UCONN
COLLEGE OF AGRICULTURE, HEALTH AND NATURAL RESOURCES
EXTENSION

Identification and Control of Invasive Plants in School & Municipal Landscapes

By Vickie Wallace, Alyssa Siegel-Miles, and Laura Jones
UConn Extension

Connecticut legislation was enacted in 2010 that banned the application of pesticides on the grounds of public and private K-8 grade schools. Since that time, control of weeds on school ground properties, especially invasives, has been a great challenge for K-8 school grounds managers. **This document is a resource in the identification of some of the most commonly observed invasive weeds in school landscapes and suggests primarily pesticide-free control techniques to limit their spread.** Key identification characteristics are bolded to aid in identification.

The first step in the eradication and control of weeds is the correct identification of the weed. Recognizing the plant allows the grounds manager to develop an effective eradication program based on the lifecycle of the weed and its method of competition with desirable plants.

Allowable methods of control include both non-chemical treatments and certain use of chemical products. Non-chemical methods of control include mulching of beds, mechanical removal (tilling, weed-whacking, hand-pulling), and torching. Herbicides are allowed in certain situations, including EPA exempt "minimum risk" 25(b) products (most of which are non-selective, with limited efficacy information available), and non-exempt pesticides.

For Connecticut schools, allowable use of herbicides differs depending on the students' grade level. **Minimum risk, EPA exempt herbicides are the only products allowed on daycare and K-8 school properties to control invading weeds.** Any herbicide with an EPA registration number, whether synthetic or organic, cannot be used on these school properties (microbials are now allowed). **We have included limited information on use of these products for their potential use on permitted locations (municipal properties and high schools that do not share space with a middle school).**

Protocols for applying herbicides include both common sense and legal requirements related to pesticide application. Any pesticide product applied on municipal or school grounds must be applied by a CT licensed pesticide applicator. When using herbicides, the information on the label as to use and precaution is to be treated as "the law." Further, herbicides should not be applied during a drought, as plants will not translocate chemicals effectively.

What Are Invasive Plants?

An invasive plant is a non-native species that has been introduced or escaped cultivation into a new habitat and causes environmental harm in habitats that are not intensely managed. The CT definition of invasive plants excludes non-native weeds that are problematic only in roadsides, agricultural areas, or other highly managed landscapes, although many invasives are also problematic in intensively managed areas. For a complete list of Connecticut invasive species and their identification and management, visit the Connecticut Invasive Plant Working Group (CIPWG) at cipwg.uconn.edu.

Why Are Plants Invasive?

- They are able to establish new plants and grow rapidly under a wide variety of site conditions.
- They have a high reproductive rate.
- They are able to disperse over great distances, often by the spreading of vegetative fragments as well as seeds.
- They lack any natural controls on growth and reproduction that would be found where the invader is native.

INDEX OF INVASIVE PLANTS COMMONLY FOUND IN SCHOOL & MUNICIPAL LANDSCAPES:

HERBACEOUS WEEDS

Garlic Mustard
(*Alliaria petiolata*)

Key Identifying Features:

- **Biennial**: takes two years to fully mature and set seed. Matures rapidly in the second year, produces flower stalks, sets seed, and then dies. Grows to a height of 3 ft. the second year; flowers can also appear on much shorter stems. A vigorous, multi-stemmed plant that grows in sun or shade.
- **First-year basal rosettes** with rounded leaves (*Figure 1*) up to 4 in. across that remain green in fall and winter; spring growth resumes very early. Leaf venation is palmate and margins are toothed. When crushed, rosettes and new foliage have an **odor of garlic.** Leaves on flower stalk are triangular and smaller.
- **White flowers with four petals in May to June** held above the foliage (*Figure 2*). It is commonly the only tall, broad-leafed, four-petaled white woodland plant blooming in early spring. Flowers can be self-pollinated or cross-pollinated by insects. Because it is self-fertile, a single plant can populate or repopulate an entire site (*Figure 3*).
- The **seed pods (siliques) are long, narrow,** four-sided (*Figure 4*) and contain rows of small, black, oblong seeds.
- **White tap root has an S-shaped curve at the top** (*Figure 5*).
- **Reproduces by seed only**. An average, single plant produces between 600-7,500 seeds. Soil disturbance aids in seed production so reproduction is highest in the most disturbed sites.
- **Allelopathic** (releases chemicals that can inhibit the growth of neighboring plant species).

Control:

Mechanical Control:

- Plants can be easily **hand-pulled year-round** prior to seed formation. If capsules are present, place removed plant material in bags and dispose of in garbage. Extensive seedbank will require several years of control.

Chemical Control:

- **Foliar application** of a non-selective herbicide, such as glyphosate (during basal stage).

Biological Control:

- In Europe, garlic mustard is managed by many native biological enemies. To date in the United States, biological control is still being evaluated.

Figure 1.

From top left: basal rosette in the juvenile stage; mature plant; an invasion of garlic mustard in a forested area; seed pods (siliques); basal rosette with S-root.

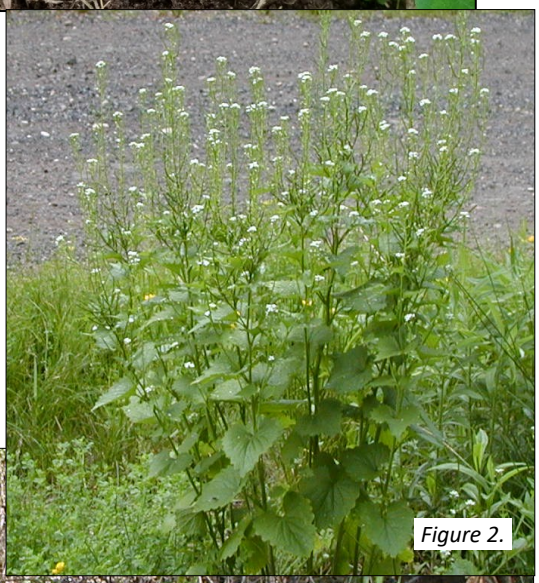


Figure 2.

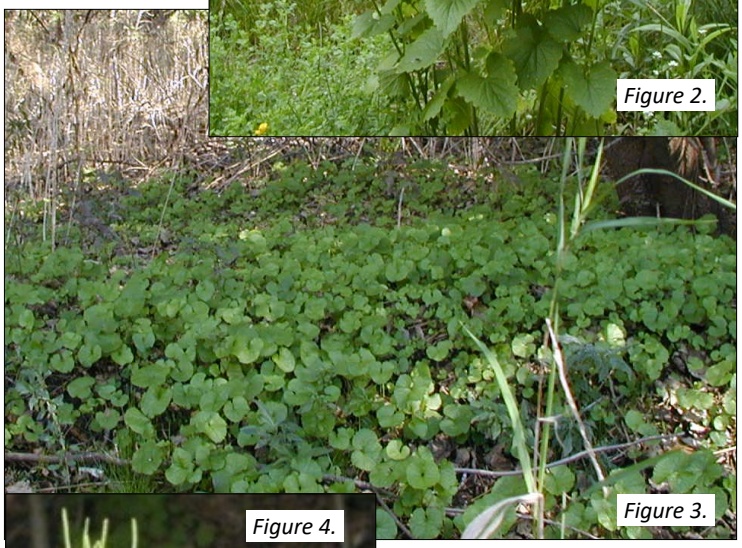


Figure 3.

Figure 4.

Figure 5.

Japanese Knotweed

(*Fallopia japonica,* syn. *Polygonum cuspidatum, Reynoutria japonica)*

Key Identifying Features:

- **Perennial**. Height 6-13 ft. Shrubby in appearance (*Figure 1*). Grows along roadsides, on streambanks, and in disturbed areas.
- **Large leaf comes very suddenly to a point.** Lacey clusters of white flowers appear in late summer/early fall, along length of stem (*Figure 2*).
- Smooth stems, **noticeably jointed, hollow between nodes, reddish purple mottling, ocrea (thin sheath) present at nodes.** Emerging stems are visually similar to bamboo.
- **Rhizomes can quickly crowd out surrounding vegetation.** Will regenerate from small pieces of stem or root tissue (*Figure 3*).
- Reproduction is primarily vegetative by rhizomes, and, to a lesser extent, by seed. **Allelopathic**.

Control:

Mechanical Control:

- Hand-pulling is recommended for very young plants only.
- **Don't dig, weed whack or pull out of the ground.** Rhizome fragments easily form new shoots. Stems left on the ground can re-sprout.
- **Cut plants 3-4 times per year below the lowest node (*Figure 4*) in early June, mid-July, and late August before it flowers.**
- **Cut before fall so the plant does not have a chance to move its energy from its leaves to its rhizomes.**
- **Place in heavy duty contractor bags.** Tie bags at the top and dispose of with regular trash. **Do not place in compost pile or leave cut stems on site.**
- Can combine cutting with shading (black or clear plastic) or chemical control.
- **May require multiple years** to eliminate sprouting from all rhizomes.

Chemical Control:

- **Foliar sprays**, cut stem applications, or injections of glyphosate in August or Sept. (before first frost).
- **Do not spray when plants are in flower**, as many pollinators feed on the flowers.
- The foliage of plants cut to the ground in July and allowed to resprout may be sprayed, following flowering, shortly before the first likelihood of frost.
- May require **repeated applications** over multiple years to eliminate sprouting from all rhizomes.
- Glyphosate may kill top growth but is often not effectively transported to the roots.

Figure 1.

Leaf, flower, and plant habit (above) Photo by Tom Heutte, USDA Forest Service, Bugwood.org.

Close up of leaves and flowers (right).

Figure 2.

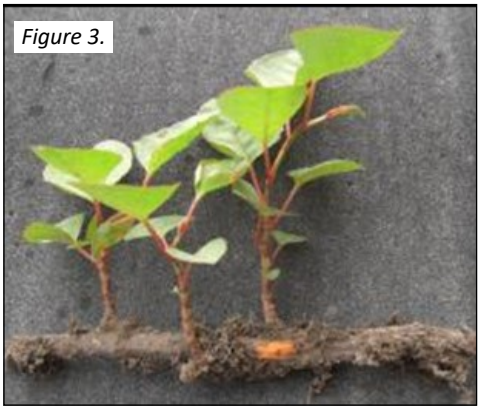
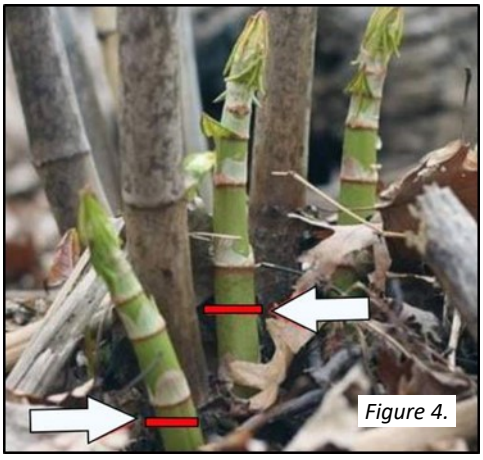


Figure 3.

Sprouts regrowing from rhizomes (right). Photo by Tom Heutte, USDA Forest Service, Bugwood.org.



Arrows indicate the ideal location to cut stems multiple times during the growing season for mechanical control (right). Photo by Petie Reed.

Figure 4.

Common Mugwort
(*Artemisia vulgaris)*

Key Identifying Features:

- **Perennial**. Height 2-5 ft. tall. Aggressive establishment and colonization in roadsides, waste places, and uncultivated areas (*Figure 1*).
- **Leaves are alternate,** papery, **with large pinnate lobes** (*Figure 2*). Green on upper surface, while **undersides are covered with dense white to gray hairs** (*Figure 3*). **Foliage is aromatic** with a sage-like odor. Leaves emerging from ground have **shallower and broader lobes, whereas leaves on mid and upper portion of the plant have lobes that are more linear** and deeper.
- **Stems** are purplish-brown, branched, and covered with short hairs. Inconspicuous flowers (*Figure 4*).
- **Reproduces by rhizome and seed. Aggressive rhizomes form large, fast-spreading patches**. Seeds sprout wherever the ground is bare, especially on disturbed soil and roadsides.
- **Allelopathic**. Mugwort causes hay fever, wherever abundant.
- Tolerates dry, infertile conditions, as well as shady, moist, fertile habitats.

Control:

Mechanical Control:

- **Mow from** early summer to mid-September, before seed head production, to prevent seed dispersal.
- The first two weeks of September are the best time to mow, before the seed has matured. Cut immature seeds will not mature into viable seed.
- Mowing from mid-fall through winter is not recommended, as it would disperse mature, viable seed. However, it is better to mow late than not at all. If mowing after the second week in September, collect and bag mugwort cuttings, if feasible based on the size of the infestation.
- **Pulling very young plants in spring or early summer, before formation of rhizomes, may prevent establishment of new colonies. Scouting and prompt removal is essential.**
- Seeds sprout wherever the ground is bare, especially roadsides. **Stabilization of bare soil** on roadsides with a grass cover will reduce seeding of mugwort.

Chemical Control:

- Foliar spray of glyphosate applied in late summer or early fall will suppress mugwort the following year, but generally not eradicate it. More selective herbicides, such as triclopyr and clopyralid, effectively control mugwort. Clopyralid is applied at very low doses, so it may be the best option from an ecological view.[1]
- The dense hairs on the undersides of the mugwort leaf make herbicide penetration difficult. Therefore, a surfactant is often recommended.[2]

[1] https://cipwg.uconn.edu/wp-content/uploads/sites/244/2016/10/Mugwort-Poster-10-10-16-36x48Landscaperevised.pdf

[2] https://www.mathersenvironmental.com/wp-content/uploads/2016/06/Five-Most-Unwanted-Midwest-Nursery-Weeds-Mugwort.pdf

Figure 1.

Figure 2.

Figure 4.

Colonization of an area (top); close up of foliage (above and below); flower (right).

Figure 3.

Swallow-wort, black and pale

(*Cynanchum louiseae;* syn. *Vincetoxicum nigrum*) and (*C. rossicum;* syn. *V. rossicum*)

Key Identifying Features:

- Perennial, **herbaceous climbing vine**. 3'-9' long, spiraling around self and up other plants in extensive patches. Twines around itself, another support, or trails along the ground. It does not stand upright without support.
- **Leaves are long, oval, and opposite, with a pointed tip** (*Figure 1*); 3"-4" long, 2"-3" wide with **smooth edges**; dark, glossy green, drying to bright yellow. Stems are twining and covered in downy hairs, with **clear sap when stem is broken.**
- **Flowers are flat, star-shaped,** about 1/8" across, with 5 fused petals, forming a short tube at the base. Flowers grow in clusters along the length of the stem. Black swallow-wort has dark purple, triangular petals. Pale swallow-wort has dull pink to burgundy petals (*Figure 2*).
- 1.5"-3" long **seed pods resemble smooth, slender milkweed pods** in both species (*Figure 3*). Pods change from green to yellow to brown, then split on one side to release mature windblown seeds in autumn. Flat, brown seeds are attached to white fluffy hairs which help them disperse.
- Roots are dense and fibrous (*Figure 4*).
- Shade and drought tolerant; can also tolerate periods of brief flooding. Common along roadsides, in gardens, agricultural fields, and woodlands. Spreads quickly once established.
- Colonizes new sites by seed; spreads locally from roots. A square-meter stand can produce 1000-2,000 seeds per year. Capable of self-pollinating. Plants initially grow slowly and do not reproduce by seed for the first several years.

Control:

Controlling large populations of swallow-wort requires a **multi-year effort**. Multiple, simultaneous control strategies are most effective. Plans for re-vegetating sites should be incorporated into control efforts, as newly exposed sites are vulnerable to reinvasion. Annual monitoring is required for successful control.

Mechanical Control:

- Most effective if only a few plants are present; may be used as a **supplement to chemical controls**. Can be an adequate stand-alone control only in the initial stages of invasion.
- **Hand-pulling/digging**: Plants may be dug out if entire root crown is removed. Best success with very young plants.
- **Cutting/mowing**: Plants should be cut after flowering, just as pods are beginning to form, but before seeds begin to mature (late June to early July). If cut earlier, plants are more likely to flower again. Repeated cutting will prevent production and dispersal of seeds, but regrowth from root crowns will occur that may result in denser infestations the following season.
- **Pod removal**, to prevent seed spread: most useful when volunteer labor is available, following mowing or chemical treatment. **Chemical Control**: effective and most typically used for large infestations. Several consecutive years of repeated applications are required for effective control. **Foliar sprays**: triclopyr or glyphosate with surfactant.
- Triclopyr most effective in late spring to early summer, after flowering period. One application per season is adequate.
- Glyphosate does not provide effective control and will provide only a temporary stunting of the plant.


Figure 1.


Figure 2.

Flowering black swallow-wort on left; pale swallow-wort on right. Source: Krishna Ramanujan, Cornell Chronicle 2014


Figure 3.

Pale swallow-wort intertwined on itself with seed pods present. Photo: Chris Evans, Illinois Wildlife Action Plan, Bugwood.org. Source: New York Invasive Species Information.


Figure 4.

Black swallow-wort roots. Photo: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org. Source: New York Invasive Species Information.

Disposal of plant parts: Root crowns, fragments, and seedpods should not be left on the ground or composted, as they will resprout. Instead, they should be burned, allowed to dry in direct sunlight in sealed plastic bags for several weeks, or disposed of in a municipal landfill.

Biological Control: Several species have been identified as potential biocontrols for swallow-wort. In 2018, defoliating moth *Hypena opulenta* was approved for trial release at several sites in Connecticut. It is not yet approved for widespread use.

Correct ID is critical, as leaves are similar to several native species:

- Milkweeds (*Asclepias* spp.) - distinguished by milky latex sap in leaves.
- Dogbanes (*Apocynum* spp.) - distinguished as upright shrubs, with bell-shaped flowers arranged in clusters at stem tips.
- Young dogwoods (*Cornus* spp.) - woody, but appear similar to swallow-wort when young. Upright saplings with smaller oval-shaped leaves.

WOODY VINES, SHRUBS, AND TREES

Japanese Barberry (*Berberis thunbergii*)

Key Identifying Features:

- Perennial deciduous shrub. **Typically 2-3 ft. tall, but can grow up to 6 ft. Slightly wider than tall.** May grow in dense, continuous clusters (*Figure 1*).
- Leaves are alternate, **small (up to an inch long), spoon-shaped**, **with smooth edges; grow in clusters** (*Figure 2*). Leaf tip wider than the leaf base. Leaves of straight species bright green in spring and summer; **maroon, purple, or red in autumn**. Horticultural varieties include yellow, red, and purple foliage spring through fall. **Produces leaves and flowers much earlier than most native species, so usually highly conspicuous in early spring.**
- Stems are very twiggy, with **multiple thin woody stems branching out from one point in the ground**. **Covered in sharp, long thorns at each leaf node.** Bark reddish brown.
- Small, dangling yellow flowers in April and May, profuse along the entire length of the stem.
- **Roots are yellow**, fibrous, and shallow, but tough. Can re-sprout when the stem is cut.
- Many hard, elliptical, **bright red drupes (fruit)** produced late summer through October (*Figure 3*); sometimes persist into winter after leaves have been shed. Most seeds fall close to the parent plant.
- Barberry escapes into abandoned fields and meadows, forest edges, early successional forest, forest wetlands, stream banks, roadsides. Prefers well-drained soils in semi-shade. Invasive in all New England States.
- Seeds dispersed by birds and small mammals; germinate in the spring. Clonal shoots from rhizomes sprout below ground, and tips of branches can root when they touch the ground. Re-sprouts vigorously when damaged by cutting or fire.
- **Associated with the spread of Lyme disease** due to higher densities of rodent hosts and deer ticks preferring shelter under barberry than under native shrubs. When populations of barberry are controlled, fewer mice and ticks are present.
- **Resistant to deer browsing**. When deer numbers are high, palatable native species are replaced by barberry. Once established, barberry outcompetes native species by overshading.


Figure 1.

Control:
It is not recommended to plant seed-bearing Japanese barberry. Seedless cultivars have recently become commercially available, but are not yet common in the trade and do not provide the wildlife benefits of native shrubs. Common winterberry (*Ilex verticillata*) and blueberry (*Vaccinium corymbosum*) are recommended native alternatives.

A primary focus in controlling the spread of this invasive species is to prevent seed production and dispersal. Plants growing in full sun produce more seeds than those in shade, so their control should be prioritized. Control efforts should be concentrated in spring and fall, while desirable native species are still dormant. Mechanical controls may be adequate to eradicate small infestations, and can be used in conjunction with chemical controls for more established stands.

Mechanical Control:

- **Pulling/digging**: Thick gloves and long canvas sleeves are needed for protection from the plant's sharp spines. Roots are shallow, so pulling seedlings is effective.


Figure 2.


Figure 3.

Barberry bushes at a forest edge (above). Barberry fruits in autumn (right). Flowers and foliage in April (above). Photos by Leslie J. Mehrhoff, University of Connecticut Plant Database, Bugwood.org

- Removal is easiest when the soil is moist. Root crowns must be removed in order to prevent resprouting. Minimize soil disturbance. Tools (e.g., Extractigators, weed wrenches, and spades) can help facilitate removal of larger plants.
- **Cutting/mowing:** Repeated cutting and mowing will limit barberry's spread, but resprouting will occur from the root crown. Resprouts can be treated with herbicide or burned with a propane torch later in the season.

Directed burning:

- A propane torch can be used effectively to heat the base of stems near the ground (which kills the tissues that transport nutrients and water). For large specimens, first cutting or foliar spraying makes the stems accessible to the torch. After the initial cutting or spraying, allow the plants to re-sprout to deplete their root reserves before using a torch. Where pesticide use is restricted, mechanical removal followed by burning of resprouts is likely the most effective strategy.

Chemical Control:

- **Cut-stem treatments**: cutting stems and then painting cut stems is effective but labor intensive; can be used with smaller infestations. Cut-stump treatment can be done in any season, except when sap is flowing upwards in spring. Plants treated with any herbicide should be monitored for at least a year, as they may still resprout.
- **Foliar sprays** are preferred with triclopyr or glyphosate; recommended for large infestations and effective from one month after leaf expansion until autumn when leaf color begins. Read label for rates and spray recommendations.
- Ward et. al (2009) found triclopyr to be more effective than glyphosate at controlling large stands of Japanese barberry. As a non-selective herbicide, glyphosate will also kill surrounding desirable non-target species.

Oriental Bittersweet

(*Celastrus orbiculatus)*

Clockwise from top: Mature bittersweet strangles trees; leaves with orange capsules; orange capsules open to reveal red fruit; close up of foliage and orange capsules.

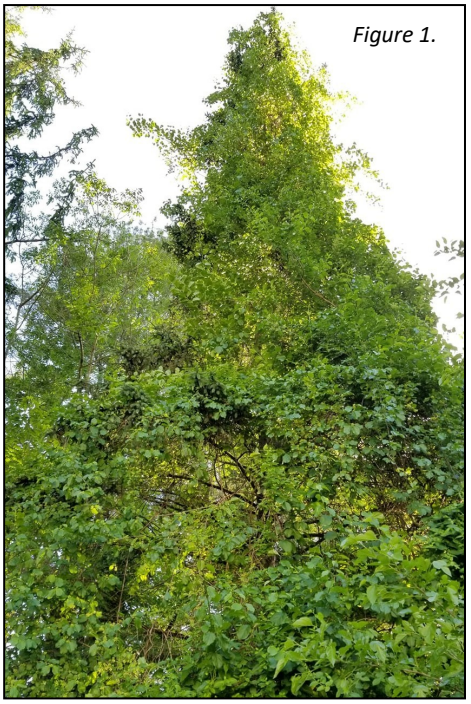


Figure 1.

Key Identifying Features:

- **Perennial, deciduous vine** that climbs, suffocates and strangles other plants. Vines can grow up to 60 feet tall and 4 in. in diameter (*Figure 1*).
- Leaves are **alternate**, 1-4 in. long, **round, pointed or round tip, bluntly toothed margins, glossy** (not hairy) (*Figure 2*). **Yellow in autumn.**
- Stems are **green when young, maturing to tan**; climb for support, lack tendrils, and have **obvious lenticels** (raised pores).
- **Flowers** are small and greenish; **grow among the leaves on the vine** (in contrast to the native Bittersweet's flowers/fruit only at twig tips).
- **Fruit casing is green, maturing to yellow** *(Figures 2 and 3)***; casing splits open to reveal red berry-like fruit** *(Figure 4)***.** Fruit is poisonous to humans, but eaten and dispersed by birds.
- **Roots are orange.** Reproduction is by seed. **Roots sucker aggressively**, especially when plant is cut at soil line or pulled without removal of all roots.

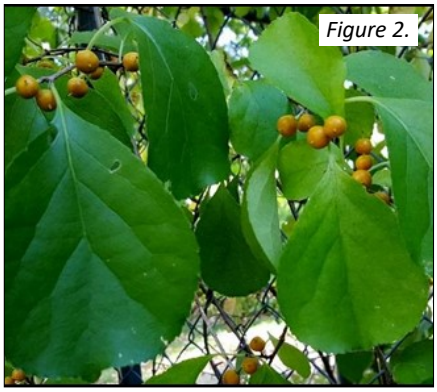


Figure 2.

Figure 4.

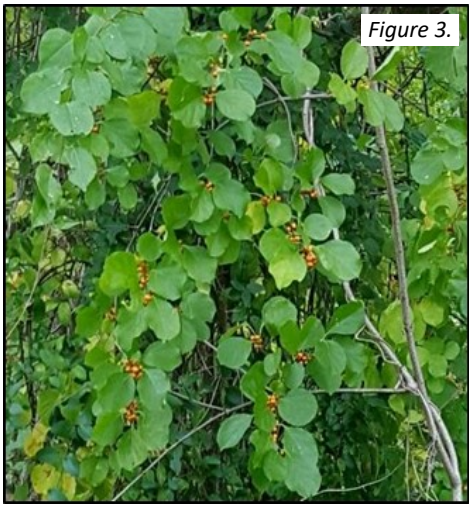


Figure 3.

Control:

Mechanical Control:

- Seedlings can be pulled or removed without difficulty. Routine monitoring for seedling emergence is critical; seedlings are easiest to remove when the soil is moist and the population is small. Pull steadily and slowly to minimize soil disturbance and tamp down the soil afterwards.
- Bittersweet's deep root system often makes pulling or torching impractical.
- **It is not recommended to cut the plant at the soil line,** as it stimulates resprouting of multiple plants and increases

the extent of the infestation.

- **Cutting a mature plant repeatedly at 1-2 ft. in height can reduce its energy supply.** Cut at 2' for the first cut; subsequent cuts may be closer to 1'. This will reduce its destructive effects on the trees and shrubs it is climbing. Vines that are left hanging in the canopy will deteriorate and eventually fall down in two or three years.
- **Each time mature vines have been cut (1-3x) at the 1-2 ft. line, and resprouted at the point of cut, the plant becomes weaker and can more easily be pulled from the soil.**
- Commitment and follow through are required to achieve control.

Chemical Control:

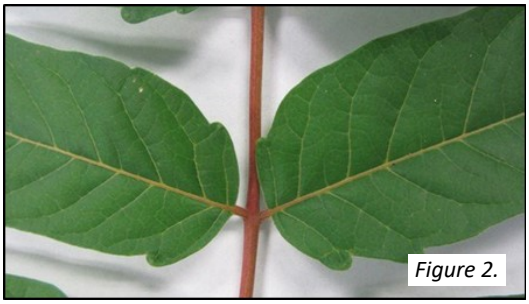
- **Paint cut stems** in late summer with glyphosate or triclopyr. Triclopyr can also be used as a foliar spray. Note that glyphosate will be drawn down into the cut stem off season, but it is not effective in temperatures below 40° F.
- If using a non-selective foliar spray, care must be taken to avoid injury to neighboring plants.

Tree-of-Heaven (*Ailanthus altissima*)

Key Identifying Features:

- Tree-of-heaven grows almost anywhere, including urban areas, woodland edges, and roadsides. Intolerant of shade, but will quickly colonize disturbed areas. Grows quickly, up to 80-100'.
- **Leaves are pinnately compound** (central stem with leaflets attached on each side), ranging from 1-4' in length. Each leaf has 10-40 lance-shaped leaflets, with smooth margins (*Figure 1*). **One to two protruding bumps, called glandular teeth, are at the base of each leaflet** (*Figure 2*). **When crushed, the leaves and all plant parts give off a strong, offensive odor.**
- Twigs of tree-of-heaven are **alternate** on the tree, stout, greenish to brown, and lack a terminal bud. They have large **V- or heart-shaped leaf scars** (*Figure 3*). The twigs easily break to expose the **large, spongy, brown center,** or pith.
- Bark is smooth and green when young, eventually turning light brown to gray, resembling the skin of a cantaloupe.
- Flowers in late May through early June. **Fruit (samara) is wind dispersed** (*Figure 4*). Trees are either male or female (dioecious). Female trees are prolific seeders, with the potential to produce more than 300,000 seeds annually. Sprouts as young as two years of age are capable of producing seed.
- Established trees spread aggressively by root suckers, which may emerge as far as 50' from the parent tree, creating dense colonies.
- Tree-of-heaven produces **allelopathic** chemicals in its leaves, roots, and bark that can limit or prevent the establishment of other plants.
- **Spotted Lanternfly, an invasive pest, is particularly attracted to tree-of-heaven.**

Whole leaf (left); leaf scar (above); glandular teeth at base of a leaflet (below); samaras (bottom). Photos: Dave Jackson, Penn State



Control:

Mechanical Control:

- **Due to its extensive root system and resprouting ability, tree-of-heaven is difficult to control.** The timing of the treatment and follow up during subsequent years are critical to success.
- **Young seedlings can be pulled by hand**, most effectively when the soil is moist. The entire root must be removed since broken fragments may re-sprout. Once plants develop a significant taproot, which can occur within 3 months, they become very difficult to remove. Seedlings can be easily confused with root suckers, which are nearly impossible to pull by hand.
- Larger trees may be cut at ground level with power or manual saws. Cutting is most effective when trees have begun to flower.
- **A cut or injured tree-of-heaven may send up dozens of root sprouts.** Two cuttings per year may be necessary (one early in the growing season and one late in the growing season).
- Although plants may not be killed after cutting, seed production will be inhibited and vigor will be reduced. **If repeated for several years**,

plants will be severely stressed by cutting and will eventually be killed.

- **Girdling** may be effective for large trees. Using a hand-axe, make a cut through the bark approximately 6 in. above the ground, and cut completely around the trunk, deep enough to cut well into or below the cambium layer. Girdling will kill the top of the tree but re-sprouts are common, and may require follow-up treatments for several years.

Chemical Control:

- **A foliar spray** with glyphosate (after mid-August) or a basal bark application of triclopyr (year-round) can be effective. Follow label directions when using all chemical treatments.
- **Target the roots** with systemic herbicides applied in mid- to late summer (July to onset of fall color) when the tree is moving carbohydrates to the roots. Herbicide applications made outside this late growing season window will only injure aboveground growth. Following treatment, repeated site monitoring for signs of regrowth is critical to prevent reinfestation.
- **Herbicides applied to foliage, bark, or frill girdles** are effective at controlling tree-of-heaven. Note that cut stump herbicide applications encourage root suckering and are not generally recommended without repeated follow up treatments. Apply all herbicide treatments after July 1, up until the tree begins to show fall colors.
- Tree-of-heaven tends to be more susceptible to triclopyr than to glyphosate, especially prior to late summer. Where permitted, foliar sprays are effective once the leaves are fully expanded. For larger trees, three approaches are possible: 1) Girdle the tree (see description above), and apply undiluted triclopyr in the cut around the trunk; 2) Cut down tree and apply undiluted triclopyr into the freshly cut surfaces of the stump to prevent re-sprouting, or 3) Cut down tree and spray re-sprouts before they get too tall to correctly spray top surface.
- **Well-established tree-of-heaven stands are only eliminated through repeated monitoring and control efforts. Initial treatments often only reduce the root systems, making follow-up measures necessary. Persistence is the key to success.**

Figure 5. Staghorn Sumac fruit panicle.

Tree-of-Heaven vs. Sumac (Staghorn and Smooth)

Tree-of-heaven resembles several native species that have compound leaves and numerous leaflets, such as staghorn sumac, black walnut, and hickory.

- **Size**: Tree-of-heaven can grow to 80 ft., while sumacs typically grow to 15-20 ft.
- **Leaves**: While both have compound leaves, tree-of-heaven has **smooth** edges; sumacs have **serrated** edges. Tree-of-heaven leaflets contain one or more **glandular bumps** at the base of the leaflet, which are not present on sumac leaves. The **foul odor** produced by the crushed foliage and broken twigs is also unique to tree-of-heaven.
- **Seeds**: Tree-of-heaven produces samaras, which hang in clusters and turn a dull orange/brown color. Sumacs have a panicle of flowers that produce fuzzy fruits (*Figure 5*), which often persist into winter.

Disposal of Invasive Plants

Correct identification and recognizing how the invasive plant reproduces helps determine the appropriate disposal method. Careful movement of material is imperative, so that there is no spread of invasives during disposal.

After mechanical removal of any invasive plant, **seedlings and young shrubs should be laid to dry in the sun**, on a plastic barrier or other area where roots do not touch soil, until their roots are completely dried out. **If fruit is absent,** dried uprooted shrubs can be piled and left as cover for small animals. **If fruit is present, the pulled shrub should be burned or bagged and placed in a landfill.**

Burning:

- Large woody branches and trunks can be used as firewood or burned in piles.
- **Plants with airborne seeds** (e.g., Swallow-wort) **should not be burned**, as seeds could be dispersed by the hot air. **Note:** Local regulations may forbid or require a permit for burning.

Bagging (solarization):

- For killing **herbaceous plants**: Use heavy black or clear plastic bags; let sit in sun for several weeks and on dark pavement for the best effect.

Tarping and Drying:

- Pile material on a plastic sheet; cover with a tarp, fasten the tarp to the ground, and let dry for several weeks.

Chipping:

- For **woody plants that do not reproduce vegetatively only**. **Note:** Invasive vines, such as Oriental bittersweet, may be difficult to chip because vines can wrap around and clog the chipper.

Composting:

- **Do not** compost any invasive plants unless there is no viable (living) plant material left, as invasive plants can take root in compost.

GLOSSARY:

Ocrea at the nodes.

Allelopathy: suppression of growth of a plant by a toxin released from a nearby plant of the same or another species.
Alternate: leaf pattern arrangement is one leaf per node (as opposed to opposite).
Annual: a plant that completes its life cycle from seed to a mature plant that produces seed in one year. Winter annuals complete their life cycles from fall to spring. Summer annuals complete their life cycle from spring to fall.
Cambium layer: A cylindrical layer of tissue in the stems and roots of many seed-bearing plants, consisting of cells that divide rapidly to form new layers of tissue. Cambium is a kind of meristem and is most active in woody plants, where it lies between the bark and wood of the stem.
Compound leaf: divided into several leaflets.
Drupe: a fleshy fruit with thin skin and a central stone containing the seed, e.g., a plum, cherry, almond, or olive.
Frill girdle: A girdle made on a stump or tree to be killed by herbicide. A series of downward cuts are made through the bark and into the region of the vascular cambium or outer sapwood, and at each cut the peripheral tissues are levered outward creating the frill, with a channel between it and the sapwood.
Node: the joint of a stem; the region of attachment of leaves to a stem.
Ocrea: papery sheath that encloses the stem at the nodes; made from the fusion of 2 stipules.
Opposite: Leaves grow in pairs along the stem (as opposed to alternate).
Perennial: a non-woody plant that lives for more than two years. Returns each year and continues growing until it reaches maturity (3-5 years on average).
Pinnate: (of a compound leaf) having leaflets arranged on either side of the stem, typically in pairs opposite each other.
Rhizome: an underground, elongated stem (or shoot) with scale leaves and adventitious roots arising from the nodes.
Samara: a fruit consisting of a seed in a dry, unsplitting cover, attached to a papery wing, as in ash and maple.
Sessile: stalkless and attached directly at the base (ex. sessile leaf).
Simple leaf: a leaf not separated into multiple leaflets; its edges may be deeply lobed or otherwise divided.

Bibliography:

General:
Uva, Richard, Joseph Neal, Joseph DiTomaso. *Weeds of the Northeast*. Ithaca: Cornell University Press, 1997.
Connecticut Invasive Plant Working Group (CIPWG): http://cipwg.uconn.edu/invasive_plant_list/
A Field Guide to Invasive Plants of Wisconsin: https://dnr.wi.gov/files/pdf/pubs/fr/fr0436a.pdf
Center for Invasive Species and Ecosystem Health: www.invasive.org
Garlic mustard:
Identification, Control, and Impact of Garlic Mustard, *Alliaria petiolata*. Irene O. Sabin, Master Gardener, RCE of Hunterdon County. Nicholas Polanin, Agriculture and Natural Resources Agent, Somerset County.
https://njaes.rutgers.edu/fs1212/
Japanese knotweed:
Japanese knotweed, *Fallopia japonica (Polygonum cuspidatum).* Michigan Department of Natural Resources. Michigan Natural Features Inventory. 2012. https://mnfi.anr.msu.edu/invasive-species/JapaneseKnotweedBCP.pdf
http://www.naturespot.org.uk/species/japanese-knotweed
Mugwort:
The Five Most Unwanted Midwest Nursery Weeds. Part 2. Mugwort (*Artemisia vulgaris* L.). Hannah Mathers, PhD, 2016. https://www.mathersenvironmental.com/wp-content/uploads/2016/06/Five-Most-Unwanted-Midwest-Nursery-Weeds-Mugwort.pdf
Artemisia vulgaris (Mugwort): Overlooked Infiltrator of Meadow Habitats. Sigrun N. Gadwa, MS and Todd L. Mervosh, PhD. Poster, 2016. https://cipwg.uconn.edu/wp-content/uploads/sites/244/2016/10/Mugwort-Poster-10-10-16-36x48Landscaperevised.pdf
Swallow-wort:
Connecticut Invasive Plant Working Group. Chemical Control Options for Other Invasive Plants.
Cornell Cooperative Extension, Putnam County. Natural Resources, Invasive Plants Program. Swallow-worts. Jennifer Learner, 2018.
Michigan Department of Natural Resources. Invasive Species – Best Control Practices. Black and Pale Swallow-worts. MI Natural Features Inventory, 2012.
New York Invasive Species (IS) Information. Swallow-wort, Pale and Black. Cornell University Cooperative Extension, 2019.
U.S. Environmental Protection Agency. Inert Ingredients Eligible for FIFRA 25(b) Pesticide Products, revised November 2016.
U.S.D.A. Natural Resources Conservation Service Connecticut. Invasive Species Sheet – Swallow-wort.

Japanese barberry:
College of Agriculture, Health and Natural Resources Horticulture Plant Database, University of Connecticut. *Berberis thunbergii*, Japanese Barberry, Berberidaceae. Mark H. Brand, 1997-2015.
College of Agriculture, Health and Natural Resources Horticulture Plant Database, University of Connecticut. *Ilex verticillata*, Common Winterberry, Aquifoliaceae. Mark H. Brand, 1997-2015.
Connecticut Invasive Plant Working Group (CIPWG), University of Connecticut. Japanese Barberry (*Berberis thunbergii*). Invasive Plant Atlas of New England. University of George Center for Invasive Species and Ecosystem Health, 2019. Japanese Barberry.
Michigan Department of Natural Resources, Michigan Natural Features Inventory, 2012. Invasive Species – Best Control Practices. Japanese barberry, *Berberis thunbergii*, pp. 1-7.
USDA Forest Service, Forest Health Staff. Invasive Plants Fact Sheet, Japanese Barberry.
Ward, Jeffrey S., Thomas E. Worthley, Scott C. Williams, 2009. Controlling Japanese barberry (*Berberis thunbergii*) in southern New England, USA. Forest Ecology and Management, 257:2, 561-566. DOI: https://doi.org/10.1016/j.foreco.2008.09.032
Ward, Jeffrey & Williams, Scott. (2011). Controlling an Invasive Shrub, Japanese Barberry (*Berberis thunbergii*), Using Directed Heating with Propane Torches. Natural Areas Journal. 31. 500-506. 10.3375/043.031.0208.
Wenning, Bruce. Ecological Landscaping Alliance, 2012. Japanese Barberry: An Exotic Invasive Plant Fact Sheet.
Oriental bittersweet:
https://mnfi.anr.msu.edu/invasive-species/OrientalBittersweetBCP.pdf
Invasive.org, Oriental bittersweet http://www.invasive.org/browse/subinfo.cfm?sub=3012
Invasipedia at BugwoodWiki, Celastrus orbiculatus http://wiki.bugwood.org/Celastrus_orbiculatus

Funds to support the creation of this document were provided by the Connecticut Department of Energy and Environmental Protection and by the Crop Protection and Pest Management Extension Implementation Program [grant no. 2017-70006-27201/project accession no. 1013777] from the USDA National Institute of Food and Agriculture.

United States Department of Agriculture
National Institute of Food and Agriculture

For more information, contact:
Vickie Wallace
UConn Extension
Extension Educator
Sustainable Turf and Landscape
Phone: (860) 885-2826
Email: victoria.wallace@uconn.edu

Updated October 2019