primary dispersers of honeysuckle seeds. (Consumption by deer may be incidental to their browsing on honeysuckle leaves and twigs.)[3] The viability of seeds declines significantly after the first two years, but a few seeds may remain viable for many years. Seedlings often establish under shrubs or trees used as perches by seed-dispersing birds, and establish most successfully where litter cover and herbaceous plant cover are sparse. Bell's honeysuckle also reproduces vegetatively, by root sprouting (generally within 1 m of the root crown) and by layering (branch tips can root where they touch the ground).

Management Goals:

- Remove seed sources (mature shrubs) in a way that minimizes root sprouting; kill root sprouts annually until root is dead.
- Where shrubs occupy forest understory and forest edge, focus on mature shrubs in edge (high-light environments) first, since their fruit production is much greater.[17]
- Remove seedlings until seed bank is depleted.
- Monitor annually to prevent re-establishment, especially if there are seed sources nearby.
- Plant or facilitate re-establishment of native shrubs (particularly fruiting ones) such as viburnums, dogwoods, spicebush, heath shrubs, and others to replace songbird nesting habitat and food resources.
- If occurrence is part of a large oldfield or shrubland potentially important to New England cottontail (only east of the Hudson River) or declining grassland- or shrubland-nesting birds such as yellow-breasted chat, golden-winged warbler, or northern harrier, discuss management with NYS DEC or appropriate conservation organizations (removal might not be desirable).

Management Methods:

- Hand-pull small to medium shrubs prior to fruiting. They have shallow root systems, but can resprout from small root fragments if any are left. Uprooting medium to large shrubs has a high success rate but is more labor-intensive than many other methods.[18]
- Annual clipping promotes shrub honeysuckle growth in full-light conditions, but in forest three years of a single July clipping killed 70% of shrubs.[3] In another forest experiment, however, killing 90% of shrubs required over three years of clipping every two weeks.[3] Winter cutting apparently encourages vigorous re-sprouting and should be avoided.
- A two-step process has been successful with Japanese barberry, resulting in 80% mortality after one year,[19] and could be tried with honeysuckle. In early spring, cut stems near ground level with a brush cutter. After stems resprout (summer), follow this with directed flame treatment (when forest floor is damp or wet, use a 400K BTU propane torch to apply a direct flame for 3-40 seconds, until individual stems become carbonized and begin to glow). This process minimizes soil disturbance and the chance of other invasive plants establishing.
- After fruiting shrubs have been cut or removed, focus on hand-pulling seedlings and killing root sprouts. This will need to continue for several years, until seed bank is depleted and all roots are dead.
- Soil disturbance may encourage establishment of new honeysuckle seedlings, so measures should be taken to minimize soil disturbance and quickly revegetate disturbed soils with native herbs, shrubs, and trees.
- Handle pulled shrubs carefully to prevent re-rooting: construct a brush pile (roots up) or burn. Cut stems can also root in moist conditions. Avoid cutting plants when fruits are present, or else carefully bag and dispose of fruiting branches.

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PURPLE LOOSESTRIFE *(Lythrum salicaria)*

Prohibited Invasive Species in New York *(6 NYCRR § 575.3(d)(2)(lx))*

Purple loosestrife showing leaf damage and reduced flowering due to biocontrol beetle damage

An herbaceous, multi-stemmed, wetland perennial to 2-3 m tall, becoming somewhat woody at the base. Has opposite leaves with smooth margins, and a terminal spike of showy, pinkish-purple flowers.

Purple loosestrife was introduced to North America from Europe around 1820 and has spread throughout most of the US and southern Canada. It was reported to form very dense stands, displacing native species, in eastern North American wetlands in the mid-1900s. Although still a common and abundant wetland invader in the East, it may form less dominant stands now than formerly.[1]

Similar species: Native wetland plants that may be confused with purple loosestrife include winged loosestrife (*Lythrum alatum*), which is a much smaller plant (around 30 cm tall) with smaller, alternate or opposite leaves, and swamp loosestrife (*Decodon verticillatus*), a shrub with long, arching stems. Both of these species have flowers at the bases of leaves (instead of in a terminal spike). Blue vervain (*Verbena hastata*) has opposite leaves with toothed margins and small bluish-purple flowers.

Where found: Purple loosestrife is a plant of freshwater wetlands, including marshes, wet meadows, fens, bogs, openings in forested swamps, intermittent streams and pools, pond and lake

shores, stream banks, and ditches.[2] It is also common in fresh and brackish tidal wetlands. Loosestrife can establish on recently disturbed upland soils, although it remains smaller there than in wetlands. In recently-disturbed wetlands such as drawn-down ponds and abandoned beaver ponds and pastures, loosestrife may be highly dominant. Much more commonly in our region, loosestrife co-occurs with a reasonable diversity of other plants, even in wetlands where it is the dominant species.[1]

Threats/benefits: Purple loosestrife changed soil organic matter, nitrogen cycling, and water chemistry in New York wetlands, resulting in higher levels of available nitrogen.[3] It had double the transpiration rate of cattail (high transpiration can have a positive, cooling effect on the surroundings as well as a potential negative effect of wetland drying), and outcompeted cattail in high-nutrient conditions.[3] Purple loosestrife may have negative effects on detrital food chains, and suppress the growth of aquatic plants that are important food sources.[2] It can reduce or eliminate open water and open mudflat areas, important for foraging waterfowl.[2] Purple loosestrife tannins added to water decrease survival of American toad tadpoles.[1] Purple loosestrife may decrease habitat quality for muskrat, because muskrats prefer to eat cattail and thereby give loosestrife a competitive advantage.[2] Purple loosestrife-dominated habitats may support higher densities but lower diversities of birds than other wetland vegetation types.[4]

Although purple loosestrife is purported to decrease native plant diversity, evidence is lacking. In Ontario wetlands, nonnative and native species richness were positively correlated, nonnatives were not more likely to be dominant, and purple loosestrife did not reduce plant diversity.[5] A study of Hudson River tidal wetlands found modest effects of loosestrife on native plant abundance, but none on species composition or richness.[6] In the Pacific Northwest, however, purple loosestrife cover was negatively correlated with species richness,[7] although it was not a stronger competitor than native tidal marsh plant species.[8] Loosestrife is very efficient at pollution removal and wastewater treatment.[9] Many birds nest in purple loosestrife stands, including goldfinch,[10] pied-billed grebe, and red-winged blackbird.[4] Swamp sparrow preferred wetland areas with loosestrife for nesting,[4] but marsh wren and common grackle avoided nesting in loosestrife stands[11] (although marsh wren in Tivoli North Bay, which nested only in cattail in the 1970s, has gradually begun to nest in loosestrife). Loosestrife stands are also used for roosting, and there are some reports of birds eating its seeds (or arthropods on seedheads). Tender, new growth is a preferred forage for livestock and deer, and grazing can limit purple loosestrife. Native saturniid moths, including polyphemus (*Antheraea polyphemus*), cecropia (*Hyalophora cecropia*), io (*Automeris io*), and buck moths (*Hemileuca* sp.) occasionally to frequently feed on loosestrife, although the buck moths suffer from increased parasitism compared those feeding on native hosts.[12,13] Short-statured purple loosestrife in rich fens seems to permit the coexistence of fen plants, and can be used by bog turtle, but dense, tall loosestrife is very poor bog turtle habitat. The woody root crowns ("hummocks") of vigorous clumps are good substrates for many mosses and liverworts. The flowers are often intensively visited by diverse butterflies, moths, bees, and flies.

Purple loosestrife

Reproduction: Purple loosestrife germinates best in sunny, wet, warm conditions, and seedlings quickly establish a woody taproot. Starting in the second season, plants may produce additional stems from the rootstock. Individual stems live for one year (standing, dead stems may persist for 1-2 years), and plants may live over 20 years, attaining a maximum root crown width of 0.5 m and height of 3 m, with numerous basal stems. Purple loosestrife can flower in its first growing season. It blooms from late June-late September, and is pollinated by honeybees and many other bees and butterflies. It can hybridize with the native winged loosestrife (*L. alatum* var. *alatum*). Seed production is prolific, 100,000 to 2.5 million seeds per plant, depending on plant size. Seeds are dispersed via water, perhaps wind, and passive transport by humans and other animals. The seed bank persists at least 2-3 years.[2]

Special note: biocontrol beetles. Four biocontrol agents have been approved for purple loosestrife: two leaf-feeding beetles (*Galerucella calmariensis*, *G. pusilla*) and two weevils, a flower bud-feeder (*Nanophys marmoratus*) and a root-feeder (*Hylobius transversovittatus*). Effects of the different beetles on purple loosestrife are variable, but all of them (often in combination) are capable of significantly decreasing plant height, cover, and/or seed production under at least some circumstances. The *Galerucella* (leaf-feeding) beetles are the most studied. Sometimes their release has little effect, but sometimes there is a reduction in seed production (after 1-2 years) or plant height, cover, and biomass (after 4-10 years).[14,15,16] Interestingly, *Galerucella* beetles have been most successful in controlling purple loosestrife in wetlands with low nutrient availability (measured as total soil nitrogen).[16] All the biocontrol beetles have been released and have established populations in New York. Even though they have spread naturally and are widely distributed, release sites have higher herbivory levels, so it may be worthwhile to release more even when they are present. The *Galerucella* beetles are licensed in New York, but may require permits to transport across county or state lines (contact NYS DEC). They can be collected from existing populations in the field (by you or a cooperator), reared on plants in pots, or bought from a supplier (generally the most expensive option).[17] See [17] for detailed methods on collecting and rearing.

Management Goals:

- Eradicate small/light infestations early.
- For large/dense patches, reduce height, density, and seed production.
- If purple loosestrife exists as a stable (not increasing) part of a diverse wetland flora, it may not need management.
- If it occurs in a rich fen, calcareous wet meadow, acidic bog, kettle shrub pool, or other rare wetland or wetland that may support rare species, consult with the NYS DEC or appropriate conservation organizations about management.

Management Methods:

- Plant native woody species to eventually shade out areas of purple loosestrife.
- Where possible, minimize water fluctuations that lead to areas of exposed, wet soils.
- For small or sparse patches, hand-pull or dig with weed wrench when ground is wet. (Use a small piece of wood for leverage with the weed wrench in mucky conditions.) All plant parts can re-root and re-sprout, so bag and dispose of all material. Soil disturbance will promote loosestrife germination and resprouting, so hand-pulling must be repeated until seed bank and viable root fragments are depleted (2-3 years).
- Seeds (including those from previous years) are easily spread, so clean boots, clothing, and equipment of seeds, dirt, and mud before leaving the site.
- For medium- to high-density patches of at least ½ acre, release biocontrol agents (*Galerucella* beetles). To increase chances of success with this method, consider having soil samples analyzed for total nitrogen, and prioritize beetle release for sites with soil N < 0.33%.[16]
- Cutting stems during flowering prevents seed production and depletes the seed bank, and may be helpful when combined with other control measures. Mowing can result in spread via stem fragments, but regular mowing can also stunt or kill loosestrife and can be a good way to contain a stand if the soil is not too soft, such as around the edge of a pond.
- Intensive rotational grazing (a specific type of grazing) with sheep has greatly reduced loosestrife cover and increased plant diversity in wet meadows.[18] Light cattle grazing is effective at inhibiting loosestrife but might not eradicate it.
- Monitor to prevent establishment of other nonnative wetland plants such as reed canarygrass (*Phalaris arundinacea*) or common reed (*Phragmites australis*).[17]

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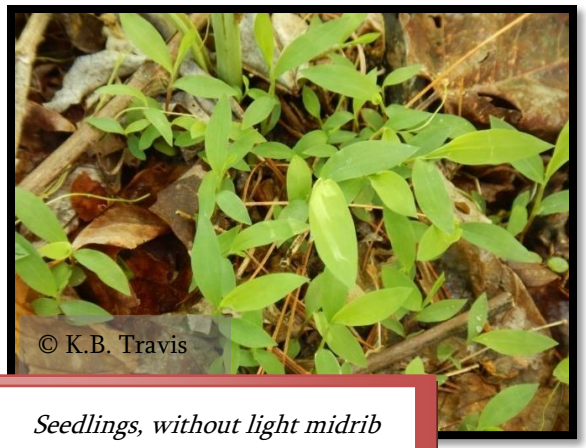
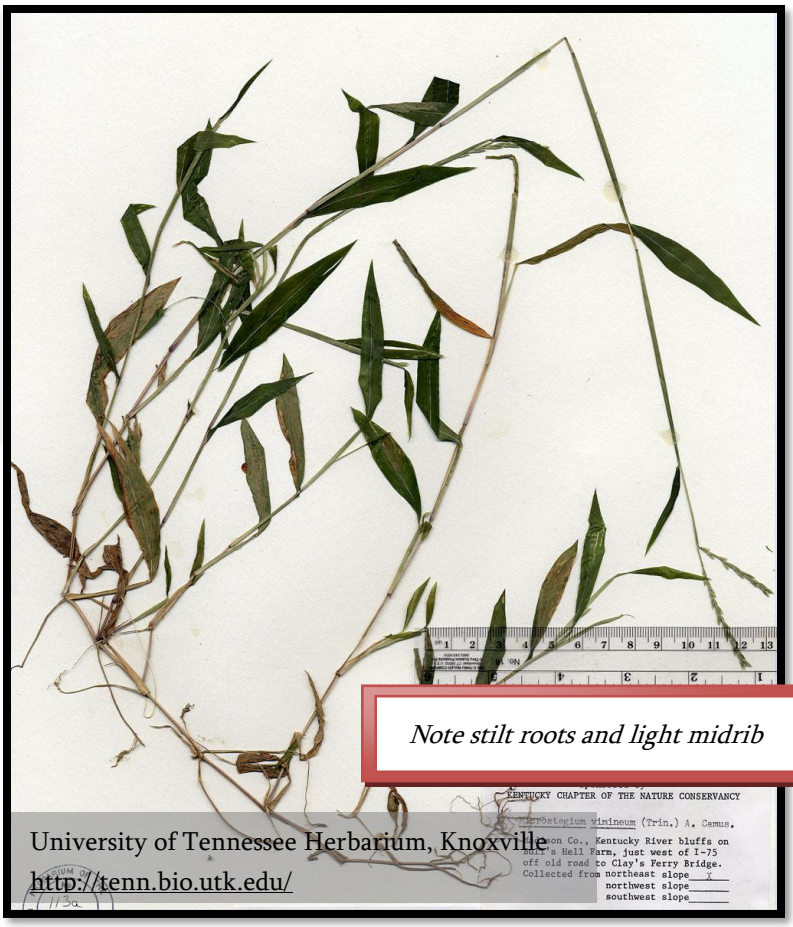
STILTGRASS *(Microstegium viminuem)*

Prohibited Invasive Species in New York *(6 NYCRR § 575.3(d)(2)(lx))*



Seedlings, without light midrib



Note stilt roots and light midrib

An annual grass that grows to 1 m or more (but often shorter), often forming dense stands. Leaves with smooth edges, often with a glossy, light midrib, spaced along the stem. Stems are thin, tend to sprawl, and may branch at the base into several stems. Roots are shallow and pull out very easily; lower stem nodes may produce stilt roots, hence the common name. Dead grass often persists in winter as a conspicuous thatch layer.

Stiltgrass is native to parts of Asia and the Caucasus Mountains, and is now found around the world. It first appeared in North America in the early 1900s, and has a sporadic distribution throughout the eastern US and Caribbean; rapid spread in the Northeast began around the 1990s.

Similar species: Stiltgrass (also called Japanese stiltgrass) can be distinguished from most other grasses by the combination of a narrow, weak stem, sprawling habit, and light-colored midrib. Whitegrass (*Leersia virginica*) is perhaps the most similar species, but it lacks the shiny midrib on upper surface and has a hairy ring at each stem node.[1]

Where found: Stiltgrass prefers disturbed, moist, partially shaded sites, such as roadsides, streambanks, utility corridors, and ditches. It typically occurs on clays and sandy or silty loam soils that are moist and nitrogen-rich, but it can also establish and persist on drier, disturbed soils.[2] From

there stiltgrass can invade relatively undisturbed forests (especially floodplain and mesic forests) and wetlands, where it can quickly become the dominant herbaceous plant in the understory. Stiltgrass tolerates full shade but thrives in the presence of moderate light (18-35%).[2] A thick leaf litter layer inhibits seed germination, but not enough to prevent invasions into mesic forest, even with little seed input.[3] Because deep shade and leaf litter inhibit stiltgrass, it is likely that nonnative earthworms (which reduce litter) and deer (which reduce shade from a browsed shrub layer) both contribute to its success.[4]

Threats/benefits: The presence of stiltgrass changes forest soils, resulting in reduced leaf litter and organic matter in soil, higher pH and magnesium, and in some cases higher available phosphorous and calcium.[5,6] As stiltgrass cover increases, native plant cover and diversity are often reduced,[2,5] although this effect is likely due to a combination of stiltgrass, deer herbivory, and nonnative earthworm abundance.[7] Stiltgrass excludes seedlings of woody species in eastern forests, potentially altering forest development.[2] Stiltgrass-invaded understories tend to have increased aboveground biomass, which in turn can lead to increased abundance and diversity of arthropods[8] (although sometimes these measures decline[6]). However, arthropod evenness tends to be reduced, as herbivores that can eat stiltgrass are favored.[8] In sites with low available nitrogen and high stiltgrass biomass, carbon cycling can accelerate and result in significant declines in microbial biomass and soil organic carbon (impacting forest carbon storage on a large scale).[9,10] Stiltgrass seems to be unpalatable to deer. The avoidance of stiltgrass and preferential foraging by deer on other plants favors the spread of stiltgrass by reducing plant competition. Stiltgrass cover was lower where deer were excluded;[4] excluding deer and removing stiltgrass increased survival of oak seedlings.[11] The replacement of forest understory shrubs and trees with stiltgrass may help explain declines in bird species that nest on the ground or in the understory or midstory.[2] In a southeastern forest, American toad metamorph survival was reduced in stiltgrass areas, likely due to the increased density of predatory wolf spiders.[12] The presence of stiltgrass can affect controlled burns in fire-adapted forests, raising maximum temperatures, reducing germination of native species, and stimulating subsequent growth of stiltgrass.[13] However, this relationship varies with soil moisture, and fire in drier sites may not promote stiltgrass.[14]

In a Westchester forest preserve with overabundant white-tailed deer and a species-impoverished understory layer, stiltgrass provided favorable habitat for three native amphibian species.[15] It may also provide important cover for white-footed mouse.[2] Native insects, including grasshoppers, katydids, crickets, and bugs graze on stiltgrass, but are not known to significantly deplete a local population. Stiltgrass seems to be avoided by cattle, goats, and horses,[2] but is grazed by sheep.[16]

Reproduction: Seeds germinate in early spring, and plants grow and spread by rooting at decumbent stem nodes throughout summer. The plant flowers in late summer and the seeds mature and disperse September-December. Stiltgrass is capable of producing large numbers of seeds, but seed production is reduced in drought or low light conditions.[17] Seeds are dispersed by wind, water, humans, and other mammals, and may remain viable in the soil for 5 years or more. The fruits can

attach to fur, feathers, and clothing, and seeds are often transported with soil material by heavy equipment.[2] Roadways and walking trails serve as dispersal corridors. Seed germination seems to be highest in open (unshaded) sites with little to no litter.[2] Leaf litter inhibits germination but increased moisture increases germination and survival even in deep leaf litter.[18]

Management Goals:

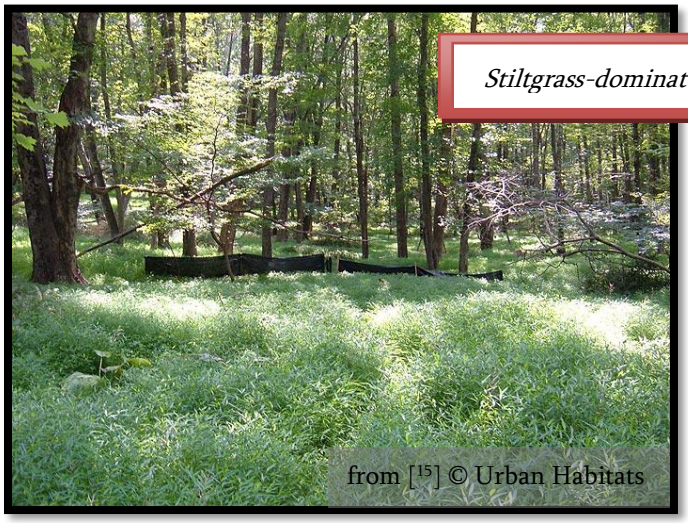
- Prevent establishment of new populations by annual monitoring and removal.
- Eradicate small patches by preventing seed production until seed bank is depleted, usually 2-5 years.
- Limit spread and reduce density of large invasions by limiting seed production. Target patches along roadsides and trails as these populations provide seed for forest invasions.[2] Management projects are effort-intensive and should be chosen thoughtfully.

Management Methods:

- Reduce or exclude deer populations. This will aid recovery of native plants, may reduce populations of nonnative earthworms,[4] and as a result slow population growth of stiltgrass.
- Minimize soil and canopy disturbance: this will slow spread and lower chances of reintroduction.
- For smaller areas, hand-pull plants once a year in the fall before seed set (but after seed development of most other plants).[17,19,20] Hand-pulling is the best method for allowing native woody plant regeneration[17] and restoring a diverse community of native plants.[21] Hand-pulling was much more effective in fall (prior to seed set)[17] than in June or July.[20,22] Avoid hand-pulling multiple times in a season; this disturbs soil more and increases recruitment of other invasive plants.[19]
- For larger areas, mow (or scythe, weed-eat, or pasture sheep) once a year any time after July 1, for multiple consecutive years.[20,23] To allow native plant recovery, mow annually for 3-4 years then take a year off.[23] Mowing multiple times in a season may stimulate stiltgrass seed production.
- Alternatively, use a 400K BTU propane torch to kill plants once a year in June or July.[22] On days following or during rains (when litter is thoroughly wet), apply flame treatment to plants until leaves are severely wilted but without igniting litter. This treatment was very effective, although much more time-consuming than weed-eating. A combined treatment may be more efficient, where plants are first cut in August, and then any remaining (green) plants spot-treated with the propane torch 2 or 3 weeks later.[22] (Torching must be done with great care to avoid starting vegetation fires. A permit might be needed.)
- Repeat annual pulling, cutting, or flame treatment for at least 3 years.[19,20] Cover may actually increase after the first year of treatment, but in one experiment, after 3 years of preventing seed production by mowing or hand-pulling, cover was reduced by 82% and the seed bank by 93%.[19] At the same time, native herb cover increased by 325%, and the native herb seed bank and species richness also increased.[19]

- For large invaded areas, an alternative approach is to plant tree seedlings (species appropriate to the forest type). In addition to aiding forest regeneration, the more dense shade created by a subcanopy layer could help suppress stiltgrass. Survival of two-year-old seedlings planted at 0.5-m spacing in a dense stiltgrass understory was unaffected by the stiltgrass.[24] However, if overabundant deer are a problem, seedlings may need protection to survive.

Special note: an uncertain future. Stiltgrass growth is reduced in the presence of a suite of fungal pathogens that have recently been identified. The abundance and diversity of these pathogens was correlated with the approximate time since establishment of stiltgrass populations across the eastern US, indicating that their increasing accumulation and spread over time has at least the possibility of suppressing stiltgrass to some extent.[25] Increases in available nitrogen may actually stabilize carbon cycling of stiltgrass-dominated communities,[9] while increases in atmospheric carbon dioxide may reduce its primary productivity (and thus, competitive advantage).[26] On the other hand, stiltgrass in its new range shows evidence of recent, rapid evolutionary adaptation to local climatic conditions; this ability could enhance its invasive potential.[27]



Stiltgrass-dominated understory

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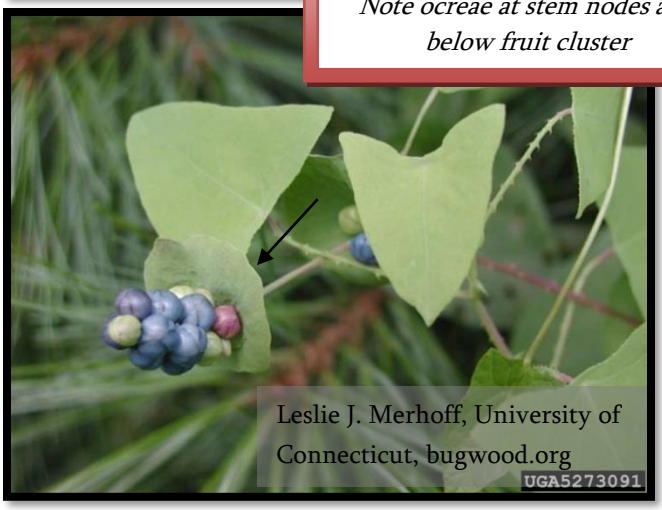
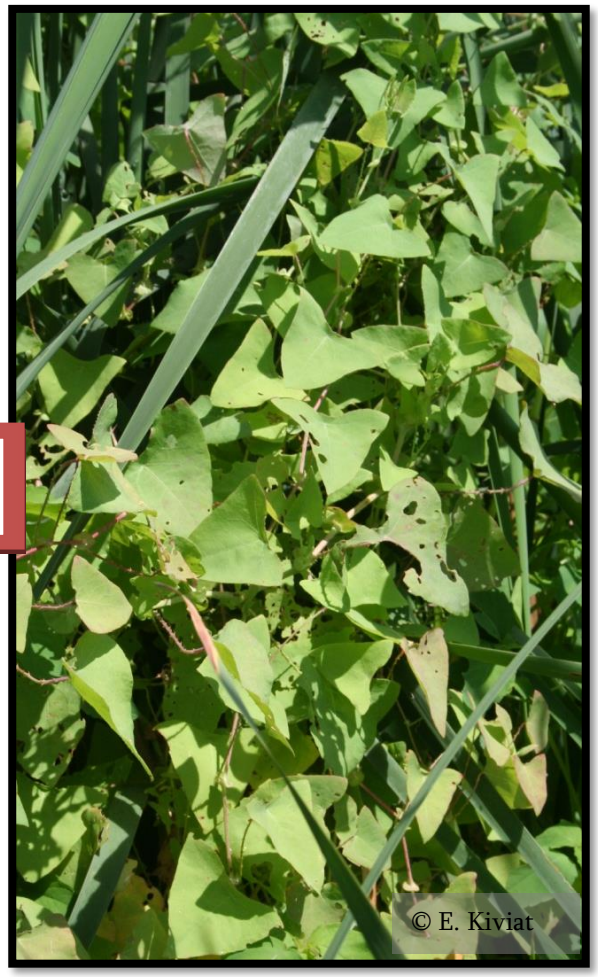
Fact sheet prepared by Kristen Bell Travis (Hudsonia) with assistance from Erik Kiviat, Gretchen Stevens, and Chris Graham (Hudsonia) and other Lower Hudson PRISM members, 2016.

MILE-A-MINUTE *(Persicaria perfoliata)*

Prohibited Invasive Species in New York *(6 NYCRR § 575.3(d)(2)(lx))*



Note ocreae at stem nodes and below fruit cluster



An annual (sometimes perennial), herbaceous, prickly vine to 4 m long. The vine's base may become woody with age, and stems may climb or recline on other plants. Leaves are alternate, triangular, and with prickles on the underside of veins. Each leaf node has a saucer-shaped ocrea encircling the stem. Flowers are inconspicuous, and fruits are fleshy and blue.

Mile-a-minute is native to eastern Asia. It was introduced to the eastern US in the 1930s and has since spread to the mid-Atlantic states and parts of New England and the Midwest.

Similar species: Arrow-leaf tearthumb (*Persicaria sagittata*) and halberd-leaf tearthumb (*Persicaria arifolia*) are closely-related native species in our region, but neither has saucer-shaped ocreae or fleshy fruits.

Mile-a-minute

Where found:

Mile-a-minute can be found in wetlands and floodplains, along waterways, and in moist forests and woodlands, as well as in upland disturbed sites, shrublands, deciduous forests and conifer plantations.[1] It frequently occurs along forest, road, and trail edges, and in logged or natural canopy gaps in forest.[1]

Threats/benefits:

Mile-a-minute can form very dense monocultures or persist at lower densities mixed with other plants. It extirpated one population of a rare plant in New Jersey, manyflower flatsedge (*Cyperus lancastriensis*).[1] Mile-a-minute can overtake and kill stands of both native and nonnative perennials. It has been an expensive problem in forestry after tree harvest, in cases where mile-a-minute needs to be removed and tree seedlings planted for forest regeneration.[1] Because this plant is a fairly recent invader, little research has been published on its ecological effects.

Mile-a-minute foliage is consumed by many herbivorous insects, and its fruits are eaten by birds, mammals, and insects. Fruits are also edible to humans; and various parts of the plant have medicinal and/or insecticidal properties.[1]

Reproduction:

Seeds germinate in early April, and vines can grow up to 15 cm per day. Flowering begins in June or July. Flowers can self-fertilize, and fruits ripen from September-November (the plant usually dies at the end of the season). Fruits can be numerous, although production is lowered by shade or drought. Seeds are dispersed by water, birds, mammals (including chipmunks, squirrels, and deer), and inadvertently by humans via nursery plants, logging equipment, or other means. Seeds can persist in the seed bank for up to 6 years. Unlike many other invasive plants, the germination rate does not appear to increase with disturbance of plants or soil. However, plant establishment is most successful in open, disturbed, moist sites. Seeds will germinate in the shaded forest understory but plants usually do not survive.[1]

Management Goals:

- Maintain wide, forested stream buffers and limit forest disturbance to prevent establishment.
- Monitor annually along stream banks, roads, and trails, to find and remove any new occurrence.
- Eradicate small patches by preventing seed production until seed bank is depleted, usually 3-6 years.
- Limit spread and reduce density of large invasions by limiting seed production. Target patches along roadsides and trails as these populations provide seed for forest invasions.[2]

Management Methods:

- Hand-pull to remove small populations. Plants have shallow roots and are easy to pull. Wear gloves to protect from painful prickles. Aim to pull plants prior to prickles hardening, and definitely prior to any fruit production, which generally begins in June (35% of seeds in green fruit were viable).[2]
- Mow, or cut with scythe or weed eater, prior to fruit production. Cut close to ground level: plants cut too high may resprout in time to produce fruit. A second cutting in late summer may be needed.
- Pulling or cutting efforts will need to be repeated until the seed bank is exhausted, up to 6 years.
- Dispose of pulled plants to prevent rerooting. If any fruits are present on pulled or cut plants, bag whole plants and let sit in the sun for several weeks before landfilling. Or pile in a frequently-mowed area that can be easily monitored for sprouts.
- Consider introducing mile-a-minute weevil (*Rhinoncomimus latipes*). This classical biocontrol insect can reduce cover and seed production, especially in warm and dry conditions,[3] delay seed maturation, and sometimes eliminate populations after a number of years.[4] Generally, a single release of weevils will be sufficient to establish a population. There will be no dramatic, immediate effect, but after 2-6 years you may see a 25% reduction in density (sometimes 100%), a 35% reduction in seed production, and a 7-week delay in seed maturation.[5] Weevil impacts can help make other control methods more effective.
- Consider seeding native herbs (remove litter and mile-a-minute thatch to seed, then replace) – this has been shown to have an additive effect with weevil biocontrol to lower density of mile-a-minute.[6] Reducing or excluding deer populations will also aid recovery of native plants. Planting tree seedlings will eventually increase shade, which discourages mile-a-minute (as long as it is not allowed to smother the trees when small).
- Minimize soil and canopy disturbance: this will slow spread and lower chances of reintroduction.
- Experiment with directed heating with a propane torch (only when ground is wet) to spot kill plants missed by mowing or hand-pulling.

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Fact sheet prepared by Kristen Bell Travis (Hudsonia) with assistance from Erik Kiviat, Gretchen Stevens, and Chris Graham (Hudsonia) and other Lower Hudson PRISM members, 2016.

Mile-a-minute

COMMON REED *(Phragmites australis* ssp. *australis)*

Prohibited Invasive Species in New York *(6 NYCRR § 575.3(d)(2)(lx))*

High-density stand in a tidal, brackish wetland showing exposed rhizomes

Lower-density stand with native forb understory in a nontidal, freshwater wetland

A very large, perennial grass, reaching a height of 1-3.5 m (or more), often found in extensive, dense stands in wetlands. Stems are stout, unbranched, and hollow, bearing long, flat leaves on one or two sides. Rhizomes can grow to 20 m long. Large, feathery, plumed flower spikes are produced in August and September and often persist through the winter.

The Old World subspecies of common reed is native to the Middle East and Europe, and is one of the most widespread and successful invasive plants around the world. It occurs in most regions of the US, from southwestern deserts to eastern salt marshes to northern lakes.

Similar species: The native subspecies of common reed (*Phragmites australis* ssp. *americanus*) is very similar to the nonnative subspecies (for identification tips, see [1]); it has not been identified in

the Hudson Valley but may occur here. No other native grass is so large; there are some other large, nonnative grasses such as Chinese silvergrass (*Miscanthus sinensis*).

Where found: Common reed is most often found in wet or flooded areas around marshes, ponds, lakes, ditches, streams, and rivers. It can tolerate brackish conditions up to about one-half seawater salinity, although it is more vigorous in fresh or slightly brackish water. It is also common on disturbed upland soils. It prefers full sun, and is shorter and sparser in shaded conditions.[2] In Canada, roadside ditches shaded by shrubs or trees were less likely to support common reed than unshaded ones.[4] Along the Hudson River, common reed is found in the supratidal and upper intertidal zones, and sometimes in the middle intertidal zone.[3] It usually becomes established at the upland edge of a tidal marsh, along a stream bank or pool margin, or in a fill deposit, and spreads until it encounters an obstacle such as deep water.[3] Storms and soil disturbance appear to be important for dispersal and establishment, but stands reach highest densities in the absence of soil or grazing disturbance.[2] Nutrient enrichment favors reed establishment and spread.

Threats/benefits: Common reed tends to form dense, extensive, high-biomass colonies. It can substantially modify soil, hydrology, microclimate, and vegetation.[3] The interior of a dense reed stand often contains very few other plants. Along the outer margin other plants are commonly admixed, often (at upland edges) including dense vines which use the sturdy grass for support. Reedbeds have supplanted cordgrass (*Spartina*)-dominated plant communities in brackish tidal marshes, cattail (*Typha*)-dominated communities in tidal fresh or brackish marshes, and cattail or sedge (*Carex*)-dominated communities in nontidal marshes and wet meadows. While the density of common reed leads to the supposition that it reduces native plant diversity, colonies may have become established on bare soil, or supplanted a low-diversity, dense stand of a native species such as cattail.[3] Removal of common reed often increases native plant diversity, but this phenomenon is generally short-lived without active management.[3] Compared to areas dominated with cordgrass and other native salt-marsh vegetation, older reedbeds have less varied wetland microtopography; reduced populations of salt-marsh breeding birds; lower levels of breeding bird activity in general (although some birds, such as red-winged blackbird and marsh wren, prefer to nest in reed); reduced abundance of wintering waterfowl; and decreased use by larval and juvenile mummichog.[3]

Wetlands and other habitats that have been altered by the disruption of natural hydrology, the addition of fill or pollutants, or other effects of human land use and development may benefit from the habitat values and environmental services of reedbeds. Also, individual reedbeds vary greatly in their ability to provide those values and services based on variables such as stand density, hydrology, etc. Common reed plant parts are eaten by muskrat, eastern cottontail, white-tailed deer, and various insects—including larvae of Henry's marsh moth (*Simyra insularis*) and broad-winged skipper (*Poanes viator*).[3] Various bird species forage on the abundant reed scale (insect), insects overwintering within the reed culm, and seeds. (Common reed supports a higher insect biomass than cattail or purple loosestrife.) Reedbeds provide favorable roosting habitat for nonbreeding songbirds, short-eared owl, and other birds, as well as nest sites for certain species. Most livestock

will graze on young shoots of common reed, which provides moderately nutritious forage; horses and sometimes cattle also eat the mature foliage. Dense stands provide cover and protection from humans and other predators for mammals such as deer, raccoon, striped skunk, bear, and muskrat. The deep litter layer provides shelter for small animals and food for decomposers. Fish communities are generally comparable between reed and other tidal marsh communities.[3]

Common reed has a high tolerance for pollution. It sequesters heavy metals, rather than releasing them into the water column. It is commonly used for wastewater treatment and sludge dewatering in water treatment plants. Reed builds up the soil level due to high biomass production and slow decomposition. Dense beds increase sediment deposition and stabilize soils. This can dry wetlands, and decrease access to fish, crabs, and shrimp in tidal wetlands, but the same properties can benefit wetlands in danger of flooding due to sea level rise, or at risk of shore erosion from storms.[5]

Reproduction: Common reed mainly reproduces vegetatively, via its spreading rhizomes (underground stems) or stolons (aboveground horizontal stems), as well as rhizome or culm (aboveground stem) fragments. It can grow up to 4 cm/day. Rhizome fragments are commonly spread through water (especially due to storms and flooding) and passively by machinery, humans, or other animals. Reed produces at least some viable seeds, and seeds are thought to contribute to reed establishment and spread under certain conditions.

Management Goals:

- For very small stands: Remove, and restore native plant community.
- For wetlands that are entirely dominated by common reed and where it cannot expand further, and where beneficial habitat functions or ecosystem services outweigh those that are detrimental (in view of management goals and potential nontarget impacts of management), for example, in contaminated sites, or in areas at risk due to sea level rise: No action.
- For smaller stands and the edges of larger stands, where there is no immediate risk to a rare species or community: Monitor.
- For medium-large, dense stands that are threatening a nearby rare species or community: Consult with the NYS DEC or a reed specialist. Containment, grazing, or another strategy may be better depending on the specific community or species.
- For medium-large, dense stands where the goal is habitat improvement: Use a combination of the below methods to slow or prevent spread and create a more varied stand structure, including (for example) areas of shallow open water, forested or shrub swamp, low-density reedbeds, and high-density areas for roosting birds and shelter for other animals.

Management Methods:

- Very small stands: Hand-dig, being sure to remove the entire rhizome system; or smother by covering with heavy-duty black plastic (after cutting and removing stems) for at least two years; or cut stems repeatedly below water level (see below). Replant with native species.

- Contain stands that threaten to spread into valuable habitat, using ditching (water must be at least 1 m deep and 1 m wide); belowground installation of vertical rigid plastic sheeting (such as [6]) or metal sheet piling; or the previous methods if suitable.
- Monitoring: Mark the boundary of a stand with stakes, establish onsite photopoints, or analyze aerial photos (small or low-density stands may not be visible on aerial photos). Reexamine every 1-2 years, with no management necessary as long as the boundary is stable, declining, or slowly expanding. If rapid expansion occurs, management can start promptly.[3]
- Plant trees and shrubs to thin and eventually replace reed stands. Common reed around woody plantings will need to be frequently cut or smothered to allow the plantings to establish and grow. Managing nearby areas for maximum canopy density will help limit spread and establishment of new populations. (Planting trees and shrubs—or allowing natural regeneration—in wetland and riparian areas has many other benefits as well, including habitat improvement for breeding birds.)
- Raising water levels may fragment large areas of common reed and create improved marsh and water bird habitat. Restoring tidal flow to diked salt marshes increases salinity and reduces dominance of common reed.[3]
- Dredging a pond can result in water too deep for common reed to re-colonize. In large wetlands, "scrapes" or large, shallow pools can be excavated to create marsh and water bird habitat.[3]
- Livestock grazing can be used to manage common reed in pastures, wet meadows, fens, and other open, dry-end wetlands. Goats, or goats and sheep together, have been used successfully to decrease reed height and cover in bog turtle habitat,[7] and cattle have also been used for bog turtle habitat management[8] and consume reed.[3] Goats grazing for 3 rotations of < one month each over a year reduced reed cover and increased plant diversity.[9] Their reed-based diet during this time was high enough quality to pose no detriment to health. When livestock are given a larger pasture with more choice, however, reed may be avoided and increase in density.[9]
- A combination of summer cutting of stems below water level and raising or maintaining high water levels (to keep roots and stems submerged) can result in significant mortality. Grasp the stem with both hands and kick it sideways, breaking it at or near the base (this was easier than clipping with tools in one study).[10]
- Where muskrats are present (especially in tidal wetlands), the addition of raised structures (hay bales, logs, wooden platforms) within the wetland may encourage muskrats to build lodges, which could help manage common reed.[3] Muskrat harvesting of reed is most concentrated within 5-10 m of the winter lodge, but in this area they can create clearings or sparse vegetation.[3]
- Mowing regularly (e.g., twice a year during the growing season for six years) and removing cut material can reduce reed biomass and increase plant species richness. However, mowing in wetlands can compact and damage soils.[3] Cutting once per year in June (with a hand-held brush-cutter) and removing cut material resulted in reduced reed cover and increased cover of other plants.[11]

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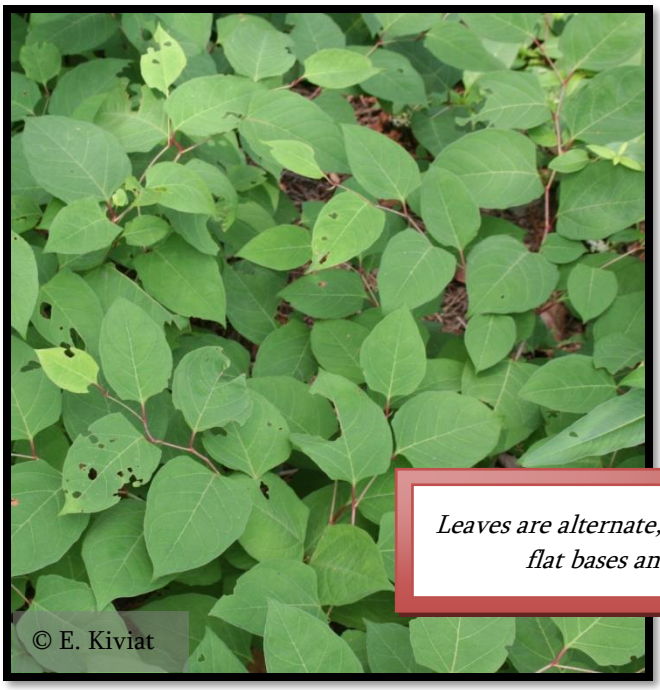
Fact sheet prepared by Kristen Bell Travis (Hudsonia) with assistance from Erik Kiviat, Gretchen Stevens, and Chris Graham (Hudsonia) and other Lower Hudson PRISM members, 2016.

KNOTWEED *(Polygonum* spp.*)*

Bohemian knotweed (*Polygonum × bohemica*) is a hybrid between Japanese knotweed (*P. cuspidatum*) and giant knotweed (*P. sachalinensis*). In the northeastern US, all three knotweeds are present.[1] Because they are difficult to distinguish and have similar ecological characteristics, we discuss them together as simply "knotweed."

Prohibited Invasive Species in New York (all three knotweeds) *(6 NYCRR § 575.3(d)(2)(lx))*



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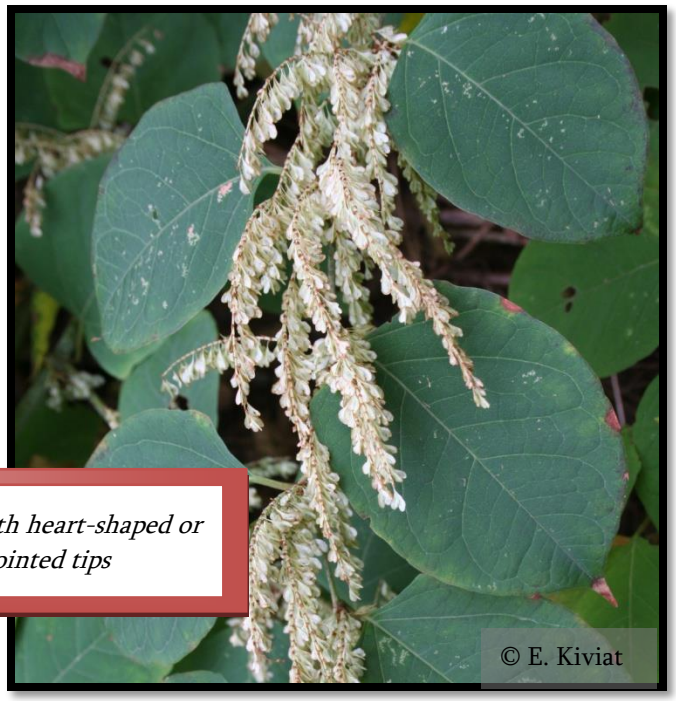
Leaves are alternate, with heart-shaped or flat bases and pointed tips



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A tall, robust, semi-woody perennial that forms dense stands. Long-lived, extensive rhizomes can extend over 2 m deep and 7-20 m from the root crown. Annual stems are thick, hollow, and jointed, with swollen nodes. Stems grow 1-3 m tall and then die back to near ground level in autumn.

Knotweed flowers in late July-late September, and seeds develop in August-October. Seeds may be sterile or viable depending on the plant.

Japanese and giant knotweeds are native to Asia, and were introduced to North America in the late 19th century. Japanese and Bohemian knotweeds are invasive in many parts of the eastern, midwestern, and western US.

Where found: Knotweed is usually found in riparian areas (stream and river banks, floodplains), roadsides, urban and suburban yards and vacant lots, dumps, and similar locations where soils have been heavily disturbed or transported (either by humans or water). Knotweed plants are most

productive and competitive under high-light conditions,[2] and patches tend to be less dense under forest canopies.

Threats/benefits: Once established, knotweed tends to form dense stands that exclude most other vascular plants and bryophytes.[13] Native plant cover and species richness are greatly diminished (and sometimes absent) in these stands.[4,5,6,7] Knotweed also reduces regeneration of trees and shrubs,[8] possibly due to allelopathic (toxic) compounds.[10] Knotweed produces copious leaf litter, which is lower in nutrients (high C:N ratio) than native riparian vegetation, with the potential to change nutrient cycling and availability in riparian ecosystems.[9] Arthropod and gastropod abundance and richness were lower in knotweed-invaded areas in Europe,[6,7] and an experiment in New York suggested that green frogs have reduced foraging success in knotweed stands.[5]

Nevertheless, knotweed may stabilize streambank soils better than other herbaceous plants, and it can accumulate heavy metals in its large roots and rhizomes.[4] Knotweed blooms late in the summer, providing a valuable source of nectar and pollen for honeybees;[15] flowers are heavily visited by native bees, wasps, and flies, as well. Sparrows and eastern cottontail eat knotweed seeds. Many invertebrates (including a snail of conservation concern in Europe[7]) and vertebrates (including nesting songbirds) can be found in knotweed stands, but little is known about the relative value to animals of invaded versus noninvaded habitats.[4]

Reproduction: Japanese knotweed is usually spread by transportation of rhizome or stem fragments, either by water or humans (in fill material, for example). A new plant can sprout from even a tiny piece of plant material. Most Japanese knotweed in North America is genetically a single (female) clone and produces sterile seed unless a pollen source is nearby, but Bohemian knotweed produces viable pollen and seed.[1] Since the more recent spread of the fertile hybrid, reproduction by seed is increasing. Seeds mature in August-October and often remain on the plant through winter. The majority fall near the parent plant, but seeds can also be dispersed via water, wind, or birds.[10] Longevity of the seed bank is unknown.

Management Goals:

- Prevent establishment of new populations by annual monitoring of key areas and hand-digging new sprouts.
- Eliminate small patches by repeated cutting.
- Reduce vigor and density of large patches and limit seed production.
- Limit spread by carefully disposing of all cut material.

Management Methods:

- Prevent establishment of new populations by annual monitoring and treatment of riparian areas and roadsides. After flood events, survey the floodplain and stream channel the following summer and hand-dig any new plants sprouting from fragments (loosen soil with spade and carefully excavate entire root/rhizome by hand – they will mostly be < 30 cm long). Survey again the second spring after the flood and repeat. Knotweed fragments can remain viable for over a year. Also, roots/rhizomes remain small enough into the second spring to easily hand-dig.[11]
- Help limit establishment of new populations and aid control efforts by managing stream banks and floodplains for maximum canopy density.[2] (Planting trees and shrubs—or allowing natural regeneration—in riparian areas has many other benefits as well.)
- Focus first on sparsely invaded areas and on patches in more shaded, less disturbed sites, as native plant communities are more likely to reestablish under these conditions.[3]
- For established patches, focus on weakening the root system by repeated cuts (e.g., monthly cuts July-October for 3 years resulted in a 79% reduction in aboveground volume;[12] cutting every two weeks for most of the growing season for 2 years yielded a 90% reduction[13]). This can be combined with planting trees for eventual shade (e.g., one year of monthly cuts followed by planting willow cuttings in spring, then monthly cuts May-October for two years, resulted in a 99.7% reduction in volume).[12]
- Or, after cutting stems to ground level, install a piece of sturdy wire mesh with 13-mm openings (such as 1/2-inch hardware cloth) over the entire area. As new stems grow they are gradually girdled and killed by the wire, weakening the roots over several years in the same way as repeated cutting.[14] (Although wire mesh will also eventually girdle any establishing woody plants and may be very difficult to remove.)
- Disposal of cut material: do not shred or home compost. Cut stems can be piled in a paved or frequently mowed area to dry (not in a floodplain) and then burned or else bagged and landfilled. Thorough, prolonged drying (e.g., on pavement or hung in a tree) should kill plant parts.
- Herbicide injection can be quite effective, while limiting nontarget effects on other species compared to other application methods.[13] Glyphosate, injected once in August or September, resulted in a 100% volume reduction in the first year, and 99.9% in the second year (small, sparse shoots).[12] For larger stands, a single treatment could reduce the density enough for fairly easy mechanical management. Using pure glyphosate (rather than a formulation that contains a surfactant, such as Roundup®) would likely be just as effective and much safer, as surfactants are generally more toxic to animals than glyphosate. Glyphosate injection may allow more vigorous regeneration of native plants (compared to frequent cutting).[13] In New York, herbicide injection must be done by a licensed applicator.
- Check soon for availability of a classical biocontrol option: a leaf-feeding psyllid, *Aphalara itadori,* from knotweed's native range is recommended for release pending approval at the federal and state levels (http://www.nyisri.org/resources/biocontrol/). Classical biocontrol

can be a useful component of integrated weed management, but does not always work, and in some cases has adverse impacts on nontarget plants.

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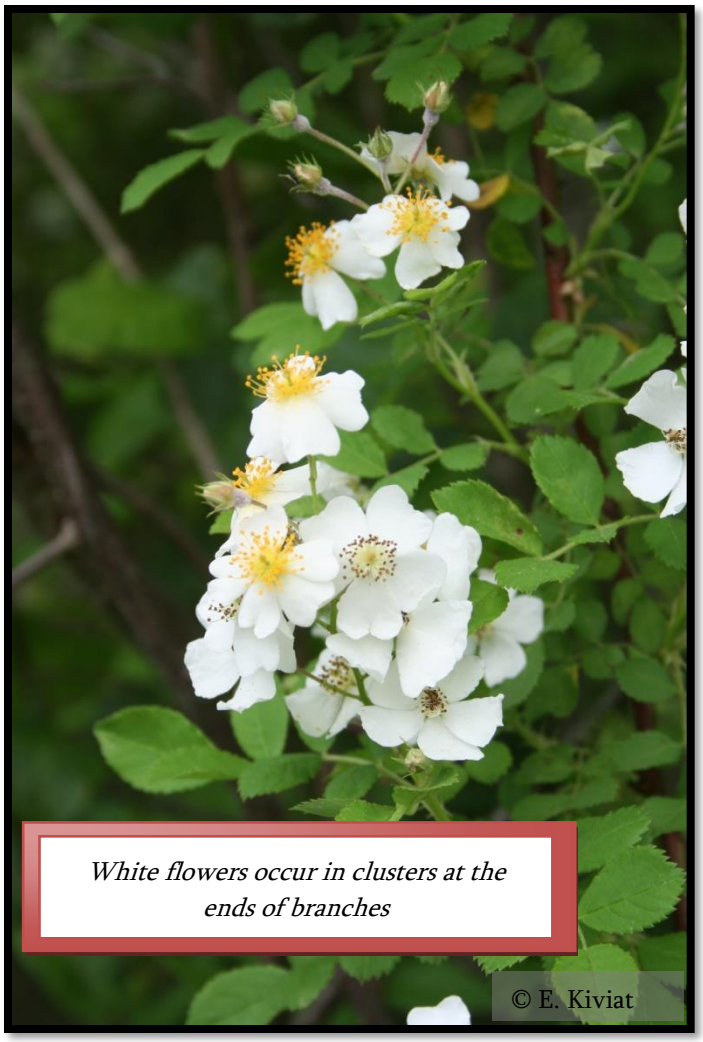
Fact sheet prepared by Kristen Bell Travis (Hudsonia) with assistance from Erik Kiviat, Gretchen Stevens, and Chris Graham (Hudsonia) and other Lower Hudson PRISM members, 2016.

MULTIFLORA ROSE *(Rosa multiflora)*

Prohibited Invasive Species in New York *(6 NYCRR § 575.3(d)(2)(lx))*

A thorny shrub that forms dense clumps and can grow to 5 m or taller. Sometimes clambers into trees. Leaves have 5-11 leaflets, and fruits (hips) are small, numerous, and red (around 5 mm diameter).



Multiflora rose was first introduced to North America from Japan in 1866 as rootstock for rose cultivation. By the early 1930s, it was being planted for erosion control, wildlife cover, and livestock fences. Today it is naturalized widely in the US, and is one of the most common invasive species in the Northeast and Midwest.

Similar species: There are numerous native rose (*Rosa*) species, all of which have entire (unfringed) stipules, pink flowers, and larger hips. Other nonnative roses also have entire stipules, as well as large flowers and hips.

Multiflora rose

Where found: Multiflora rose is most frequently found in oldfields, pastures, and along farm fencerows, roadsides, and forest edges. It can also be abundant in forests and shallow wetlands and along stream banks. As with many other invasive shrubs, multiflora rose will tolerate a wide range of soil, light, and moisture conditions, though it thrives especially in high-light situations with well-drained soils.[1] As an oldfield develops into forest, multiflora declines.[2] In a Pennsylvania deciduous forest, occurrence and abundance of multiflora rose was best predicted by a land use history of agriculture, mining, or logging, and occurrence was more likely near roads.[3]

Threats/benefits: This shrub grows vigorously, and often forms dense thickets, impenetrable by humans, outcompeting native plants for resources and space. It lowers pasture quality for cattle, replacing edible forage, and can lower crop yields in fields adjacent to a multiflora hedge.[4] Multiflora rose can establish in forests, and may have a negative effect on native understory plant abundance or richness, but strong evidence is lacking. In a Midwestern deciduous forest, a negative trend in native understory plant richness was best explained by a combination of the densities of two nonnative earthworm species and cover of multiflora rose.[5] Birds that nest in shrublands and forest understories often nest in multiflora. In some cases this has been shown to reduce nesting success compared to nesting in native shrubs (e.g., for northern cardinal and American robin in more developed areas);[6] in other cases this rose appears to provide good nesting habitat (e.g., for the same species in less developed areas;[6] for veery in forest understory;[7] and for gray catbird and chestnut-sided warbler in shrubland).[8] In an oldfield, higher densities of multiflora resulted in higher rates of maple seed predation due to the higher densities of white-footed mice,[9] with implications for both altered forest regeneration and abundances of small mammals and their predators.

Multiflora rose provides high-quality habitat for many mammal and bird species, including mice, opossum, eastern cottontail, bobwhite, and songbirds. The hips are consumed by many species of birds including ruffed grouse, wild turkey, cedar waxwing, and American robin. Leaves and hips are consumed by many mammal species, and the hips may be especially valuable to wildlife in winter.[1] White-tailed deer can control multiflora rose to a certain extent by browsing; in a long-term exclosure experiment, multiflora was almost four times more abundant in the absence of deer.[10] Goats are even more effective browsers.[11] Multiflora rose and other invasive shrubs can provide important habitat for New England cottontail (a Special Concern species in NY) in shrublands and young forests.[12]

Reproduction: Multiflora rose blooms in May-June; fruits develop in late summer-fall, and often remain on the plant through the winter. A single plant can produce as many as 500,000 seeds per year, and the seeds can remain viable for up to 20 years in the soil, allowing the rose to quickly overwhelm a newly colonized site.[1] Seeds are dispersed widely by many birds and mammals. Multiflora also spreads by sprouting from roots and branch tips.[1]

Multiflora rose

Special note: rose rosette disease. This disease—which may be native or nonnative in North America—is caused by a virus transmitted by a mite. Stems and leaves of affected multiflora rose emerge in dense clusters, stunted and usually pinkish to bright red. This disease generally kills the plant in 2-6 years; however, it cannot eliminate a population because it does not prevent seed production. The natural rate of spread is fairly low, but it can be augmented by grafting infected buds onto healthy plants.[13] This avenue of biocontrol has not been developed because rose rosette disease can also spread to nearby wild roses, cultivated roses, and some other species.[14]

Branch infected with rose rosette disease

Management Goals:

- Eradicate small patches or single shrubs.
- For large or extensive occurrences, limit spread by preventing fruiting each year.
- If occurrence is part of a large oldfield or shrubland potentially important to New England cottontail (only east of the Hudson River) or declining grassland- or shrubland-nesting birds such as yellow-breasted chat, golden-winged warbler, or northern harrier, discuss management with NYS DEC or appropriate conservation organizations (removal might not be desirable).

Management Methods:

- For eradication: Hand-pull or dig small plants (with shovel, weed wrench, or grubbing hoe), removing all roots as multiflora rose readily re-sprouts from root fragments. Any fruiting material should be bagged and landfilled.
- For eradication: Cut (along fences, in forests) or brush-hog (in fields, along forest edges) 3-6 times/year for at least 4 years, with regular monitoring thereafter. Seedlings may emerge from the seedbank for up to 20 years.

Multiflora rose

- Or try: In early spring, cut stems near ground level with a rotary wood shredder or brush saw. After stems resprout, follow this with directed flame treatment (when forest floor is damp or wet, use a propane torch to apply a direct flame for 3-40 seconds, until individual stems become carbonized and begin to glow). When used on Japanese barberry, one treatment (summer) with a 400K BTU torch resulted in about 80% mortality.[18,19] This two-step process also minimizes soil disturbance and the chance of other invasive plants establishing.
- For preventing spread: Cut or brush-hog once a year, just after flowering. Large plants can be top cut with a saw or brush cutter, then mowed annually.
- For preventing spread: Graze goats or goats and cattle to restore and maintain heavily-invaded pastures. Sheep and goats will feed on leaves, buds, and shoots of multiflora rose. In one study, goats alone or combined with cattle killed all or almost all multiflora rose shoots in infested pastures within four years.[11] However, root sprouts and seedlings were evident after 2 fallow years, so ongoing grazing may be necessary. Overgrazing, however, may make pastures more susceptible to colonization by multiflora rose and other invasive plants.
- Monitor un-infested as well as treated areas regularly and remove new plants.
- Consider leaving plants with rose rosette disease uncut (or experiment with cutting and placing diseased branches in healthy plants in early-mid July), to facilitate spread of this potential control agent. Alternatively, if protection of nearby cultivated roses is a goal, remove all nearby multiflora rose at the first sign of infection and dispose of plant parts offsite.

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WATER CHESTNUT *(Trapa natans)*

Prohibited Invasive Species in New York *(6 NYCRR § 575.3(d)(2)(lx))*

Submerged stem growing from nut hull

An aquatic, annual plant with floating rosettes of leaves, often forming dense mats. Floating leaves have toothed margins and prominent veins on the undersides, and each leaf has a swollen petiole to keep it afloat. The plants are rooted in bottom sediments, and feathery, submerged leaves occur along the stem.

Water chestnut is native to Eurasia and Africa, and was introduced to North America in the 1870s. In the US, it is invasive in the northeastern states south to Virginia, and in the Great Lakes basin.

Where found: Water chestnut is found in ponds, lakes, wetlands, slow-moving parts of rivers, and estuaries, where water is fresh to slightly brackish and 0.2-3.6 m deep. It prefers full sun, soft bottom sediments, and sluggish, nutrient-rich fresh water.[1] Interestingly, water chestnut may have reached the limit of suitable habitat in the freshwater tidal Hudson River, as over a 10-year period water chestnut expanded at the expense of submerged aquatic vegetation only slightly more than the opposite, suggesting that coverage of both types is controlled by other factors.[2]

Threats/benefits: Once established in a water body with suitable conditions, water chestnut can spread very rapidly. Under ideal conditions it forms a thick mat, completely covering the water's surface and intercepting 95% of sunlight.[1] In other conditions it persists at lower densities, along with other aquatic plants. Dense water chestnut beds completely shade out submerged aquatic vegetation (SAV) and reduce dissolved oxygen (DO) to levels lethal to fish and other aquatic organisms.[1,3] Low levels of DO may also result in the release of significant amounts of methane, a greenhouse gas, into the atmosphere.[4] SAV provides food for ducks and other waterfowl and

supports a more diverse fish assemblage through much higher densities of microorganisms, algae, and (at times) macroinvertebrates than water chestnut. Fish found in water chestnut beds are those species tolerant of water pollution, low DO, and high turbidity. Human recreational and commercial use of shallow waters and access to deeper water is limited or prevented where dense water chestnut beds occur.[1,3]

Nevertheless, water chestnut provides an important ecosystem service – the low DO in water chestnut beds results in the removal of large amounts of inorganic nitrogen to the atmosphere (e.g., water chestnut in the Hudson downstream of Albany removes the equivalent of all of that city's wastewater nitrogen that enters the river).[5] The plants can also accumulate polluting heavy metals.[1] Water chestnut supports a high richness and abundance of invertebrates (although different in composition than that supported by SAV) and may enhance total fish production in the Hudson (although favoring only certain species).[1,3] Water chestnut beds are used by snapping turtle, blue crab, and various marsh and water birds, and many mammals consume the seeds, including beaver, muskrat, and red squirrel.[1]

Reproduction: Plants emerge in spring from seeds in bottom sediments and remain rooted there; rosettes are submerged as stems lengthen in May; rosettes surface in June and plants bloom in July-August. Each flower forms a one-seeded fruit with four barbed spines, which ripens starting in mid-late July. Its fleshy exterior soon disintegrates and the hard, woody nut is heavy enough to sink to the bottom and overwinter in sediment. Seeds remain viable for up to 12 years.[1] Seeds are generally spread by humans, boats, or water birds. Clonal reproduction is also common: each water chestnut plant can produce many ramets (stems), each of which is capable of surviving and producing nuts if detached from the main stem.[6]

Management Goals:

- Eliminate small occurrences by annual pulling until seed bank is depleted. This must be done in the first year the plant is noticed, and repeated annually until entirely eliminated.
- Reduce the density of large invasions by annual pulling.
- Prevent introduction into new areas by removal and proper disposal of all plant parts.
- Check boats, nets, and other equipment to prevent dispersal of seeds.

Management Methods:

- In July, before any fruits mature: Hand-pull plants, being sure to remove roots, entire stem, and all plant parts (rooted or unattached stems can regrow, and even small rosettes can produce fruits). This is usually best done by canoe or other small boat with cargo space. Use heavy gloves to protect from spiny fruits.[7,8]
- All plant parts should be piled carefully at an upland site 15 m or more from water to prevent unintentional spread and the return of nutrients from the rotting material.

- To eliminate a bed, this will need to be repeated annually for 5-12 years (to exhaust the seed bank).
- For large, dense beds in large bodies of water, water-chestnut can be removed using large mechanical harvesters, transport barges, and dump trucks, and then composted. This method has worked at some sites to reduce densities enough to continue management by hand harvesting only.[7]
- Check soon for the availability of a biocontrol option: a leaf beetle (*Galerucella birmanica*) from water chestnut's native range is in the final stages of host specificity testing (http://www.nyisri.org/resources/biocontrol/). Classical biocontrol can be a useful component of integrated weed management, but does not always work, and in some cases has adverse impacts on nontarget plants.

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