**Acknowledgements**

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**Table of Contents**

The problem of biological pollution is a relatively new notion to the public. It has only recently become a defining management issue for foresters, recreational specialists, resource managers, ecologists, native plant enthusiasts, and to some extent public policy makers who have in some states passed laws to ban the continued introduction of exotic pest species. While public awareness is lagging, more recognition of this issue is steadily filtering down into the professional ranks as these impacts have caused serious management concerns. As the significance of this issue becomes more urgent, professional associations and land managing agencies are attempting to educate their members through professional journals, symposia, and conferences about this threat.

In Tennessee, a statewide coordinated effort to educate the public, natural resource professionals, and public policy makers has been on-going since 1994 with the establishment of the Tennessee Exotic Pest Plant Council (TN-EPPC), an affiliate of the National Association of Exotic Pest Plant Councils. This effort has been maintained through annual symposiums, membership newsletters, workshops, the development of an exotic pest plant list for the state, and educational brochures. Since its inception, TN-EPPC has recognized a need for providing resource managers with information to help control and manage exotic pest plants in Tennessee's natural areas (as defined generically). Through the cooperation of many of the professional affiliates of TN-EPPC, this Tennessee Exotic Plant Management Manual has been developed to accomplish that goal. Sponsorship for this manual and much of the technical information contained in it have come from the National Park Service (NPS). TN-EPPC recognizes NPS as an important participating member and is appreciative of its commitment. Much of the recent work in the Great Smoky Mountains National Park on controlling and managing exotic pest plant species has been very important in developing many of these management guidelines.

**Statement of Problem**

Recently the native vegetation throughout Tennessee has been severely impacted by introduced plant species that are invasive. These plants are called exotics because they are introduced into a region by humans either deliberately or accidentally. While not all exotics are invasive, those that naturalize may become prolific reproducers and rampantly spread throughout natural areas. Since they lack the natural controls that keep them in check in their native range, invasive exotics outcompete and displace native vegetation. This effect drastically changes the composition of native plant communities and degrades the ecological significance of native habitats. When ecosystems are severely degraded, the integrity of the natural area is lost. If control and management does not occur, many sites become monocultures of exotics, destroying biological diversity.

**Statement of Purpose**

This vegetation management manual provides the information to implement control and management techniques of some invasive exotic pest plant species. The most effective approach is to remove them as quickly as possible long before populations become established. Unfortunately, this is often not possible due to limited resources, especially when managing large or numerous areas. In many cases, however, exotics go unnoticed simply because of general lack of awareness of the problem. It is when infestation levels become obvious that management considerations are taken into account. This makes the task of implementing successful management actions even more challenging, requiring greater use of resources, and causing difficult management choices. The effectiveness of control and management is accomplished through a proactive management approach. The intent of this manual is to provide the prescribed methods to accomplish the goal of control and management whenever possible.

The management recommendations in this manual primarily derive from field tested applications in Tennessee and from literature reviews of research, life histories, and management efforts in other states. Any observations (data) that might amend these control and management recommendations are

welcomed. Site conditions differ across Tennessee's physiographic provinces, and site variability across the state may influence results. Future changes to this vegetation manual including additional control and management for new species will be available on-line on the World Wide Web under the Tennessee Exotic Pest Plant Council's Home Page (webriver.com/tn-eppc).

**Tennessee Exotic Pest Plant List of Invasive Exotics**
The 20 species in this manual were selected from species listed as severe or significant threats to natural areas from the Invasive Exotic Pest Plants in Tennessee list developed by TN-EPPC. This comprehensive statewide list identifies and ranks invasive exotics that impact natural areas. Management recommendations for other species not included in this manual will be added as resources and management information become available. The list derives from the evaluations, observations and comments of resource managers, ecologists, and botanists across Tennessee. It is a tool to help resource managers be aware of the many other invasive exotic pest plants known to occur in Tennessee. It will be periodically reviewed and updated. Prior to this release, the list has been reviewed twice for comment by botanists statewide.

**Useful information this manual provides**
Identifying invasive exotics early in the process is an important first step which should lead to an assessment of the problem so appropriate management steps can be taken to prevent high infestation levels from occurring. The manual provides information to help identify 20 of Tennessee's most invasive exotic pest plant species with color photos, line drawings, and botanical descriptions. Additional information, such as life history, origin and distribution of exotics, and habitat information for each species is described. Similar native species that might be confused with these exotics are also described to minimize the chance of misidentification. Each exotic species account includes a bibliography of reference for those interested in more information about particular species.

**A tool for resource managers to implement integrated pest management practices**
This manual is not a management plan for exotic plant control, but rather, it is a tool for resource managers to develop such plans. The philosophy of this manual reflects that of the Tennessee Exotic Pest Plant Council and represents an approach based on integrated pest management (IPM) and ecological restoration. IPM is a multiple track approach that may require more than one type of action for successful results. IPM utilizes cultural, ecological, mechanical, chemical, and biological control. The degree of infestation, sensitivity of an area (occurrence of rare elements), and availability of resources often determines the choice of action and the level of management response.

Chemical use is only recommended when other efforts are ineffective or when infestation must be reduced to attain manageable levels by other means. The chemicals used in natural areas should be applied as recommended. These chemicals are considered to be safe when used according to the recommendations. All precautions should be made to minimize the impact on non-target species. In many cases, when degradation is so extensive, chemical application is inappropriate. Management may not be feasible, or only possible if approved biological control agents are available. Chemical control offers short-term results and is considered a stop gap measure. These chemicals are referenced by their active ingredients. The tradenames for these chemicals are not given.

Understanding ecological function is an important management need in natural resource management planning. Management actions that restore the necessary ecological processes is often a critical component of exotic species control. The absence of these ecological processes (fire, hydrology, etc.) creates favorable conditions for exotic species invasion. Frequently the degree of impact of invasive exotics is symptomatic of unhealthy ecosystems that have been disrupted from their natural disturbance regime

or severely fragmented ecosystems where exotic species invasion occurs because of excessive edge effect.

Managing exotics does not necessarily result in complete eradication but may only accomplish control measures. Managing problem areas requires a long-term commitment, and planning that incorporates a monitoring program to prevent recolonization. Soils often retain viable seeds that will germinate for many years after removal. Sites beyond the immediate management zone where seeds and other dispersal propagules originate should also be targeted. Efforts to educate neighbors and adjacent property owners about how invasive exotics spread is desirable. Raising awareness about the spread of exotics is an important goal of the Tennessee Exotic Pest Plant Council and is critical in stopping future introductions.

**Prevention is our best solution**

While the focus of this manual is natural area management, these recommendations can also be applied to any other land management units from interstate rights-of-way to private residences. The control of exotic pest plants outside of preserve boundaries is critical in preventing their dispersal into the preserve. Stopping the continued introduction and spread of invasive exotics throughout Tennessee begins with prevention. There are unlimited species of native plants that can be used instead of exotics for roadside landscaping, wildlife habitat improvement, erosion control, mining reclamation, and other purposes. We strongly encourage federal and state nursery systems that provide plant materials for public land use to help in this endeavor by eliminating exotics from their inventories. It would be highly desirable for these nurseries to propagate and grow quality native plants that can be used for landscaping and restoration purposes by public land managers.

TN-EPPC endorses the Resolution for Responsible Landscaping Practices introduced by the Tennessee Recreation and Parks Association in 1990 and recommends using native plants especially in landscaping situations that may affect natural areas. The use of native species on public lands demonstrates responsible stewardship practices. This practice was mandated on April 26,1994 as President Clinton signed an executive directive for federal agencies and all non-federal agencies (who use federal dollars) to landscape with native plants. Other rules and laws important in Tennessee prohibit the introduction of exotic plants on state lands designated as state natural areas, scenic rivers, and the state trail system under the Rules for Management of Tennessee Natural Resource Areas.

As a proactive organization, TN-EPPC has developed alternative native plant lists as substitutes for invasive exotics. These lists are published as brochures "Landscaping with Native Plants" for each of the grand regions of Tennessee. They are available upon request. It is our hope that native plants will become more available in nurseries as public demand grows. In raising awareness about the invasive exotic pest plant issue, TN-EPPC also promotes the use of native plants.

Brian Bowen, President
Tennessee Exotic Pest Plant Council
September 1996

The White House

Office of the Press Secretary

For Immediate Release April 26, 1994

Memorandum for the Heads of Executive Departments and Agencies

Subject: Environmentally and Economically Beneficial Practices on Federal Landscaped Grounds

The Report of the National Performance Review contains recommendations for a series of environmental actions, including one to increase environmentally and economically beneficial landscaping practices at Federal facilities and federally funded projects. Environmentally beneficial landscaping entails utilizing techniques that complement and enhance the local environment and seek to minimize the adverse effects that the landscaping will have on it. In particular, this means using regionally native plants and employing landscaping practices and technologies that conserve water and prevent pollution.

These landscaping practices should benefit the environment, as well as generate long-term cost savings for the Federal Government. For example, the use of native plants not only protects our natural heritage and provides wildlife habitat, but also can reduce fertilizer, pesticide, and irrigation demands and their associated costs because native plants are suited to the local environment and climate.

Because the Federal Government owns and landscapes large areas of land, our stewardship presents a unique opportunity to provide leadership in this area and to develop practical and cost-effective methods to preserve and protect that which has been entrusted to us. Therefore, for Federal grounds, Federal projects, and federally funded projects, I direct that agencies shall, where cost-effective and to the extent practicable:

(a) use regionally native plants for landscaping;

(b) design, use, or promote construction practices that minimize adverse effects on the natural habitat;

(c) seek to prevent pollution by, among other things, reducing fertilizer and pesticide use, using integrated pest management techniques, recycling green waste, and minimizing runoff. Landscaping practices that reduce the use of toxic chemicals provide one approach for agencies to reach reduction goals established in Executive Order No. 12856, "Federal Compliance with Right-To-Know Laws and Pollution Prevention Requirements;"

(d) implement water-efficient practices, such as the use of mulches, efficient irrigation systems, audits to determine exact landscaping water-use needs, and recycled or reclaimed water and the selecting and siting of plants in a manner that conserves water and controls soil erosion. Landscaping practices, such as planting regionally native shade trees around buildings to reduce air conditioning demands, can also provide innovative measures to meet the energy consumption reduction goal established in Executive Order No. 12902, "Energy Efficiency and Water Conservation at Federal Facilities;" and

(e) create outdoor demonstrations incorporating native plants, as well as pollution prevention and water conservation techniques, to promote awareness of the environmental and economic benefits of implementing this directive. Agencies are encouraged to develop other methods for sharing information on landscaping advances with interested nonfederal parties.

In order to assist agencies in implementing this directive, the Federal Environmental Executive shall:

(a) establish an interagency working group to develop recommendations for guidance, including compliance with the requirements of the National Environmental Policy Act,42 U.S.C. 4321, 4331-4335, and 4341-4347, and training needs to implement this directive. The recommendations are to be developed by November 1994; and

(b) issue the guidance by April 1995. To the extent practicable, agencies shall incorporate this guidance into their landscaping programs and practices by February 1996.

In addition, the Federal Environmental Executive shall establish annual awards to recognize outstanding landscaping efforts of agencies and individual employees. Agencies are encouraged to recognize exceptional performance in the implementation of this directive through their awards programs.

Agencies shall advise the Federal Environmental Executive by April 1996 on their progress in implementing this directive.

To enhance landscaping options and awareness, the Department of Agriculture shall conduct research on the suitability, propagation, and use of native plants for landscaping. The Department shall make available to agencies and the public the results of this research.

WILLIAM J. CLINTON

**Resolution Promoting Environmentally Responsible Landscaping Practices**

Whereas, the 1990s has been proclaimed the "decade of the environment" mandating that all citizens act in an environmentally responsible manner. It is essential that we recognize the need to protect natural areas, scenic aquatic systems, and greenspace corridors.To preserve the integrity of these places of natural heritage and biodiversity, it is imperative that a land ethic be realized that promotes environmentally responsible landscaping practices.

Whereas, some exotic plants that have been introduced into our landscapes are now known to cause devastating damage to our ecosystems. The introduction of aggressive exotic plant species changes the species composition of plant communities, reduces the native plant community diversity by stressing native plants beyond the limits of their tolerance (out competing them for space, sunlight, water, nutrients, etc.), and becomes difficult or impossible to eradicate or control (i.e., kudzu-vine, *Pueraria lobata*); and

Whereas, by introducing plant species from other countries or regions into our landscapes, our landscapes become vulnerable to invasively aggressive exotics. Even those exotics that naturalize and do not become aggressive have an undesirable effect on our native plant communities by changing their composition. Furthermore, it is impossible to predict whether a naturalized species which is seemingly neutral will remain neutral once it has successfully adapted over a long period of time; and

Whereas, there is overwhelming evidence that the foals of landscaping for the purposes of: (1) wildlife habitat improvement (2) reforestation (3) soil conservation and (4) wind-breaks and other highway plantings can be accomplished by using native indigenous pants and thus, protecting our natural heritage; then

Therefore, be it resolved that the Tennessee Exotic Pest Plant Council endorses the use of native indigenous plant species to promote environmentally responsible landscaping practices. Let it be further resolved that the Tennessee Exotic Pest Plant Council encourages government agencies (local, state and federal), businesses, and landowners to consider the content of this resolution when planning a landscape. If planned landscapes cannot be entirely native, exotics should not be used that are on the Invasive Exotic Pest Plants in Tennessee list published by TN-EPPC.

**Severe Threat** (Rank 1) - exotic plant species which possess characteristics of invasive species, spread easily into native plant communities, and displace native vegetation. Includes species which are or could become widespread in Tennessee.

*Ailanthus altissima* (Mill.) Swingle - tree-of-heaven
*Alliaria petiolata* (M. Bieb.) Cavara & Grande - garlic mustard
*Arthraxon hispidus* (Thunb.) Makino - hairy jointgrass
*Carduus nutans* L. - musk thistle, nodding thistle
*Elaeagnus umbellata* Thunb. - autumn olive
*Euonymus fortunei* (Turcz.) Hand.- Maz. - climbing euonymous
*Hydrilla verticillata* (L.f.) Royle - hydrilla
*Lespedeza cuneata* (Dum. Cours.) G. Don - sericea lespedeza
*Ligustrum sinense* Lour. - privet
*Ligustrum vulgare* L. - common privet
*Lonicera japonica* Thunb. - Japanese honeysuckle
*Lonicera maackii* (Rupr.) Maxim. - Amur bush honeysuckle
**Lonicera morrowii* A. Gray - Morrow's bush honeysuckle
*Lythrum salicaria* L. [all varieties and cultivars] - purple loosestrife
*Microstegium vimineum* (Trin.) A. Camus - Nepalgrass, Japanese grass
*Myriophyllum spicatum* L. - Eurasian water-milfoil
*Paulownia tomentosa* (Thunb.) Sieb. & Zucc. ex Steud. - Princess tree
***Phalaris arundinacea* L. - canary grass
***Phragmites australis* (Cav.) Trin. ex Steud. - common reed
*Polygonum cuspidatum* Seib. & Zucc. - Japanese knotweed, Japanese bamboo
*Pueraria montana* (Willd.) Ohwi - kudzu
*Rosa multiflora* Thunb. ex Murray - multiflora rose
*Solanum viarum* Dunal - tropical soda apple
*Sorghum halepense* (L.) Pers. - Johnson grass

**Significant Threat** (Rank 2) - exotic plant species which possess some invasive characteristics, but have less impact on native plant communities. These plants may have the capacity to invade natural communities along disturbance corridors, or to spread from stands in disturbed sites into undisturbed areas, but have fewer characteristics of invasive species than Rank 1 above.

*Albizia julibrissin* Durazz. - mimosa
*Allium vineale* L. - field garlic
*Alternathera philoxeroides* (Mart.) Griesb. - alligatorweed
*Artemisia vulgaris* L. - mugwort
*Arundo donax* L. - giant reed, elephant grass
*Berberis thunbergii* DC. - Japanese barberry
*Bromus inermis* Leyss. - Hungarian bromegrass
*Bromus japonicus* Thunb. ex Murray - Japanese bromegrass
*Bromus secalinus* L. - bromegrass
*Bromus tectorum* L. - thatch bromegrass
*Celastrus orbiculatus* Thunb. - Oriental bittersweet
*Centaurea maculosa* Lam. - spotted knapweed
*Chrysanthemum leucanthemum* L.- ox-eye daisy
*Cirsium arvense* L. (Scop.) - Canada thistle

*Cirsium vulgare* (Savi) Ten. - bull thistle
*Clematis terniflora* DC. - leatherleaf clematis
*Coronilla varia* L. - crown vetch
*Dioscorea batatas* Decne. - air-potato
**Dipsacus fullonum* L. - Fuller's teasel
*Egeria densa* Planch. - Brazilian elodea
*Elaeagnus pungens* Thunb. - Russian olive
*Euonymus atropurpureus* (Thunb.) Seib. - burning bush
*Festuca elatior* Huds. - tall fescue
*Hedera helix* L. - English ivy
*Hesperis matronalis* L. - dame's rocket
*Lespedeza bicolor* Turcz. - bicolor lespedeza
*Lonicera fragrantissima* Lindl. & Paxton - January jasmine
*Ludwigia uruguayensis* (Camb.) H. Hara - hairy water-primrose
*Lysimachia nummularia* L. - moneywort
*Melilotus alba* Medik. - white sweet clover
*Melilotus officinalis* (L.) Lam. - yellow sweet clover
*Miscanthus sinensis* Anderss. - zebra grass
*Mosla dianthera* (Buch. Ham. ex Roxb.) Maxim. - miniature beefsteak
*Murdannia keisak* (Hassk.) Hand.-Maz. - Asian spiderwort
*Myriophyllum aquaticum* (Vell.) Verdc. - parrotfeather, watermilfoil
*Nasturtium officinale* R.Br. - watercress
*Polygonum caespitosum* Blume - bunchy knotweed
**Polygonum sachalinense* F. Schmidt ex Maxim.
*Potamogeton crispus* L. - curly pondweed
*Setaria pumila* (Poir.) Roem. & Schult. - smooth millet
*Setaria viridis* (L.) P. Beauv. - green millet
*Spiraea japonica* L.f. - Japanese spiraea
*Torilis arvensis* (Huds.) Link - hedge-parsley
*Tribulus terrestris* L. - puncturevine
*Tussilago farfara* L. - coltsfoot
*Verbascum thapsus* L. - common mullein
*Vinca major* L. - large periwinkle
*Vinca minor* L. - common periwinkle
*Wisteria floribunda* (Willd.) DC. - wistera
*Wistera sinensis* (Sims) Sweet - Chinese wisteria

**Lesser Threat** (Rank 3) - exotic plant species which seem to principally spread and remain in disturbed areas, but do not readily invade natural areas. This list also includes some agronomic weeds.

*Bromus catharticus* Vahl - bromegrass
*Bromus commutatus* Schrad. - bromegrass
*Bromus hordeaceus* L. - bromegrass
*Bromus sterilis* L. - bromegrass
*Broussonetia papyrifera* (L'Her. ex Vent.) - paper mulberry
*Bupleurum rotundifolium* L. - hound's-ear
*Cardiospermum halicacabum* L. - balloonvine
*Centaurea cyanus* L. - bachelor's button

*Cichorium intybus* L. - chicory
*Conium maculatum* L. - poison hemlock
*Cosmos bipinnatus* Cav. - cosmos
*Cosmos sulphureus* Cav. - cosmos
*Daucus carota* L. - wild carrot, Queen Anne's-lace
*Eschscholtzia californica* Cham. - California poppy
*Euphorbia humistrata* Engelm. ex A. Gray - spreading spurge
*Fatoua villosa* (Thunb.) Nakai - hairy crabweed
*Hibiscus syriacus* L. - rose of Sharon
*Kummerowia stipulacea* (Maxim.) Makino - Korean clover
*Kummerowia striata* (Thunb.) Schlindl. - Japanese clover
*Lithospermum arvense* (L.) I.M. Johnson - corn gromwell
*Macleaya cordata* (Willd.) R. Br. - plume-poppy, tree celandine
*Melia azedarach* L. - Chinaberry
*Mentha spicata* L. - spearmint
*Mentha* X *piperita* L. - peppermint
*Muscari neglectum* Boiss. & Reut. - grape hyacinth
*Muscari botryoides* (L.) Mill. - grape hyacinth
**Muscari comosum* (L.) Mill
*Ornithogalum umbellatum* L. - star of Bethlehem
*Papaver dubium* L. - poppy
*Pastinaca sativa* L. - parsnip
*Phalaris canariensis* L. - canary grass
*Polygonum orientale* L. - Prince's feather
*Polygonum persicaria* L. - lady's thumb
*Populus alba* L. - white poplar
*Rubus phoenicolasius* Maxim. - wineberry
*Senecio vulgaris* L. - ragwort
*Senna obtusifolia* (L.) H.S. Irwin & Barneby - sicklepod senna
*Senna occidentalis* (L.) Link - coffee senna
*Setaria faberi* Herrm. - nodding foxtail-grass
*Setaria italica* (L.) Beauv. - foxtail-millet
*Solanum dulcamara* L. - bittersweet
*Stachys floridana* Shuttlw. ex Benth. - hedge nettle
*Tragopogon dubius* Scop. - yellow goats-beard
*Ulmus pumila* L. - dwarf elm
*Urtica dioica* L. - stinging nettle
*Xanthium spinosum* L. - spiny cocklebur
*Xanthium strumarium* L. - common cocklebur

**Watch List** (may be a problem elsewhere; more information needed)
*Alnus glutinosa* (L.) Gaertn. - sticky alder
*Echium vulgare* L. - viper's bugloss
*Hypericum perforatum* L. - goatweed, St. John's-wort
*Najas minor* All. - water nymph
*Rhamnus frangula* L. - alder buckthorn

* Listed by reason of similarity of appearance
** A native species, however, introduced "races" are invasive

Taxonomy and nomenclature taken from:

Wofford, B. E.; Kral, R. Checklist of the Vascular Plants of Tennessee; 1993.

Sida, Botanical Miscellany No. 10.

Kartesz, J. T. A synomized checklist of vascular flora of the U. S., Canada, and Greenland. Second edition, Timber Press; 1994.

Invasive Exotic Pest Plants in Tennessee
Research Committee of the Tennessee Exotic Pest Plant Council
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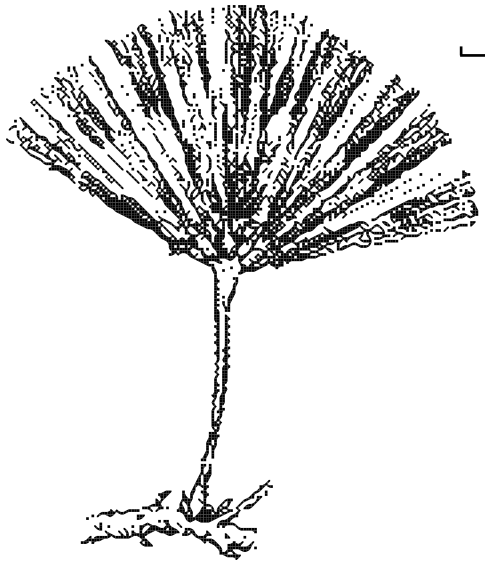
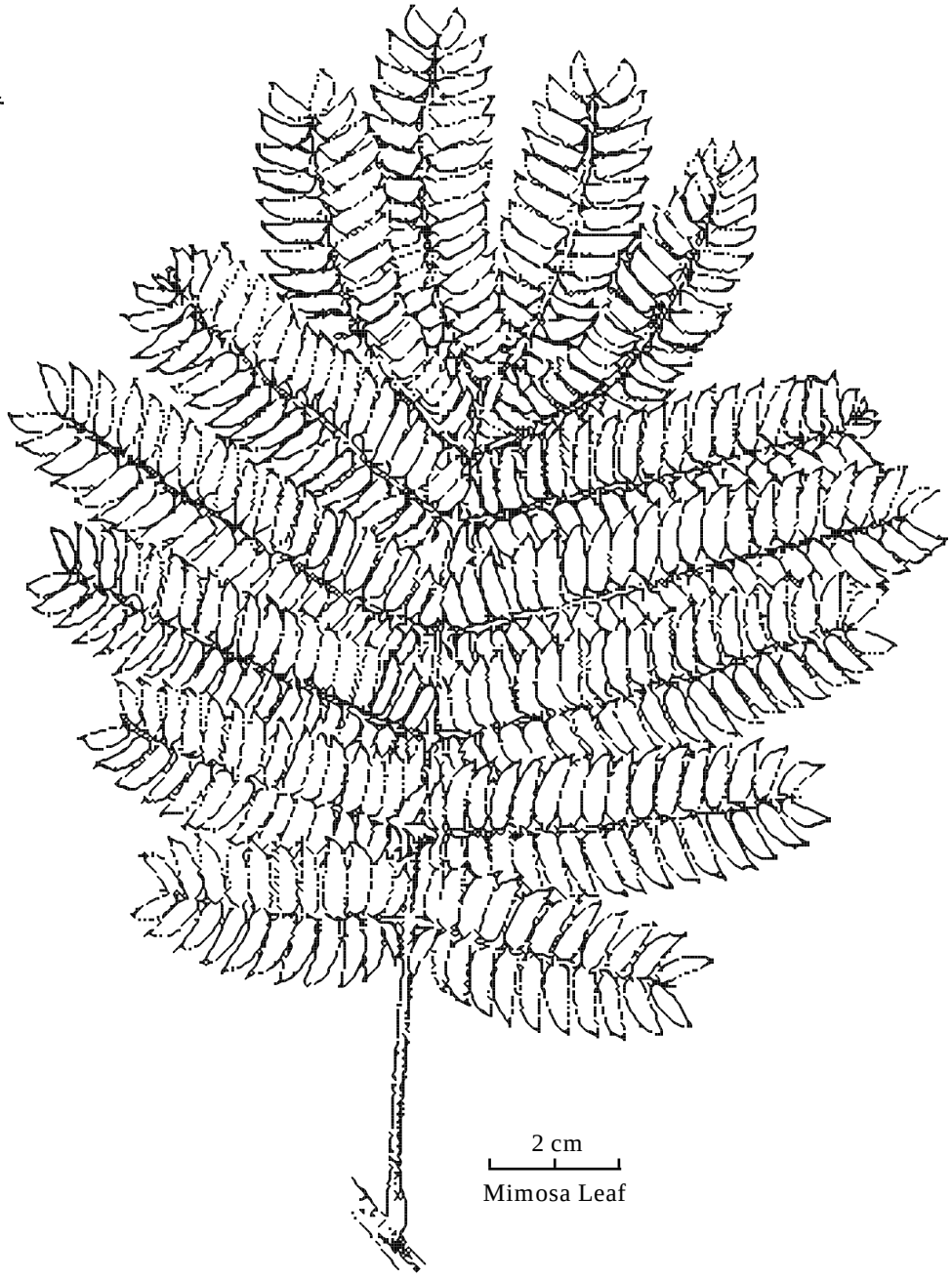


2 cm

Mimosa Flower



2 cm

Mimosa Leaf

# Mimosa

*Albizia julibrissin* Durazz

*Albizia julibrissin* is commonly known as mimosa, silk tree, or silky acacia. This hardy tree is a popular ornamental because of its fragrant and showy flowers. The tree seeds prolifically and resprouts quickly when cut. It inhabits many of the cut-and-fill slopes along roads as well as disturbed areas and stream banks throughout Tennessee.

**Height:** Mimosa can reach heights of 6-12 m (20-40 ft). Sprouts can grow over one meter (3 ft) in a season. Trunks may be single or multiple stems.

**Bark:** The thin, light brown bark is nearly smooth.

**Twigs:** Moderately slender to stout twigs are somewhat fluted below nodes, and have many light-colored lenticels. Buds are superimposed and a terminal bud is absent.

**Leaves:** Feathery, fernlike deciduous leaves are 12.5-20.0 cm (5-8 in) long. Leaves are bipinnately compound with 10-25 pinnae and 40-60 leaflets per pinnae. Leaflets are asymmetric, with the midrib near one margin and parallel to it.

**Flowers:** Showy pink blossoms are 3.8-5.0 cm (1.5-2 in) long and arranged in paniculate heads at the ends of branches. They are composed of 15-25 sessile flowers with numerous, conspicuous stamen filaments. Their fragrance is strong and sweet. Blooms May-August.

**Fruit:** Flat, light brown, oval seeds are about 1.2 cm (0.5 in) long. They are borne in flat, linear, straw-colored pods about 15 cm (6 in) long that form large clusters. The pods ripen August-September and begin to disintegrate soon after, but remain on the trees into winter.

**Life History**

Mimosa seeds have impermeable seed coats that allow them to remain dormant for years. One study showed 90% viability after five years; another Albizia species had 33% germination of seeds after 50 years in open storage. The trees grow rapidly under good conditions but have weak, brittle wood and are short-lived. They resprout quickly if cut or top-killed.

**Origin and Distribution**

There are about 50 species of the genus in subtropical and tropical Asia, Africa, and Australia. Mimosa is native to Asia, from Iran to China and was introduced to the U.S. in 1745. It is established from Virginia to Louisiana, and in California.

**Similar Species**

Mimosa can be confused with other bipinnately compound legumes, especially in the smaller seedling stages. Sensitive brier, *Schrankia microphylla* (Dry. ex Sm.) J.F. Machr., is a weakly arching perennial vine with prickly stems. Partridge pea, *Chamaecrista fasciculata* (Michx.) Greene, is a non-woody, evenly pinnate, annual herb.

**Habitat**

Mimosa takes advantage of disturbed areas, often spreading by seed from ornamentals nearby or from seed brought in on fill dirt. It prefers full sun and is often seen along roadsides and open vacant lots in urban/suburban areas. Mimosa can tolerate partial shade but is seldom found in forests with full canopy cover, or at higher elevations (above 900 m or 3,000 ft), where cold-hardiness is a limiting factor. It can, however, become a serious problem along riparian areas, where it becomes established along scoured shores and its seeds are easily transported in water. Like many successful exotics, it is capable of growing in a wide range of soil conditions.

**Management Recommendations**

**Mechanical Controls**

Cutting: Cut trees at ground level with power or manual saws. Cutting is most effective when trees have begun to flower to prevent seed production. Because mimosa spreads by suckering, resprouts are common after treatment. Cutting is an initial control measure and will require either an herbicidal control or repeated cutting for resprouts.

Girdling: Use this method on large trees where the use of herbicides is impractical. Using a hatchet, make a cut through the bark encircling the base of the tree, approximately 15 cm (6 in) above the ground. Be sure that the cut goes well into or below the cambium layer. This method will kill the top of the tree but resprouts are common and may require follow-up treatments for several years until roots are exhausted.

Hand Pulling*:* Mimosa is effectively controlled by manual removal of young seedlings. Plants should be pulled as soon as they are large enough to grasp, but before they produce seeds. Seedlings are best pulled after a rain when the soil is loose. The entire root must be removed since broken fragments may resprout.

**Biological Controls**

Mimosa Wilt: *Fusarium oxysporum* f. *perniciosum* is a fungus that attacks mimosa in the U.S. and is transferred through the soil. It infects its host through the root system and may be fatal to the tree. It is not used at present and further research is needed.

**Herbicidal Controls**

Foliar Spray Method: This method should be considered for large thickets of mimosa seedlings where risk to non-target species is minimal. Air temperature should be above 65°F to ensure absorption of herbicides.

Glyphosate: Apply a 2% solution of glyphosate and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray drift damage to non-target species. Glyphosate is a non-selective systemic herbicide that may kill non-target partially-sprayed plants.

Triclopyr: Apply a 2% solution of triclopyr and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray drift damage to non-target species. Triclopyr is a selective herbicide for broadleaf species. In areas where desirable grasses are growing under or around mimosa, triclopyr can be used without non-target damage.

Cut Stump Method: This control method should be considered when treating individual trees or where the presence of desirable species preclude foliar application. Stump treatments can be used as long as the ground is not frozen.

Glyphosate: Horizontally cut stems at or near ground level. Immediately apply a 50% solution of glyphosate and water to the cut stump, covering the outer 20% of the stump.

Triclopyr: Horizontally cut stems at or near ground level. Immediately apply a 50% solution of triclopyr and water to the cut stump, covering the outer 20% of the stump.

Basal Bark Method: This method is effective throughout the year as long as the ground is not frozen. Apply a mixture of 25% triclopyr and 75% horticultural oil to the basal parts of the tree to a height of 30-38 cm (12-15 in) from the ground. Thorough wetting is necessary for good control; spray until run-off is noticeable at the ground line.

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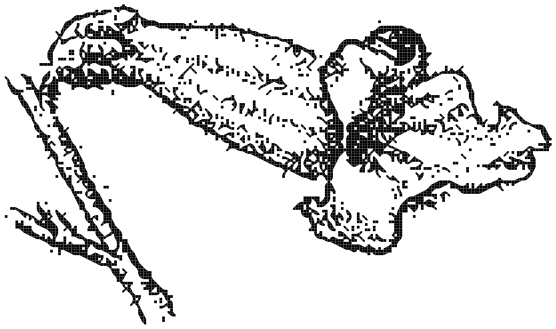
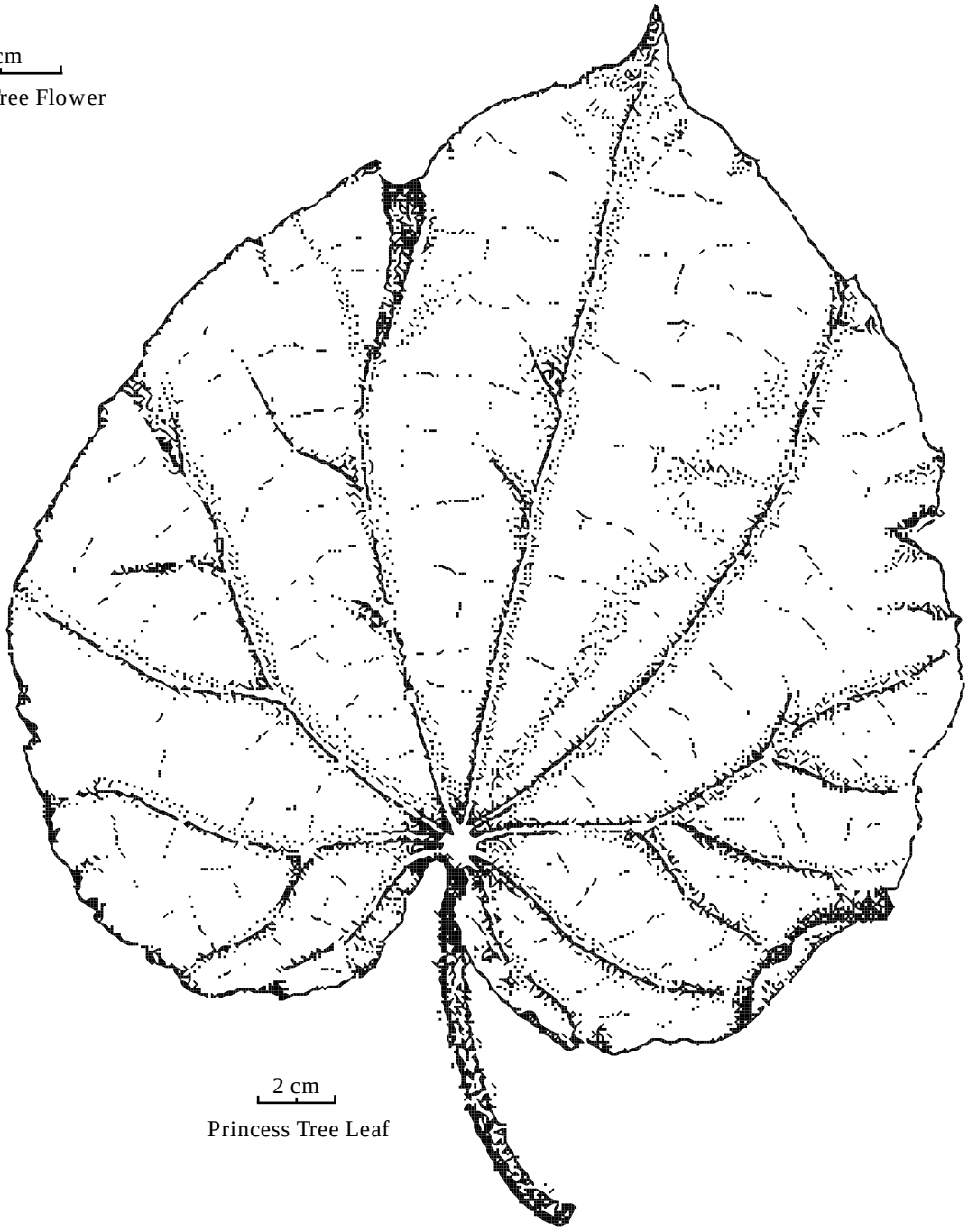


2 cm

Princess Tree Flower



2 cm

Princess Tree Leaf

# Princess Tree

*Paulownia tomentosa* (Thunb.) Sieb. & Zucc. ex Steud.

Princess tree, also known as royal paulownia or empress tree, is a showy, aggressive ornamental introduced from East Asia. It grows rapidly in disturbed areas, including steep rocky slopes that may also be habitats for rare plants. Recently it has also been grown in plantations and harvested for export to Japan where its wood is highly valued.

**Height**: Paulownia grows 9-19 m (30-60 ft) tall.

**Bark**: Trunk has rough, gray-brown bark with interlaced smooth areas that are often shiny. The smooth brown bark of young branches has prominent white lenticels.

**Twigs:** Stout, brittle twigs are markedly flattened at nodes, and olive brown to dark brown in color. They are mostly glabrous except at the tip, around buds and along upper edges of leaf scars. Lenticels are pale, prominent, and elongated longitudinally. Pith can be chambered or hollow. Terminal leaf buds are absent. Lateral leaf buds are superimposed. Leaf scars are circular.

**Leaves:** Deciduous leaves are opposite and broadly ovate, acuminate and cordate in shape. Leaf margins are entire or shallowly lobed, and may be toothed on small plants. Leaves of adult trees are 15-40 cm (6-16 in) long and 10-30 cm (4-8 in) wide, though leaves of stump sprouts may be twice as large. Surfaces are pubescent and dull, light-green above, and pale-green and tomentose beneath.

**Flowers:** Large , showy , fragrant blossoms are borne in upright clusters 15-30 cm (6-12 in) long at the ends of stout, hairy twigs. Corolla is 5 cm (2 in) long, bell-shaped, and pale violet with yellow stripes inside, ending with five round, unequal lobes. Blooms in April-May before the leaves emerge from round, brown, hairy buds formed during the previous summer.

**Fruit**: Brown, woody, beaked, ovoid capsules are 4 cm (1.5 in) long, borne in terminal clusters. The seed pod has four compartments that contain as many as 2,000 tiny winged seeds. The capsules mature in autumn, open to release the seeds and then remain attached all winter. One tree is capable of producing twenty million seeds that are easily transported in water or wind.

**Life History**

Paulownia can reproduce from seed or from root sprouts; the latter can grow to over 5m (15 ft) in a single season. The root branches are shallow and horizontal without a strong taproot. Seed-forming pollen is fully developed before the onset of winter, and in spring the flowers are pollinated by insects. Seeds germinate within a few days on suitable substrate; seedlings grow quickly and flower in 8-10 years. Mature trees are often structurally unsound and rarely live more than 70 years.

**Origin and Distribution**

Paulownia is native to western and central China where historical records describe its medicinal, ornamental, and timber uses as early as the third century B.C. It has been cultivated for centuries in Japan where it is valued in many traditions. It was imported to Europe in the 1830s by the Dutch East India Company and brought to North America a few years later. Paulownia has been naturalized in the eastern U.S. for more than 150 years and is also grown on the west coast. USDA hardiness zones 7-10 are most favorable.

**Similar Species**

Paulownia belongs to the Scrophulariaceae (Figwort) family, which in North America is otherwise composed of herbaceous species. It resembles the native catalpa tree (*Catalpa speciosa* [Warder ex Barney]) in size, leaf and flower structure. Notable differences are found in pith, leaves, and seed pods. Paulownia has a hollowed or chambered pith, while that of the catalpa is solid and whitish. Catalpa leaves are whorled and more distinctly pointed at the tip than paulownia leaves, which are not whorled and have a less elongated tip. Catalpa fruits are long, slender pods measuring 20-46 cm (8-18 in). Fruits of the princess tree measure only 3-8 mm (1.5 in) and appear in clusters of round capsules. Catalpa flowers have a two-lipped calyx and appear on the current year's growth; paulownia has a five-lobed calyx and flowers on the second year's growth.

**Habitat**

Paulownia trees are often found on roadsides, stream banks, and disturbed habitats, including fire sites, forests defoliated by pests (such as gypsy moths) and landslides. Its ability to sprout prolifically from adventitious buds on stems and roots allows it to survive fire, cutting, and even bulldozing in construction areas. Paulownia can also colonize rocky cliffs and scoured riparian zones where it may compete with rare plants in these marginal habitats. It tolerates high soil acidity, drought, and low soil fertility.

**Management Recommendations**

**Mechanical Controls**

Cutting: Cut trees at ground level with power or manual saws. Cutting is most effective when trees have begun to flower to prevent seed production. Because paulownia spreads by suckering, resprouts are common after treatment. Cutting is an initial control measure and will require either an herbicidal control or repeated cutting for resprouts.

Girdling: Use this method on large trees where the use of herbicides is impractical. Using a hand-axe, make a cut through the bark encircling the base of the tree, approximately 15 cm (6 in) above the ground. Be sure that the cut goes well into or below the cambium layer. This method will kill the top of the tree but resprouts are common and may require a follow-up treatment with a foliar herbicide.

Hand Pulling: Paulownia is effectively controlled by manual removal of young seedlings. Plants should be pulled as soon as they are large enough to grasp but before they produce seeds. Seedlings are best pulled after a rain when the soil is loose. The entire root must be removed since broken fragments may resprout.

**Herbicidal Controls**

Foliar Spray Method: This method should be considered for large thickets of paulownia seedlings where risk to non-target species is minimal. Air temperature should be above 65°F to ensure absorption of herbicides.

Glyphosate: Apply a 2% solution of glyphosate and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pat tern to reduce spray drift damage to non-target species. Glyphosate is a non-selective systemic herbicide that may kill non-target partially-sprayed plants.

Triclopyr: Apply a 2% solution of triclopyr and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray drift damage to non-target species. Triclopyr is a selective herbicide for broadleaf species. In areas where desirable grasses are growing under or around paulownia, triclopyr can be used without non-target damage.

Cut Stump Method: This control method should be considered when treating individual trees or where the presence of desirable species preclude foliar application. Stump treatments can be used as long as the ground is not frozen.

Glyphosate: Horizontally cut stems at or near ground level. Immediately apply a 25% solution of glyphosate and water to the cut stump making sure to cover the outer 50% of the stump.

Triclopyr: Horizontally cut stems at or near ground level. Immediately apply a 50% solution of triclopyr and water to the cut stump making sure to cover the outer 20% of the stump.

Basal Bark Method: This method is effective throughout the year as long as the ground is not frozen. Apply a mixture of 25% triclopyr and 75% horticultural oil to the basal parts of the tree to a height of 30-38 cm (12-15 in) from the ground. Thorough wetting is necessary for good control; spray until run-off is noticeable at the ground line.

Hack and Squirt Method: Using a hand-axe, make cuts at 6.5 cm (3 in) intervals around the trunk of the tree between 15-45 cm (6-18 in) above the ground. Be sure that each cut goes well into or below the cambium layer. Immediately treat the cut with a 50% glyphosate or triclopyr and water herbicide solution.

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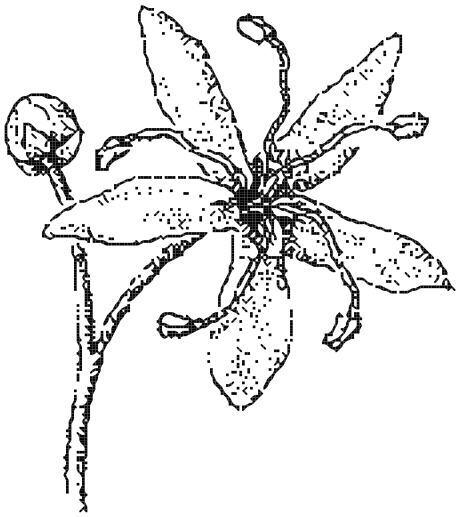

2 cm

Tree-of-Heaven Flower



2 cm

Tree-of-Heaven Leaf

# Tree-of-Heaven

*Ailanthus altissima* (Mill.) Swingle

Ailanthus, also known as tree-of-heaven or Chinese sumac, is a persistent and aggressive weed throughout much of Europe and North America. It belongs to the Simaroubaceae (Quassia) family, which is primarily tropical or subtropical. Ailanthus grows quickly and can reach a height of 2.5 m (8 ft) in its first year.

**Height:** Ailanthus can grow rapidly to 25-30 m (80-100 ft).

**Leaves:** Deciduous leaves are odd-pinnately compound with 11-41 leaflets. Shape is lanceolate, acuminate and entire except for 1-5 basal teeth, each leaflet with a prominent dark green gland on the underside near the apex. Both surfaces have minute hairs and glands. Leaflets are each 7.5-12.5 cm (3-5 in) long and 2.5-5.0 cm (1-2 in) wide. Crushed foliage has an acrid odor. Leaf scars are large and triangular with numerous bundle scars.

**Twigs:** Light brown twigs are very stout and covered with fine hairs when young. Pith is continuous and yellowish in color. Buds are relatively small and solitary. Terminal buds are absent.

**Bark:** The smooth, striped, gray-brown or light brown bark cracks with age and exhibits light-colored grooves.

**Flowers:** Male and female flowers are 0.5 cm (0.25 in) long and form large, light green terminal panicles. They are radially symmetrical with 5 or 6 petals. The trees may be polygamous, but most individuals are unisexual. Male flowers have a foul scent. Each tree may produce up to several hundred inflorescences a year. Blooms late May through early June.

**Fruit:** Fruit is a 3-8 cm (1.0-1.5 in) long schizocarp with 2-5 samaroid mericarps. Each fruit contains a single seed. Seeds mature in late summer or early fall and form dense, showy pink clusters that persist through the winter. Each cluster may contain hundreds of seeds.

**Life History**

Ailanthus reproduces from both seed and root sprouts. Seeds are easily windblown and a high percentage are viable. True seedlings are smaller and thinner-stemmed than root sprouts and have trifoliate leaves. Sprouts will have a cluster of leaves with variable numbers of leaflets. When pulled from the ground, seedlings will reveal thin, branching roots while sprouts will be firmly connected to a thick, rope-like root. Sprouts may emerge up to 15 m (50 ft) from the nearest existing stem. Most stems begin to reproduce at 10-20 years, though two-year old sprouts can produce fruit, and first-year seedlings have been observed flowering. Ailanthus is intolerant of shade; in natural stands reproduction is primarily by sprouting. The trees are typically short-lived (30-50 years), though some have survived for over 150 years.

**Origin and Distribution**

Ailanthus, native to China, was introduced to Europe and then to the United States in the late eighteenth century. An early Chinese saying refers to spoiled children as "good for nothing ailanthus sprouts." It was, nevertheless, widely planted in Europe and North America until recently. Botanists in the late 1800s noted that it was widespread and naturalized in Tennessee.

**Similar Species**

Ailanthus may be confused with other trees having compound leaves and many leaflets; particularly black walnut (*Juglans nigra* L.), butternut (*Juglans cinerea* L.), and some species of sumac (*Rhus* spp.). The leaf margins of these trees have small teeth (except for winged sumac), while those of ailanthus are smooth. The gland-tipped leaflet lobes are unique to ailanthus, as is the foul odor produced by crushed foliage and scraped bark. In winter ailanthus may be distinguished by the stout twigs, large leaf scars with numerous bundle scars, and false end buds.

**Habitat**

Ailanthus is adapted to a wide variety of soil conditions. It tolerates drought and rocky conditions to the extent of growing out of pavement cracks. The tree is common in urban areas and disturbed sites throughout its range, and it is a pioneer in succession with limited ability to compete in a closed-canopy forest. It can, however, take advantage of forests defoliated by insects (e.g., gypsy moth) or impacted by slides, windstorms, or other natural disasters. Ailanthus forms dense, clonal thickets that displace native species. A few trees along a fencerow or forest edge can rapidly invade adjacent meadows. In addition to its prolific vegetative reproduction, ailanthus has allelopathic effects on many other tree species and may consequently inhibit succession.

**Management Recommendations**

**Mechanical Controls**

Cutting: Cut trees at ground level with power or manual saws. Cutting is most effective when trees have begun to flower to prevent seed production. Because ailanthus spreads by suckering, resprouts are common after treatment. Cutting is an initial control measure, and success will require either an herbicidal control or repeated cutting for resprouts.

Girdling: Use this method on large trees where the use of herbicides is not practical. Using a hand axe, make a cut through the bark encircling the base of the tree, approximately 15 cm (6 in) above the ground. Be sure that the cut goes well into the cambium layer. This method will kill the top of the tree but resprouts are common, and may require follow-up treatments for several years until roots are exhausted.

Hand Pulling: Ailanthus is effectively controlled by manual removal of young seedlings. Plants should be pulled as soon as they are large enough to grasp, but before they produce seeds. Seedlings are best pulled after a rain when the soil is loose. The entire root must be removed since broken fragments may resprout.

**Herbicidal Controls**

Foliar Spray Method: This method should be considered for large thickets of ailanthus seedlings where risk to non-target species is minimal. Air temperature should be above 65 °F to ensure absorption of herbicides.

Glyphosate: Apply a 2% solution of glyphosate and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray drift damage to non-target species. Glyphosate is a non-selective systemic herbicide that may kill non-target partially-sprayed plants.

Triclopyr: Apply a 2% solution of triclopyr and water plus a 0.5% non-ionic thoroughly wetting all leaves. Use a low pressure and coarse spray pattern to reduce spray drift damage to non-target species. Triclopyr is a selective herbicide for broadleaf species. In areas where desirable grasses are growing under or around ailanthus, triclopyr can be used without non-target damage.

Cut Stump Method: This control method should be considered when treating large individual trees or where the presence of desirable species preclude foliar application. Stump treatments can be used as long as the ground is not frozen.

Glyphosate: Horizontally cut stems at or near ground level. Immediately apply a 50% solution of glyphosate and water to the cut stump making sure to cover the outer 20% of the stump.

Triclopyr: Horizontally cut stems at or near ground level. Immediately apply a 50% solution of triclopyr and water to the cut stump making sure to cover the outer 20% of the stump.

Basal Bark Method: This method is effective throughout the year as long as the ground is not frozen. Apply a mixture of 25% triclopyr and 75% horticultural oil to the basal parts of the tree to a height of 30-38 cm (12-15 in) from the ground. Thorough wetting is necessary for good control; spray until run-off is noticeable at the ground line.

Hack and Squirt Method: Using a hand axe, make cuts at 6.5 cm (3 in) intervals around the trunk of the tree between 15-45 cm (6-18 in) above the ground. Be sure that each cut goes well into or below the cambium layer. Immediately treat the cut with a 50% glyphosate or tricloypr herbicide solution.

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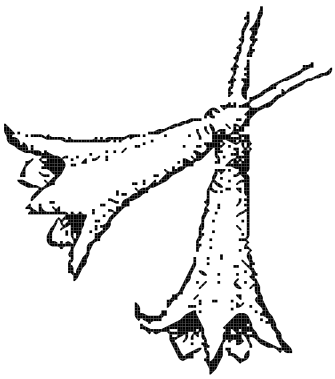

2 cm

Autumn Olive Flower

2 cm

Autumn Olive Stem

# Autumn Olive

*Elaeagnus umbellata* (Thunb.)

Autumn olive is an introduced, fast-growing woody shrub in the Elaeagnaceae (Oleaster) family. Used extensively for wildlife habitat, strip mine revegetation, and shelter belts, autumn olive thrives in disturbed areas open to full sun. It is adaptive, competitive, and vigorous, especially on open, sunny sites and it produces abundant fruit crops.

**Height**: Autumn olive grows to a height of 6 m (20 ft). Its growth habit is bushy with a spreading crown.

**Leaves:** Deciduous leaves are alternate, short-petioled, elliptic to ovate, and oblong. They are glabrous, dark green above, conspicuously silvery beneath.

**Twigs:** The silvery or golden brown twigs often have prominent spines.

**Flowers:** Fragrant flowers are axillary, pedicellate, tube-shaped, and yellowish-white, with 4 sepals and 4 stamens. Blooms May-June.

**Fruit**: Fruits are abundant, juicy, round drupes up to 1 cm (0.4 in) in length. Silvery fruit turns to red as it matures and is speckled with brown to silvery scales. Matures September-October.

**Life History**

*Elaeagnus* spp. are among the few non-legumes that fix nitrogen in the soil by means of bacterial root nodes. Plants flower and develop fruits annually after reaching three years of age. An individual can produce up to 3.6 kg (8 lbs) of fruit that are consumed and spread by birds and small mammals.

**Origin and Distribution**

Autumn olive was introduced into the United States in 1830 from China and Japan. It has been actively promoted by state and federal agencies for shelter belts, erosion control, strip mine reclamation, wildlife habitat, and was widely marketed as an ornamental. The shrub has now become naturalized in suitable habitats scattered throughout the eastern and Midwestern U.S.

**Similar Species**

Several other *Elaeagnus* species have become naturalized in the U.S. A native species *E. commutata* (Bernh.) is found in the far northern states and Canada. Minnie bush (*Menziesia pilosa* [Michx. ex Lam] Jussieu ex Pers.), a high elevation, southern Appalachian endemic, is somewhat similar but has glands, not scales, on the midrib.

**Habitat**

Autumn olive grows well in disturbed areas, open fields, margins of forests, roadsides, and clearings. Being tolerant of drought, it does not grow well in wet sites. It is

intolerant of shade and will not invade areas of dense forest. Because the fruits are eaten by a variety of wildlife, the seeds may be distributed into forest openings or open woodlands.

## Management Recommendations

### Mechanical Controls

Cutting: Cut trees at ground level with power or manual saws. Cutting is most effective when trees have begun to flower to prevent seed production. Because autumn olive spreads by suckering, resprouts are common after treatment. Cutting is an initial control measure, and success will require either an herbicidal control or repeated cutting of resprouts.

Girdling: Use this method on large trees where the use of herbicides is not practical. Using a hand-axe, make a cut through the bark encircling the base of the tree, approximately 15 cm (6 in) above the ground. Be sure that the cut goes well into or below the cambium layer. This method will kill the top of the tree but resprouts are common, and may require follow-up treatments for several years until roots are exhausted.

Hand Pulling: Autumn olive is effectively controlled by manual removal of young seedlings. Plants should be pulled as soon as they are large enough to grasp, but before they produce seeds. Seedlings are best pulled after a rain when the soil is loose. The entire root must be removed since broken fragments may resprout.

### Herbicidal Controls

Foliar Spray Method: This method should be considered for large thickets of autumn olive seedlings where risk to non-target species is minimal. Air temperature should be above 65°F to ensure absorption of herbicides.

Glyphosate: Apply a 2% solution of glyphosate and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray drift damage to non-target species. Glyphosate is a non-selective systemic herbicide that may kill non-target, partially-sprayed plants.

Triclopyr: Apply a 2% solution of triclopyr and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray drift damage to non-target species. Triclopyr is a selective herbicide for broadleaf species. In areas where desirable grasses are growing under or around autumn olive, triclopyr can be used without non-target damage.

Cut Stump Method: This control method should be considered when treating individual trees or where the presence of desirable species preclude foliar application. Stump treatments can be used as long as the ground is not frozen.

Glyphosate: Horizontally cut stems at or near ground level. Immediately apply a 50% solution of glyphosate and water to the cut stump, covering the outer 20% of the stump.

Triclopyr: Horizontally cut stems at or near ground level. Immediately apply a 50% solution of triclopyr and water to the cut stump, covering the outer 20% of the stump.

Basal Bark Method: This method is effective throughout the year as long as the ground is not frozen. Apply a mixture of 25% triclopyr and 75% horticultural oil to the basal parts of the tree to a height of 30-38 cm (12-15 in) from the ground. Thorough wetting is necessary for good control; spray until run-off is noticeable at the ground line.

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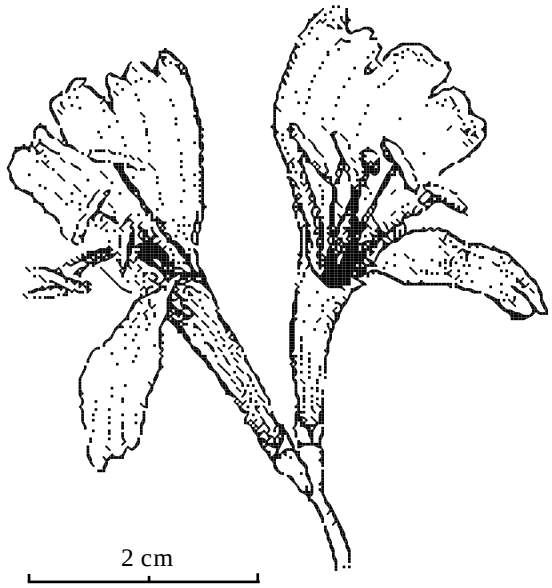
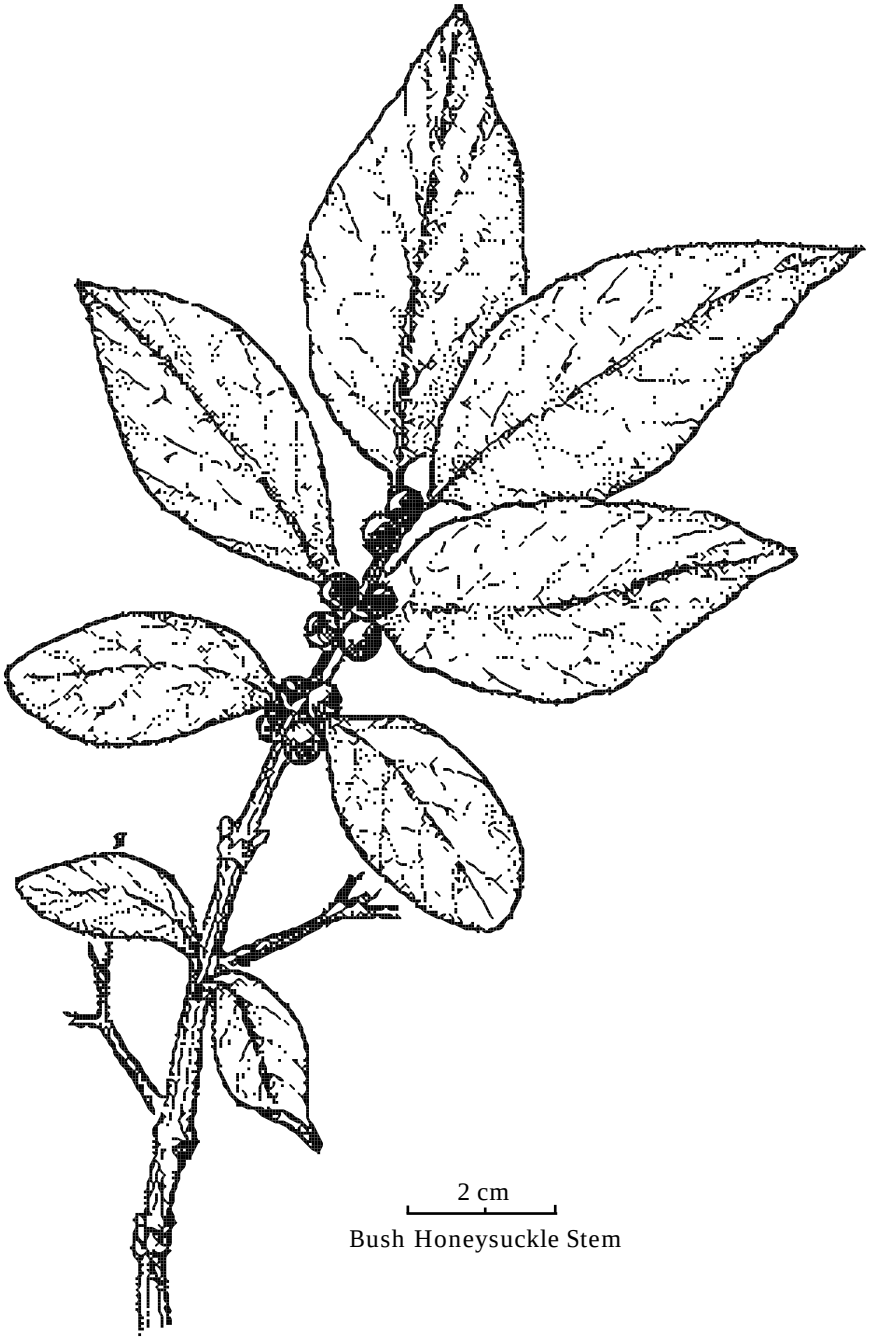


2 cm

Bush Honeysuckle Flower



2 cm

Bush Honeysuckle Stem

# Bush Honeysuckles

*Lonicera maackii* (Rupr.) Maxim; *L. morrowii* (Gray); *L. tatarica* (L.); *L. X bella* (Zabel)

The four species of bush honeysuckle that cause most invasive problems (Amur, Morrow's, Tartarian, and Belle) will be referred to as bush honeysuckle. Belle honeysuckle is a hybrid cross between Tartarian and Morrow's honeysuckles and has many characteristics of both parents. These shrubs are frequently used for landscaping and to improve wildlife habitats; they have become naturalized in many areas of Tennessee. All are members of the Caprifoliaceae (Honeysuckle) family.

**Height:** All four species of bush honeysuckles grow to heights of 1.8-6.0 m (6-20 ft).

**Twigs:** The twigs of all the bush honeysuckles are generally glabrous, thornless, and have a hollow brown pith when mature. The leaf scars are small and inconspicuous. The buds are blunt to acute.

**Leaves:** Leaves of all these species are opposite, narrowly elliptic, ovate, to lance-ovate. The significant differences between individual species are dependent on the presence of pubescence.

**Flower:** The differences between the flowers of these four species are dependent on corolla and pedicel length. Tartarian honeysuckle is typically pink but may vary from red to white. Amur and Morrow's honeysuckle flowers are white, changing to yellow. Belle honeysuckle may vary between the character of both parents. Blooms May-June.

**Fruit:** The globose berries are typically dark red, occasionally yellow, and found in pairs in the axils of the leaves. They may remain on the shrub through winter. Each berry contains 2-6 seeds. Fruit matures September-October.

For a detailed description of individual species refer to Rehder, A. Manual of cultivated trees and shrubs. 1986.

**Life History**

The distribution of bush honeysuckle seeds is primarily accomplished by birds and small mammals. Following a period of cold stratification, seeds germinate in areas of sparse vegetation and can tolerate moderate shade but produce more seeds in full sun. It is suspected that bush honeysuckle produces an allelopathic chemical that suppresses the growth of surrounding vegetation. Leaves appear early in the spring and remain into late fall, giving bush honeysuckle a competitive advantage over native plants.

**Origin and Distribution**

Bush honeysuckles are native to Asia and western Europe. Tartarian honeysuckle was first cultivated in North America in 1752. Morrow's and Amur honeysuckles were introduced into the U.S. in 1875 and 1855 respectively. Bush honeysuckle has been promoted by state and federal agencies to improve wildlife habitat and as a popular ornamental. They are present throughout Tennessee, the Northeast, and the Midwest.

**Similar Species**

The bush honeysuckles are similar to Canadian honeysuckle (*Lonicera canadensis* Bartr.), red honeysuckle (*Lonicera dioica* L.), yellow honeysuckle *(Lonicera flava* Sims.), grape honeysuckle (*Lonicera reticulata* Raf.), coralberry (*Symphoricarpos orbiculatus* Moench), and bush-honeysuckle (*Diervilla sessilifolia* Buckl.). Canadian honeysuckle grows at high elevations and reaches a maximum height of 2 m (6.5 ft). The remainder of the native honeysuckles are twining vine species and morphologically distinct. Coralberry has slender purple to brown twigs and the leaves of *D. sessilifolia* (Buckl.) are lanceolate and finely toothed.

**Habitat**

The bush honeysuckles are tolerant of a variety of edaphic and environmental conditions. Typical habitats include disturbed successional communities, wetlands, prairie, woodland edges, and partially closed forests. Most communities found in natural areas have the potential to support a population of one of the bush honeysuckle species. These shrubs are moderately shade tolerant, taking advantage of canopy gaps created by wind throw or insect defoliation. Honeysuckle bushes are commonly found growing under trees, tall shrubs, and along fence rows that act as perch sites for birds.

**Management Recommendations**

**Mechanical Controls**

Grubbing: This method is appropriate for small initial populations or environmentally sensitive areas where herbicides cannot be used. Using a pulaski or similar digging tool remove the entire plant, including all roots. Juvenile plants can be hand pulled depending on soil conditions and root development. Larger stems, up to 6 cm (2.5 in), can be removed using a Weed Wrench or similar uprooting tools. Any portions of the root system not removed may resprout. All plant parts, including mature fruit, should be bagged and disposed of to prevent reestablishment.

**Herbicidal Controls**

Foliar Spray Method: This method should be considered for large thickets of bush honeysuckle where risk to non-target species is minimal. Air temperature should be above 65°F to ensure absorption of herbicides.

Glyphosate: Apply a 2% solution of glyphosate and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray drift damage to non-target species. Glyphosate is a non-selective systemic herbicide that may kill non-target partially-sprayed plants.

Triclopyr: Apply a 2% solution of triclopyr and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray drift damage to non-target species. Triclopyr is a selective herbicide for broadleaf species. In areas where desirable grasses are growing under or around bush honeysuckle, triclopyr can be used without non-target damage.

Cut Stump Method: This control method should be considered when treating individual bushes or where the presence of desirable species precludes foliar application. This treatment is effective as long as the ground is not frozen.

Glyphosate: Horizontally cut bush honeysuckle stems at or near ground level. Immediately apply a 25% solution of glyphosate and water to the cut stump, covering the outer 20% of the stump.

Triclopyr: Horizontally cut bush honeysuckle stems at or near ground level. Immediately apply a 25% solution of triclopyr and water to the cut stump, covering the outer 20% of the stump.

Basal Bark Method: This method is effective throughout the year as long as the ground is not frozen. Apply a mixture of 25% triclopyr and 75% horticultural oil to the basal parts of the shrub to a height of 30-38 cm (12-15 in) from the ground. Thorough wetting is necessary for good control; spray until run-off is noticeable at the ground line.

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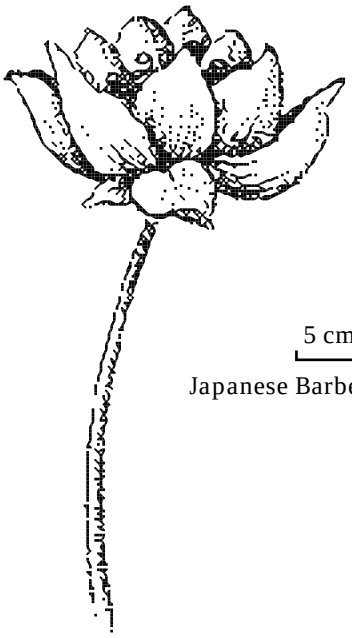
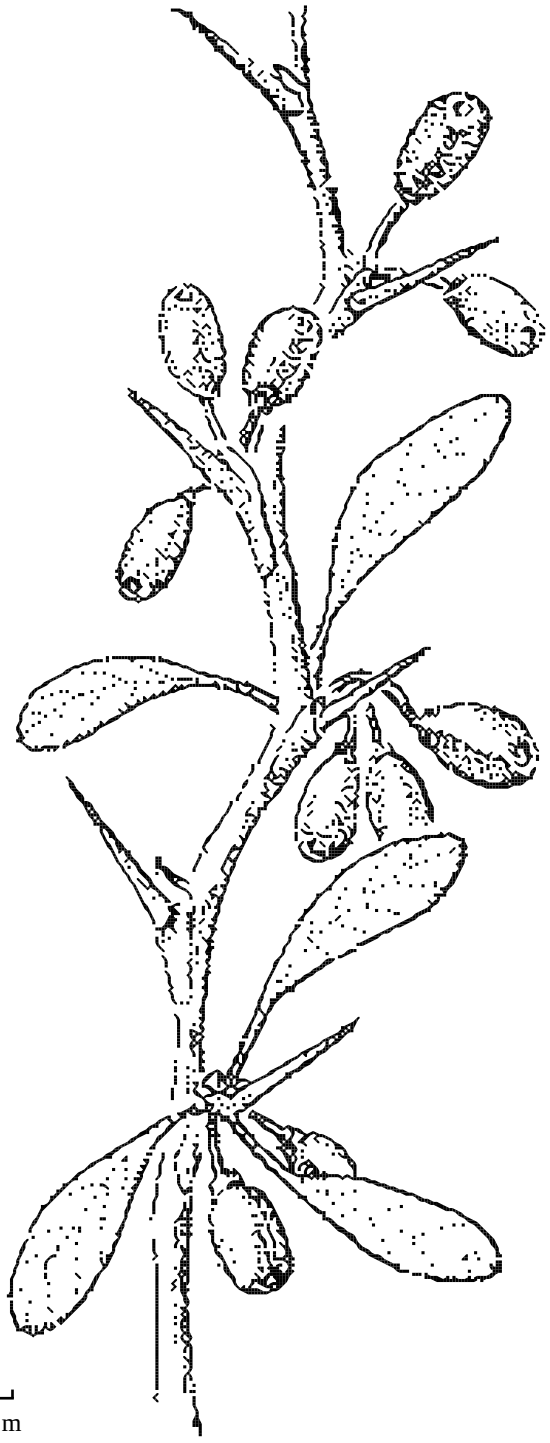


5 cm

Japanese Barberry Flower



2 cm

Japanese Barberry Stem

# Japanese Barberry

*Berberis thunbergii* DC.

Japanese barberry poses a significant threat to natural areas due to its popularity as a landscape shrub, ability to tolerate full shade, and the dispersal of its prolific seeds by birds. It belongs to the Berberidaceae (Barberry) family, which is represented by one genus in our area.

**Height:** This multi-branched dense shrub grows to 2.5 m (8.2 ft). Seedlings may grow 2-4 ft in one season.

**Leaves:** The semi-evergreen leaves are alternate, or grow in alternate clusters. They are entire, and 1-3 cm (0.4-1.2 in) long. Leaves are bright green to burgundy, and wedge-shaped at the base.

**Stems:** Twigs are brown, three-ridged downward from the node, with simple thorns. Inner bark and wood are yellow.

**Flowers:** Flowers are solitary or in umbel-like clusters, corolla yellow, 8-10 mm (0.3-0.4 in) broad. Blooms March-April.

**Fruits:** Berries are red, ellipsoid to globular, 8-10 mm (0.3-0.4 in) long, and often present through winter. Fruit matures May-September.

**Life History**

Japanese barberry reproduces from prolific seeds, rhizomes, or layering. Seeds have a germination rate as high as 90%, and are distributed by birds including ruffed grouse, bobwhite, pheasant, and wild turkey. Because barberry is shade tolerant, an extensive population can become established in a short time under a closed forest canopy. Severe drought or extreme winters have little effect on overall mortality or seed production. Deer avoid barberry while often browsing surrounding vegetation, which may effectively increase barberry's competitive advantage.

**Origin and Distribution**

Barberry was introduced to the United States in 1864 as an ornamental. It is prevalent in the northeastern states, but can be found from Nova Scotia and Michigan to North Carolina, Missouri, and throughout Tennessee. It continues to be a popular landscape plant with several varieties sold to the public.

**Similar Species**

Japanese barberry resembles American barberry *(Berberis canadensis* P. Mill.), which grows in dry woods or bluffs. Distinguishing features are the sharply toothed leaves and three pronged spines of American barberry. In most habitats, Japanese barberry is easily recognizable because of its distinctive coloration.

**Habitat**

Barberry tolerates a variety of habitats from damp lowlands to dry roadsides and waste places. Populations do not expand rapidly into oak-dominant forests or on extreme north- facing slopes. Because it is widely dispersed by the nursery industry, barberry has the potential to impact most natural area ecosystems throughout Tennessee.

**Management Recommendations**

**Mechanical Controls**

Hand Pull: This method of control is effective for small populations of Japanese barberry, since plants pull up easily in most forested habitats. Hand-pulling is an extremely effective method of reducing population and seed productivity; this can be done during most of the year. Barberry is especially easy to see in the winter and early spring before deciduous plants leaf out. If plants have fruit present, they should be bagged and disposed of to prevent seed dispersal. Care should be taken to minimize soil disturbance.

Mowing/Cutting: This method is appropriate for initial small populations or environmentally sensitive areas where herbicides cannot be used. Repeated mowing or cutting will control the spread of Japanese barberry but will not eradicate it. Stems should be cut at least once per growing season as close to ground level as possible. Hand-cutting of established clumps is difficult and time consuming due to the long arching stems and prolific thorns.

**Herbicidal Controls**

Foliar Spray Method: This method should be considered for large thickets of barberry where risk to non-target species is minimal. Air temperature should be above 65°F to ensure absorption of herbicides.

Glyphosate: Apply a 2% solution of glyphosate and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray drift damage to non-target species. Glyphosate is a non-selective systemic herbicide that may kill non-target partially-sprayed plants.

Triclopyr: Apply a 2% solution of triclopyr and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray drift damage to non-target species. Triclopyr is a selective herbicide for broadleaf species. In areas where desirable grasses are growing under or around Japanese barberry, triclopyr can be used without non-target damage.

Cut Stump Method: This control method should be considered when treating individual bushes or where the presence of desirable species precludes foliar application. Stump treatments can be used as long as the ground is not frozen.

Glyphosate: Horizontally cut barberry stems at or near ground level. Immediately apply a 25% solution of glyphosate and water to the cut stump, covering the outer 20% of the stump.

Triclopyr: Horizontally cut barberry stems at or near ground level. Immediately apply a 25% solution of triclopyr and water to the cut stump, covering the outer 20% of the stump.

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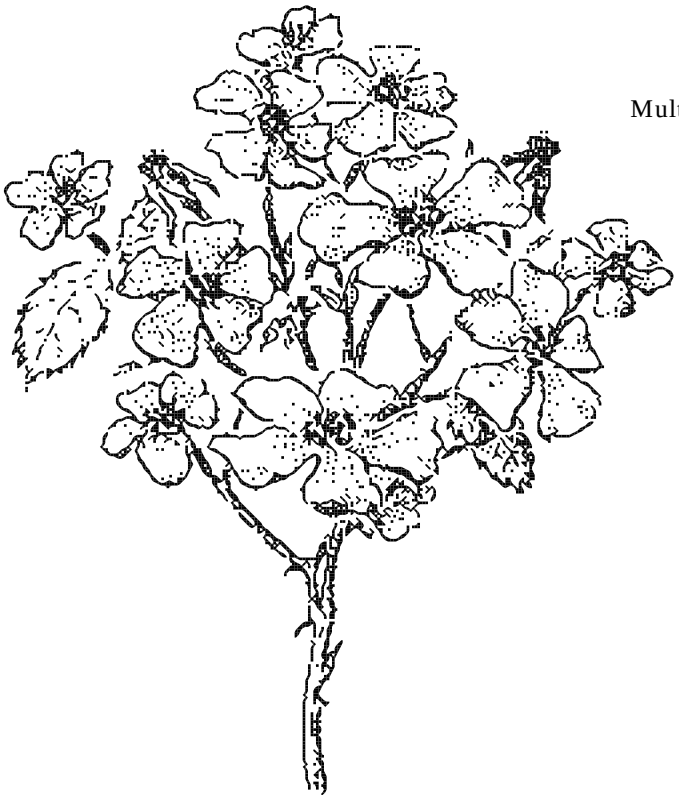
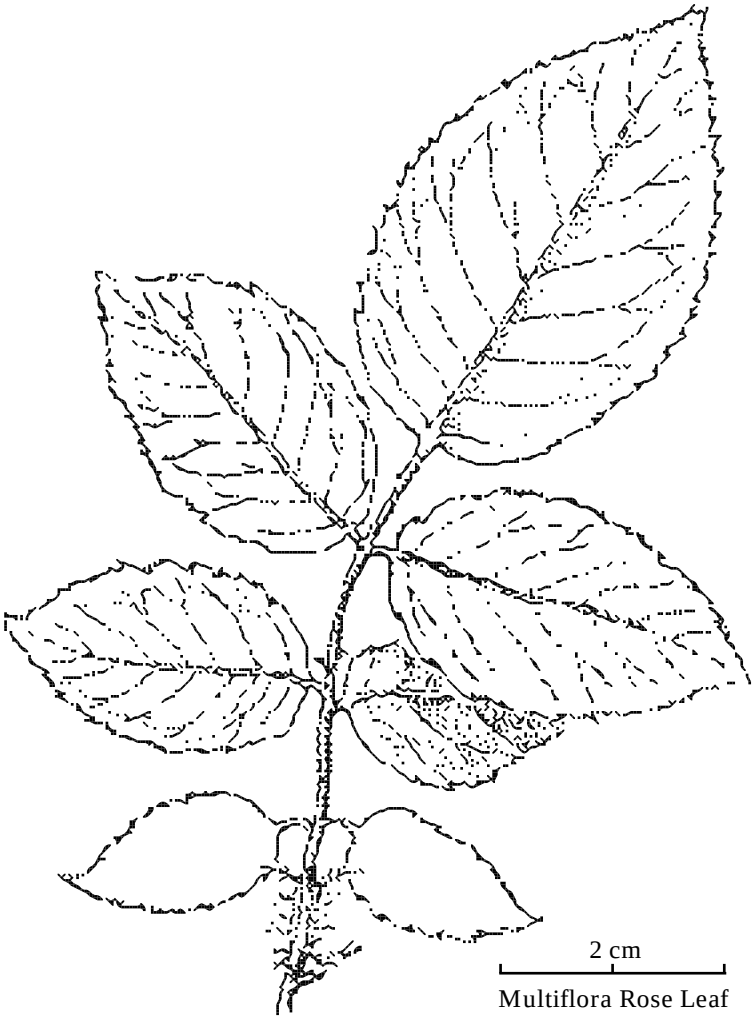


2 cm

Multiflora Rose Flower



2 cm

Multiflora Rose Leaf

# Multiflora Rose

*Rosa multiflora* (Thunb. ex Murr.)

Multiflora rose was introduced more than 40 years ago for high quality wildlife cover, living farm fences, and windbreaks. In some states, multiflora rose was used as a crash barrier along highways. Multiflora rose spreads rapidly into adjacent fields and undisturbed areas, often forming monotypic thickets. Many states list it as a noxious weed. It belongs to the Rosaceae (Rose) family.

**Height**: Multiflora rose grows to 4 m (13 ft). The first 1.5-2.0 m (5.0-6.5 ft) of the stem are typically erect with the tips arching back to the ground.

**Leaves:** Pinnately compound leaves are divided into 7-9 leaflets. Leaflets are less than 4.0 cm (1.5 in) long, obovate to elliptic, glabrous, and finely serrate.

**Stems:** Stems are glabrous, erect, and arching with curved, flattened, broad-based thorns.

**Flowers:** Flowers are white to pinkish-white with 1.0-1.5 cm (0.4-0.6 in) long petals. The five sepals are lanceolate and glabrous to puberulent. Blooms May - July.

**Fruit:** Rose hips are red, 6-9 mm (0.2-0.4 in) long, ovoid, and fleshy. Eventually they become firm and remain on the plant into the winter months. A medium-sized bush is capable of producing 500,000 to 1,000,000 seeds. Fruit matures September-October.

**Life History**

Multiflora rose reproduces by seed, root sprouts, and layering (rooting from the tips of arching branches). Flowers emerge from May to July and the fruits (rose hips) develop in September through October. Its prolific seeds are eaten and spread by birds and other animals. Seeds may remain viable in the soil for 10-20 years. Seedlings develop within 60 days at soil temperatures above freezing. Plants grow slowly for the first one or two years followed by rapid expansion through layering and root sprouts.

**Origin and Distribution**

Multiflora rose was introduced from Japan, Korea, and eastern China in 1886 as root stock for ornamental roses. In the 1930s it was widely promoted as a "living fence" for soil conservation and in wildlife programs. Present distribution is throughout the United States with the exception of the southeastern coastal plains, Rocky Mountains, and western desert areas. In Tennessee, multiflora rose occurs throughout the state along fence rows, successional fields, and pastures. It may invade natural areas, especially fields, flood plains, and light gaps in forests.

**Similar Species**

There are three native roses that resemble multiflora rose: prairie rose (*Rosa setigera* Michx.), swamp rose (*Rosa palustris* Marsh.), and Arkansas rose (*Rosa arkansana* Por-

ter.). Prairie rose is distinguished from multiflora rose by longer, trailing, and arching stems, larger (2-3 cm; 0.8-1.2 in) white flowers in a pyramidal inflorescence, and smaller fruit. Swamp rose is distinguished from multiflora rose by having a shorter overall height (2 m; 79 in) and solitary flowers. Arkansas rose stems are densely covered by slender, straight thorns and shorter overall stature (rarely over 1 m or 39 in).

**Habitat**

Multiflora rose will tolerate a wide range of edaphic and environmental conditions. It grows well in full sun or shade, loamy soils to eroded clay pans, and on moist to dry sites. Once established, multiflora rose grows rapidly forming dense, impenetrable thickets.

**Management Recommendations**

**Mechanical Controls**

Mowing / Cutting: This method is appropriate for small initial populations or environmentally sensitive areas where herbicides cannot be used. Repeated mowing or cutting will control the spread of multiflora rose, but will not eradicate it. Stems should be cut at least once per growing season as close to ground level as possible. Hand cutting of established clumps is difficult and time consuming due to the long arching stems and prolific thorns.

**Biological Controls**

Rose Rosette Disease (RRD): Rose rosette disease is an endemic disease in the Midwestern states and affects several species of roses. The pathogen appears to be a virus or mycoplasma-like organism spread by the eriophyid mite (*Phyllocoptes fructiphilus* Keifer). Once infected, most plants die within one or two years with large plants surviving up to four years. Although multiflora rose seems to be the primary host, native and ornamental roses are susceptible. Current research indicates that commercially important relatives such as apples, plums, cherries, etc. are not susceptible to rose rosette disease.

RRD has spread into west and middle Tennessee and is likely to reach the eastern portion of the state in the foreseeable future. Its use as a biological control is not feasible until further research verifies the causal agent and some reliable protection is available for native and cultivated rose species.

Rose Seed Chalcid (*Megastigmus aculeatus* var. *nigroflavus* [Hoffmeyer]): The rose seed chalcid was imported from Japan with multiflora rose seed in 1917. The wasp deposits its eggs into the developing rose ovule just after petal-fall. The larvae develop in the ovules, consuming the contents of the seeds and killing them. Surveys conducted in West Virginia found 50% of viable seed infested with chalcid oviposits. Dispersal is by movement of seed by birds, which may explain the relatively low colonization rate. It is estimated that 90% of the multiflora rose in West Virginia and surrounding states will be infested by this wasp in the next 20 years or more.

**Herbicidal Controls**

Foliar Spray Method: This method should be considered for large thickets of multiflora rose where risk to non-target species is minimal. Air temperature should be above 65°F to ensure absorption of herbicides.

Glyphosate: Apply a 2% solution of glyphosate and water plus a 0.5% non-ionic surfactant thoroughly wetting all leaves. Use a low pressure and coarse spray pattern to reduce spray drift damage to non-target species. Glyphosate is a non-selective systemic herbicide that may kill non-target partially-sprayed plants.

Triclopyr: Apply a 2% solution of triclopyr and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray-drift damage to non-target species. Triclopyr is a selective herbicide for broadleaf species. In areas where desirable grasses are growing under or around multiflora rose, triclopyr can be used without non-target damage.

Cut Stump Method: This control method should be considered when treating individual bushes or where the presence of desirable species preclude foliar application. This treatment remains effective at low temperatures as long as the ground is not frozen.

Glyphosate: Horizontally cut multiflora rose stems at or near ground level. Immediately apply a 25% solution of glyphosate and water to the cut stump making sure to cover the entire surface.

Triclopyr: Horizontally cut multiflora rose stems at or near ground level. Immediately apply a 25% solution of triclopyr and water to the cut stump making sure the entire surface is covered.

Basal Bark Method: This method is effective throughout the year as long as the ground is not frozen. Apply a mixture of 25% triclopyr and 75% horticultural oil to the basal parts of the shrub to a height of 30-38 cm (12-15 in) from the ground. Thorough wetting is necessary for good control; spray until run-off is noticeable at the ground line.

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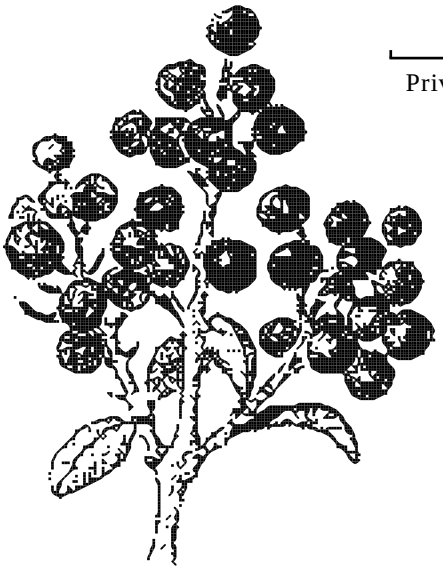
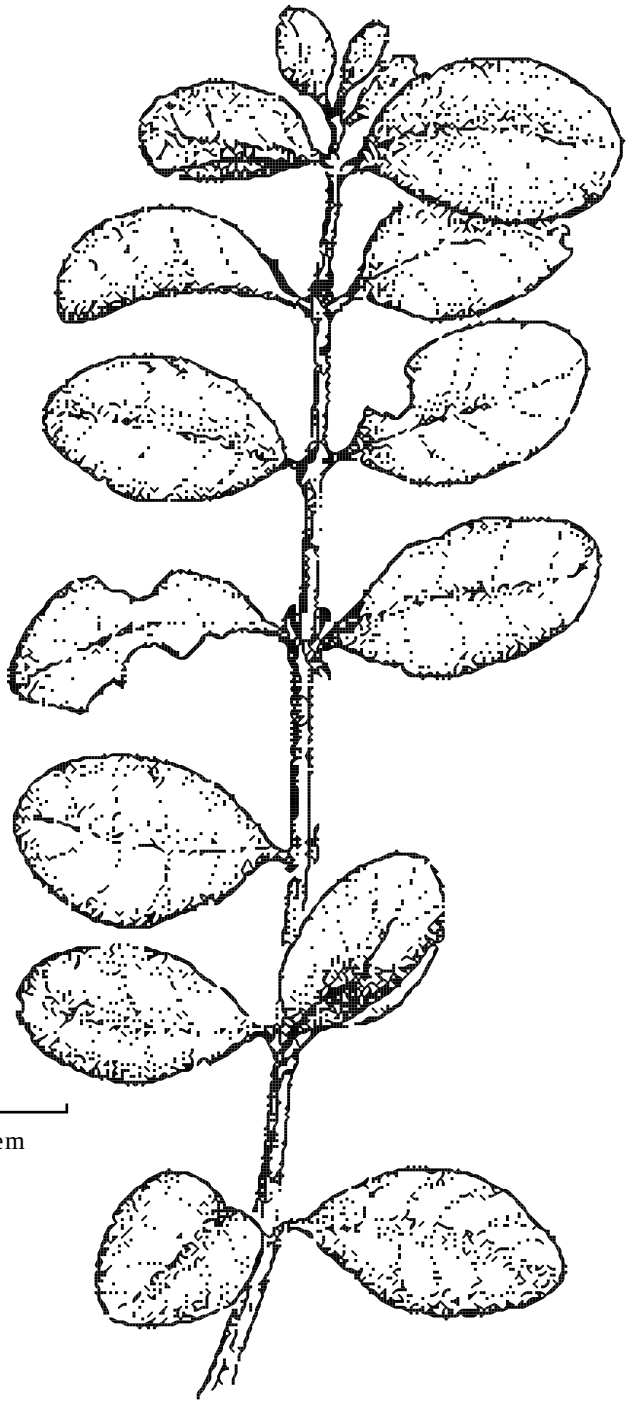


2 cm

Privet Fruit



2 cm

Privet Stem

# Privet

*Ligustrum* spp. L.

Several species of privet have been widely planted in Tennessee, primarily as a hedge in landscaping. They are difficult to distinguish and include common privet (*L. vulgare* L.), Chinese privet (*L. sinense* Lour.), and Japanese privet (*L. japonicum* Thunb.). All belong to the Oleaceae (Olive) family and easily escape cultivation to invade adjacent areas and form dense monocultural thickets.

**Height:** Privet can grow up to 5 m (16 ft) tall and to a diameter of 2.5-25 cm (1-10 in).

**Bark:** Privet bark is whitish-tan to gray in color and smooth in texture. Young branches are minutely hairy.

**Twigs:** Slender twigs are straight, rounded or four-angled below the nodes, and gray-green in color. Terminal buds are present.

**Leaves:** These deciduous or half-evergreen plants hold foliage into winter, but drop it before spring. Leaves are elliptic to ovate in shape. They are oppositely arranged on slender twigs and have 4-5 pairs of indistinct veins. Privet leaves are less than 6 cm (2.5 in) long, glabrous, leathery and thick, with a glossy cuticle on upper surface.

**Flowers:** The perfect flowers are small and white. Bloom time is June-July.

**Fruit:** The black, berrylike fruits contain 1-4 seeds and are borne in terminal clusters. Fruits are subglobose or ovoid and are 6-8 mm (0.25 in) long. The fruit clusters ripen during September and October and persist through the winter. Mature specimens can produce hundreds of fruit.

**Life History**

Privet is a perennial shrub that readily grows from seed or from root and stump sprouts. Privet escapes cultivation by movement of seed, which is eaten and subsequently transported by wildlife, particularly birds. The seeds are reported to have a low germination rate: 5%-27% in two tests.

**Origin and Distribution**

The privets are native to Europe, North Africa, and Asia. This ornamental landscape plant has been cultivated since ancient times and has been developed into several horticultural varieties. Date of introduction to the United States is unknown as is any record of introduction to Tennessee. Current range maps show *L. vulgare* (L.) in four central and six eastern Tennessee counties and *L. sinense* (Lour.) in three central and two eastern Tennessee counties; however both species are suspected to have wider distributions.

**Similar Species**

The leaves of the native shrub coralberry, *Symphoricarpos orbiculatus* (Moench.), are similar in shape to common privet. Coralberry is distinguished by its very slender twigs, deciduous leaves, red berries borne in axillary clusters, and the lack of a terminal bud.

**Habitat**

Privet is often seen along roadsides and other areas of disturbed soil at elevations less than 915 m (3000 ft). Privet also becomes established in old fields and landscapes that have abundant sunlight. Blunt-leaved privet, *L. obtusifolium* (Sieb. and Zucc.), was found invading an old field succession site in Illinois. The field had an average of more than 6,082 plants per ha (2.5 acres). Privet can also spread into forests, though it does not produce fruit in low light.

**Management Recommendations**

**Mechanical Controls**

Mowing/Cutting: This method is appropriate for small initial populations or environmentally sensitive areas where herbicides cannot be used. Repeated mowing or cutting will control the spread of privet, but will not eradicate it. Stems should be cut at least once per growing season as close to ground level as possible.

Hand Pulling: Privet is effectively controlled by manual removal of young seedlings. Plants should be pulled as soon as they are large enough to grasp but before they produce seeds. Seedlings are best pulled after a rain when the soil is loose. Larger stems, up to 6 cm (2.5 in), can be removed using a Weed Wrench or similar uprooting tools. The entire root must be removed since broken fragments may resprout.

**Biological Controls**

Privet has no known biological controls. A foliage-feeding insect native to Europe, *Macrophya punctumalbum*, is a known pest. Privet is also susceptible to a fungal leaf spot, *Pseudocercospora ligustri*, and a common root crown bacteria, *Agrobacterium tumefaciens*.

**Herbicidal Controls**

Foliar Spray Method: This method should be considered for large thickets of privet where risk to non-target species is minimal. Air temperature should be above 65°F to ensure absorption of herbicides. The ideal time to treat is in late fall or early spring when many native species are dormant.

Glyphosate: Apply a 2% solution of glyphosate and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray-drift damage to non-target species. Glyphosate is a non-selective systemic herbicide that may kill non-target partially-sprayed plants.

Triclopyr: Apply a 2% solution of triclopyr and water plus a 0.5% non-ionic surfactant, to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray-drift damage to non-target species. Triclopyr is a selective herbicide for broadleaf species. In areas where desirable grasses are growing under or around privet triclopyr can be used without non-target damage.

Cut Stump Method: This control method should be considered when treating individual bushes or where the presence of desirable species preclude foliar application. This treatment is effective as long as the ground is not frozen.

Glyphosate: Horizontally cut privet stems at or near ground level. Immediately apply a 25% solution of glyphosate and water to the cut stump making sure to cover the entire surface.

Triclopyr: Horizontally cut privet stems at or near ground level. Immediately apply a 25% solution of triclopyr and water to the cut stump making sure the entire surface is covered.

Basal Bark Method: This method is effective throughout the year as long as the ground is not frozen. Apply a mixture of 25% triclopyr and 75% horticultural oil to the basal parts of the shrub to a height of 30-38 cm (12-15 in) from the ground. Thorough wetting is necessary for good control; spray until run-off is noticeable at the ground line.

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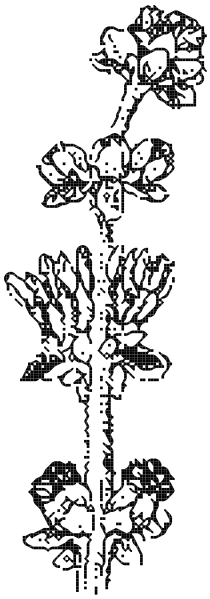
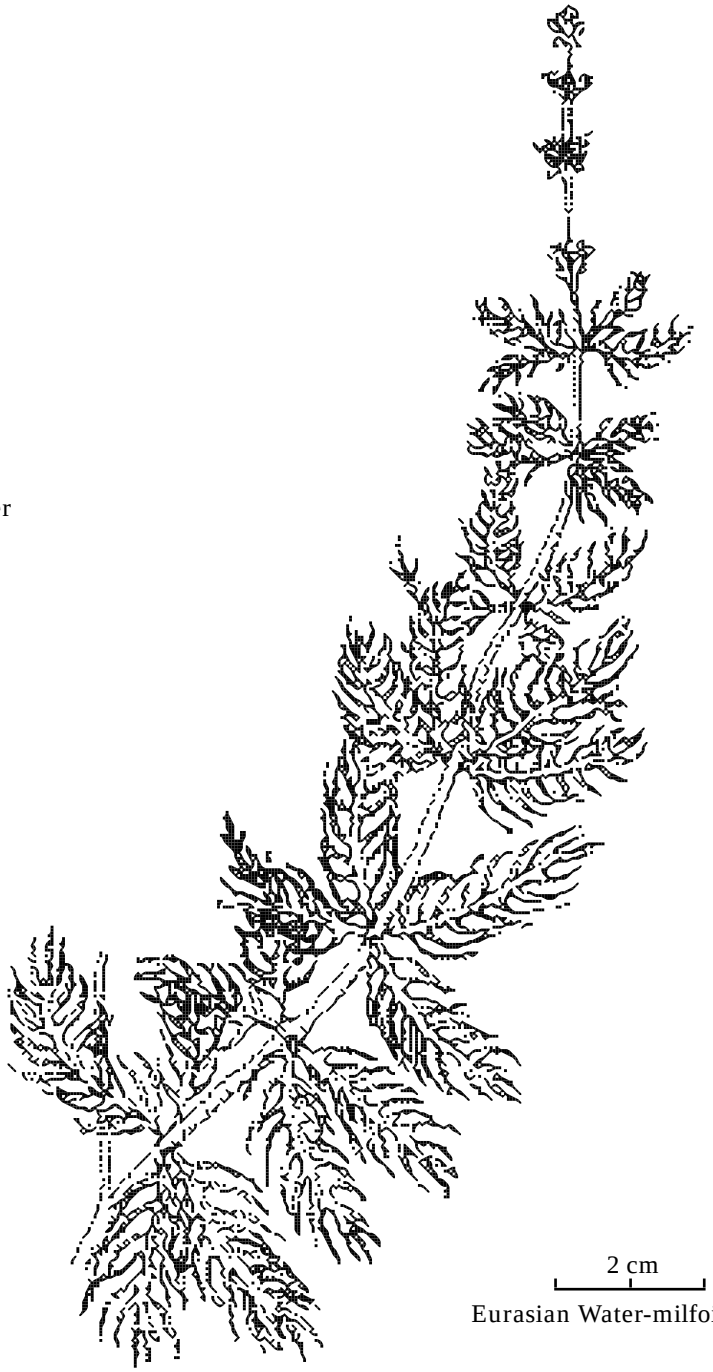


2 cm

Eurasian Water-milfoil Flower



2 cm

Eurasian Water-milfoil Stem

# Eurasian Water-milfoil

*Myriophyllum spicatum* L.

Eurasian water-milfoil is a perennial, aquatic, submersed herb that was accidentally introduced from Eurasia, probably in the 1940s. This plant can form large mats of floating vegetation on the water surface preventing light penetration thus outcompeting native plants and impeding water traffic. The preferred habitat for Eurasian water-milfoil is fresh or brackish water of fish ponds, lakes, slow-moving streams, reservoirs, and canals. Dispersal is primarily by fragmentation. It belongs to the primarily aquatic Haloragaceae family.

**Height:** The plant usually grows between 1-4 m (3.3-9.8 ft) but can extend up to 10 m (33 ft). The stems grow to the surface of the water and frequently form dense mats.

**Stem:** Stems are long, slender, branching, glabrous, and become leafless toward the base. Each floating node can become established if it comes in contact with mud.

**Leaves:** The grayish-green leaves are in whorls of three or four with 12-16 pairs of fine, thin leaflets up to 35 mm (1.4 in) long. These leaflets give the leaves a feathery appearance that is a distinguishing feature.

**Flowers:** The yellow flowers are on a spike that is produced 5-10 cm (2-4 in) above the water surface. The spike appears essentially naked and interrupted. Bracts are inconspicuous with the lower bracts usually toothed, sometimes entire, mostly exceeding the flowers. Stamen number is eight. Blooms July-September.

**Seeds:** Fruit is a schizocarp containing four seeds. Matures late July-September.

**Life History**

Seeds are usually viable, but are unimportant as a means of dispersal. Most regeneration is from rhizomes, fragmented stems, and axillary buds that develop throughout the year. Plant fragments can attach to objects in the water such as boats, trailers, or animals and be moved from one body of water to another. Motor boats can produce many fragments when traveling through the water. Flower spikes often stand above the water until after pollination and then re-submerge.

**Similar Species**

Several members of the Haloragaceae family are native to the southeastern United States, and a number of exotic milfoils are now widely naturalized. *M. spicatum* L. is distinguished by its distinctly whorled leaves, bracts, and flowers, and its deep branching.

**Origin and Distribution**

Eurasian water-milfoil is a native of Eurasia and Africa. It occurs in thirty-three states east of the Mississippi River. It is abundant in the Chesapeake Bay, the tidal Potomac River, and several Tennessee Valley reservoirs. Two theories exist as to how it entered

North America—it either escaped from an aquarium, or was released in shipping. This exotic aquatic plant species has been considered a problem in the United States since the 1940s. In the Tennessee Valley Authority reservoir system, a resort owner is thought to have introduced water-milfoil in 1953.

**Habitat**

Typical water-milfoil habitat includes fresh to brackish water of fish ponds, lakes, slow-moving streams, reservoirs, and canals. It is tolerant of many water pollutants. Eurasian water-milfoil does not spread rapidly into habitats where native plants are well established and tends to exist in habitats where native species grow poorly or cannot adapt. By altering waterways, we have created an unnatural, disturbed environment where milfoil thrives. Although short-term habitat improvement in habitat for fish and waterfowl has been experienced in disturbed habitats, the long-term effects are considered to be more damaging.

**Management Recommendations**

**Mechanical Controls**

Harvesting: Large equipment exists to mechanically remove milfoil in larger areas. A sturdy handrake can be used for smaller areas, such as around docks, swimming areas and harbors. For the single harvest, harvesting should take place just before peak biomass is obtained. There may be substantial regrowth if done too early. Better results appear with multiple harvests in the same growing season. If multiple harvests are not possible, then sustaining annual harvests is an option. All fragments of milfoil plants must be removed to achieve adequate control.

Water Levels: Where water levels are under manual control, raising or lowering of the water can have an effect on the milfoil. By raising the water level, plants can be "drowned" by not having access to enough light. By lowering the water level, plants can be dehydrated and, at the right time of the year, frozen to death. This type of control is usually used in conjunction with herbicides and shade barriers.

**Herbicidal Controls**

Fluridone: Fluridone is a selective herbicide for milfoil and several other exotic aquatic weeds. There are no restrictions on swimming, fishing, or drinking after application and season-long control can be achieved with one application. Fluridone is available in liquid or granular form and can be used as a spot treatment or on an entire waterway. For best results, applications should be made before or during the early stages of active growth. Granular 2,4-D: This method is appropriate for large unmanageable areas of milfoil. This herbicide is formulated to release the active ingredient over several days. Apply granules at a rate of 100 lbs per acre of water. The herbicide granules will sink to the root zone and kill the plant.

Liquid DMA 2,4-D: Application of liquid DMA 2,4-D may be used for milfoil control in areas with low dilution potentials such as ponds and lakes. Application rates should be less than 2.0 parts per million (ppm). Subsurface application rate has to be adjusted proportionately for varying water depths.

**Other Controls**

Heat: The viability of milfoil fragments is severely reduced after being subjected to

temperatures between 45-50°C in the cooling systems of thermal electricity generating systems.

Light: The amount of light reaching the plant can be limited by changing water levels using bankside plantings or floating plant species, light limiting dyes, or shade barriers.

Booms: Barriers are used to prevent the movement and spread of aquatic weeds in ponds and lakes. Usually the barrier is a suspended blocking screen that hangs vertically from a cable to a depth of about 4 meters, and the cable is suspended by drum floats. This will not eradicate milfoil, but it can limit its spread.

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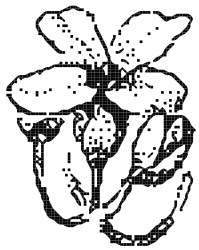
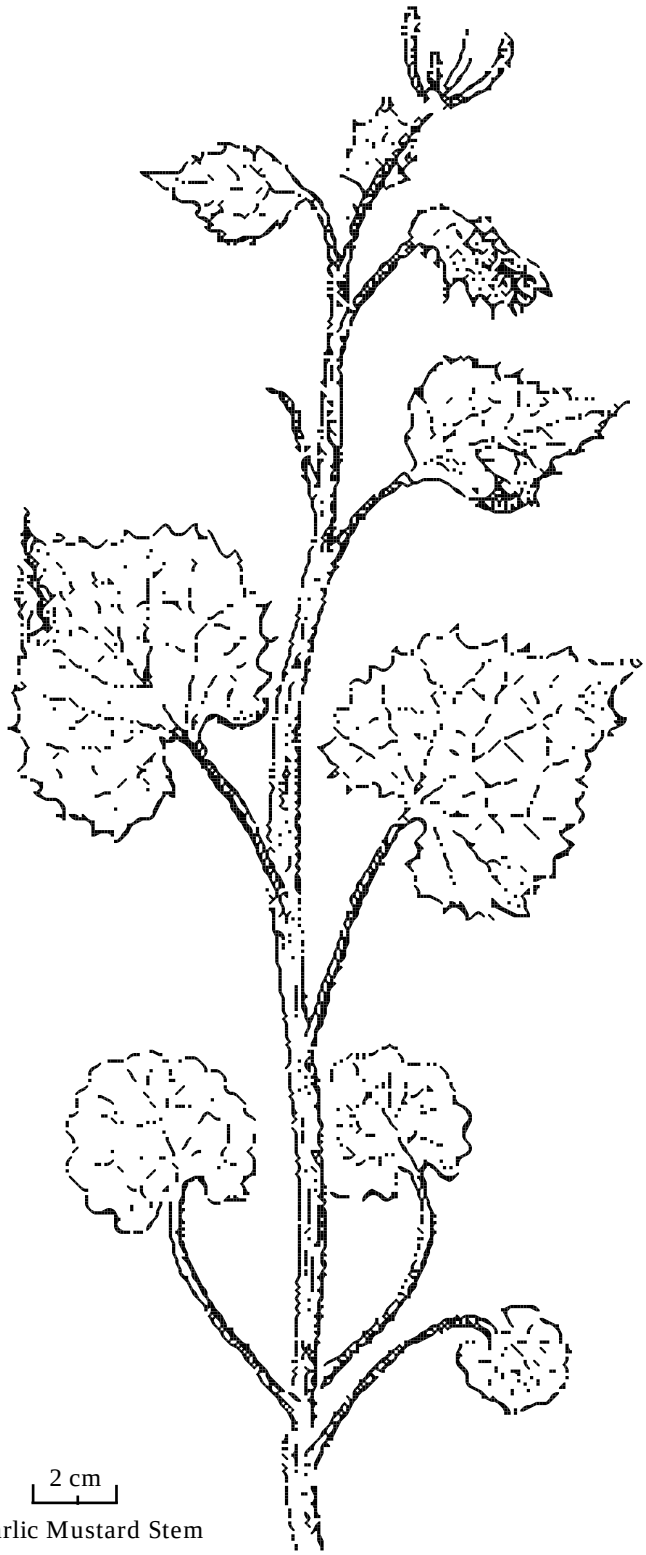


2 cm

Garlic Mustard Flower



2 cm

Garlic Mustard Stem

# Garlic Mustard

*Alliaria petiolata* (M. Bieb.) Cavara & Grande

Garlic mustard gets its name from its characteristic odor of garlic when the plant is crushed and its mustard-like appearance. It is a naturalized European biennial herb that poses a significant threat to lowland natural areas as well as gardens and field crops. It belongs to the Brassicaceae (Mustard) family.

**Height:** First-year rosettes extend to 10 cm (4 in) high. Flowering stems may reach 0.6-1.1 m (2.0-3.5 ft).

**Leaves:** First-year leaves (which remain the second year) are round to kidney-shaped and are on stems approximately 5.0-6.5 cm (2-3 in) tall. Leaves on flowering plants are alternate and are larger near the base of the stem. They are large-toothed, triangular in shape, and approximately 2.54 cm (1 in) long and 5.0-7.5 cm (2-3 in) wide.

**Flowers:** Flowers grow in clusters at the end of the stems. Each flower has four white petals (0.5 cm or 0.2 in long). Blooms in spring, usually in late April to May. Occasionally, some plants will bloom again in July-August.

**Fruit:** Fruit is a long 2.5-6.3 cm (1.0-2.5 in) green capsule called a silique, and contains many seeds. Siliques are produced summer to early fall. The capsules burst open when mature and ballistically disperse seeds several meters.

**Seeds:** Small, black seeds grow in a row inside the silique. Seeds may remain viable for up to 5 years. Plants can produce up to 868 seeds depending on habitat and population density. Seeds are dispersed by human / animal vectors or by water in riparian areas.

**Life History**

Garlic mustard is a cool-season obligate biennial herb. Seeds germinate in early spring (April-May) of the first year resulting in initially high seedling densities. Natural mortality during the first year results in only 2%-4% of the plants surviving to flower the following spring. Garlic mustard is self- or cross-pollinated and a single plant can populate an entire site. Adult plants set and disperse seed in late spring (May-June) the second year and produce an average of 165-868 seeds. The seeds are dormant for 20 months germinating in early spring of year four.

**Origin and Distribution**

Garlic mustard was introduced from Europe as food or a medicinal herb. It was first recorded in the U.S. in 1868 in Long Island, New York. By 1991, this exotic plant had spread to 28 midwestern and northeastern states. As of 1995, garlic mustard is found throughout Tennessee, although no formal statewide weed surveys have been conducted.

**Similar Species**

Garlic mustard is distinguished from other woodland herb species by its characteristic garlic odor. As the odor gradually dissipates by autumn, first-year rosettes may be mistaken for violets (*Viola* spp.) or immature white avens (*Geum canadense* [Jacquin]). Garlic mustard can be distinguished by its slender white taproot with a crook or "S" shape just below the base of the stem.

**Habitat**

Garlic mustard occurs most frequently in forested communities under partial shade. However, plants will grow on sites ranging from full shade to full sun, moist floodplains to dry, sandy forests, and in a wide variety of soils. Garlic mustard is associated with calcareous soils and is intolerant of acidic substrates. Disturbed forest and riparian communities are most susceptible to garlic mustard invasion and may dominate the herb strata within ten years. Garlic mustard will spread from disturbed areas to colonize undisturbed sites. Floodplain areas are particularly vulnerable since seeds are easily transported in water.

**Management Recommendations**

**Mechanical Control**

Hand Pull: This method of control is effective for small populations of garlic mustard, since plants pull up easily in most forested habitats. Hand-pulling is an extremely effective method of reducing population and seed productivity. Hand-pulling of plants can be done during most of the year. If plants have seed capsules present, they should be bagged and disposed of to prevent seed dispersal. Care should be taken to minimize soil disturbance. Resprouts are uncommon but may appear from mature plants not entirely removed.

Cutting: This method is effective for medium- to large- sized populations depending on available time and labor resources. Cut stems when in flower (late spring/early summer) at ground level either manually or with a mechanical brush-cutter. This technique will result in almost total mortality of existing plants. Dormant seeds in the soil are unaffected by this technique. Treatments should be continued annually until the seedbank is exhausted.

**Herbicidal Controls**

Glyphosate Foliar Spray: This method is effective on populations where mechanical control measures are not feasible or are impractical. Apply a 2% solution of glyphosate and water plus a non-ionic surfactant using a tank or backpack sprayer to thoroughly cover all leaves. Do not apply so heavily that herbicide drips off the leaf surface. Glyphosate is a non-selective herbicide requiring caution not to spray non-target species. Treatments should be done in the early spring when most other non-target vegetation is dormant. Refer to manufacturer's label for specific information and restrictions regarding use.

**Prescribed Fire**

In fire-tolerant communities, prescribed burning can be effective either alone or in conjunction with herbicide. Mid-intensity spring burns appear to reduce density of adult plants somewhat more effectively than fall burns. A program of repeated seasonal burning over several years is most effective in deterring garlic mustard and enhancing growth of native ground-layer vegetation.

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Japanese Grass or Eualia

# Japanese Grass or Eualia

*Microstegium vimineum* (Trin.) A. Camus.

Microstegium is an annual colonial grass that spreads rapidly into disturbed lowland areas. Inconspicuous at first, populations may go unnoticed until they have displaced native communities. It is a C-4 shade tolerant plant that can survive and reproduce under a closed forest canopy.

**Height:** Microstegium is a decumbent and branched annual grass reaching a height of 60-100 cm (24-39 in).

**Stem:** Culms are 1.5 m (59 in) long with glabrous nodes and internodes.

**Leaves:** Cauline leaves are alternate, lanceolate, 10 cm (4 in) long, 2-15 mm (0.08-0.6 in) wide, and sparsely pubescent on both surfaces with ciliate margins.

**Flowers:** Racemes are terminal and may be solitary or in a set of two or three. Spikelets are in pairs, one sessile and one pedicellate, and 4.5-5mm (0.17-0.2 in) long. Blooms August-September.

**Seeds:** Grain is yellow to red, ellipsoid, 2.8-3.0 mm (0.1-0.12 in) long. Seeds mature over a period of about two weeks in September-October.

## Life History

Microstegium is an annual C-4 shade tolerant grass in the Poaceae family. It is colonial in nature, rooting from the nodes, and may form dense monotypic stands. Reproduction is exclusively from seed. Each plant may produce from 100-1,000 seeds that remain viable in the soil for five or more years. Seed dispersal is primarily by animals, flooding, and deposition with fill dirt. This plant spreads rapidly into disturbed areas but can invade undisturbed areas by forming satellite populations brought in by animals or flooding. On fertile mesic sites Japanese grass can replace competing ground vegetation within 3-5 years.

Microstegium is adapted to low light conditions. At 18% of full sunlight dry matter production is not significantly reduced from production in full sunlight. It will grow and produce seed in light levels as low as 5% of full sunlight.

## Origin and Distribution

Microstegium is native to Japan, Korea, China, Malaysia, and India. It was first identified in the U.S. at Knoxville, Tennessee in 1919, and in 1933 was collected in western North Carolina. By 1964, the grass had spread to 35 counties in North Carolina. By 1972, it had been identified in 14 east-

ern states, and in 1978, it was collected in Arkansas. Microstegium can be found throughout the state of Tennessee, primarily in previously disturbed mesic areas.

**Similar Species**

Microstegium may be confused with cutgrass (*Leersia virginica* Willd.) or knotweed (*Polygonum persicaria* L.). Cutgrass has distinctly longer leaves (1.5 dm [6.0 in]) and shorter spikelets (2.5-3 cm [1.0-1.2 in]) than microstegium. Knotweed is distinguished from microstegium by pale to dark pink calyx and glossy black nutlets.

**Habitat**

Alluvial soil found in flood plains and stream sides is ideal habitat for microstegium. Other typical habitats include damp fields, lawns, mesic woodland edges, roadsides, and ditches. It is commonly found in areas of natural (e.g., flood scouring) or artificial (e.g., mowing, tilling) disturbance, but can invade undisturbed areas. Microstegium has been observed growing at an elevation of 1,200 m (3,840 ft), but typically is not found on upland sites. Deer avoid microstegium, which allows it a competitive advantage in over browsed areas.

**Management Recommendations**

**Mechanical Control**

Mow plants as close to the ground as possible using a weedeater or similar grass cutting tool. Treatments should be made when plants are in flower and before seeds are produced. Treatments made earlier may result in plants producing new seed heads in the axils of lower leaves.

**Herbicidal Control**

Herbicide treatments should be made late in the growing season but, before the plants set seed. Treatments made earlier in the growing season may allow a second cohort of plants to produce seeds.

Glyphosate: Apply a 2% solution of glyphosate and water plus a 0.5% non-ionic surfactant to thoroughly wet all foliage. Do not spray to the point of runoff. Ambient air temperature should be above 65°F to ensure translocation of the herbicide to the roots. Do not apply if rainfall is expected within two hours following application.

Sethoxydin: Apply a 1.5% solution of sethoxydin and water plus a 1% nonphytotoxic vegetable-based oil to all foliage on a spray-to-wet basis. Do not spray to the point of runoff. Ambient air temperature should be above 65°F. Do not apply if rainfall is expected within one hour following application.

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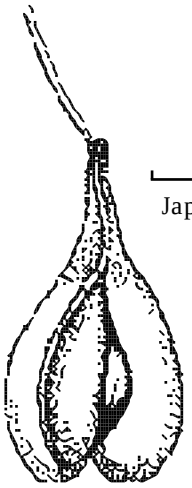
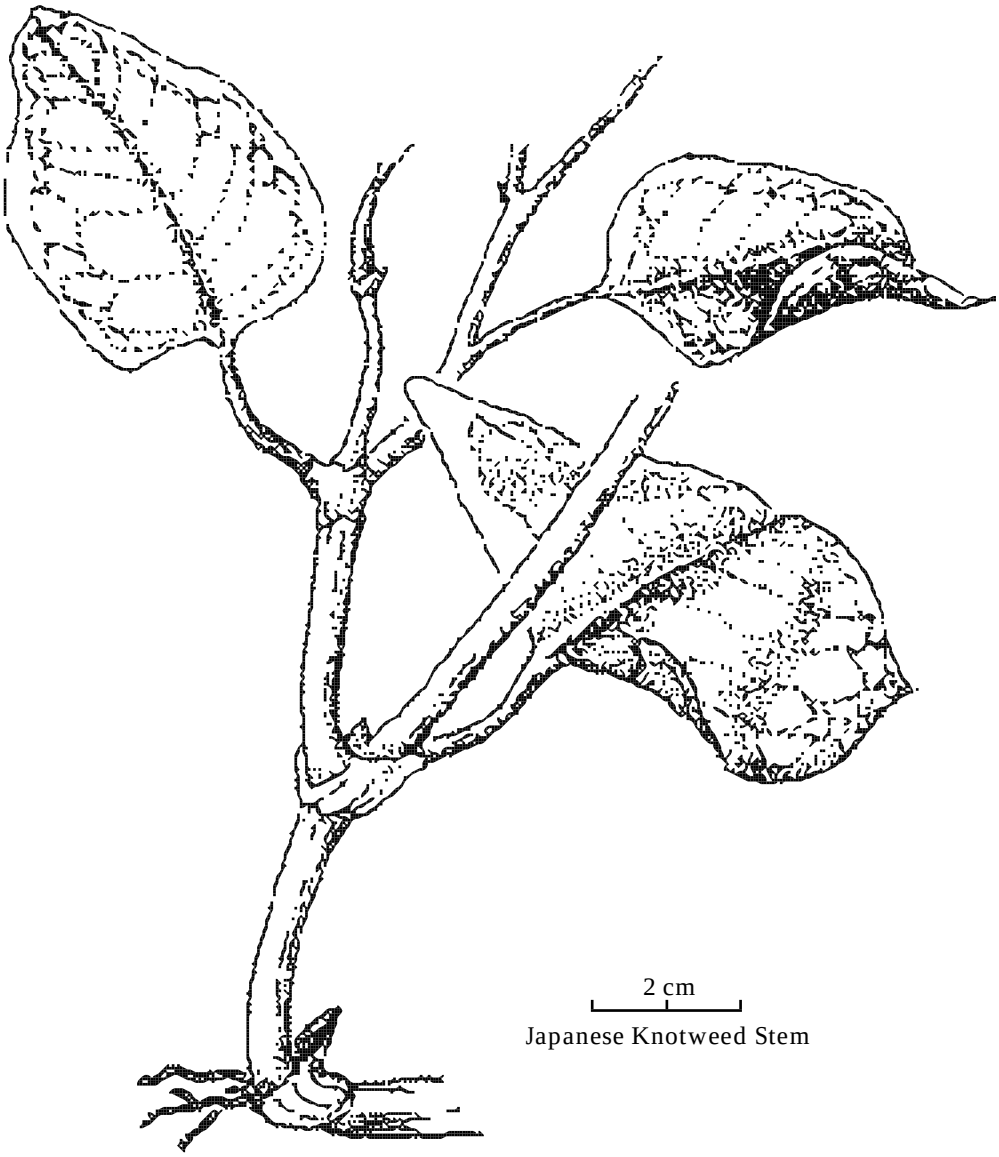


1 cm

Japanese Knotweed Seed



2 cm

Japanese Knotweed Stem

# Japanese Knotweed

*Polygonum cuspidatum* (Sieb. & Zucc.)

Japanese knotweed, commonly known as crimson beauty, Mexican bamboo, Japanese fleece flower, or Reynoutria, was probably introduced to the U.S. as an ornamental. Initially useful for erosion control, as an ornamental, and for landscape screening, Japanese knotweed spreads quickly to form dense thickets that can alter natural ecosystems or interfere with landscaping. It is a semi-woody, bushy perennial and a member of the Polygonaceae (Knotweed) family.

**Height:** Japanese knotweed can grow 1-3 m (3-10 ft) tall.

**Stem:** The stout stems are glaucous, and erect, swelling at leaf axils.

**Leaves:** The broadly ovate leaves are petiolate, truncate to somewhat triangular, and pointed at the tip. Length is generally 5-15 cm (2-6 in) long, and 5-12 cm (2-5 in) wide, with a prominent basal angle.

**Flowers:** Minute greenish-white flowers appear in axillary panicles with three styles and minute stigmas. Outer sepals are narrowly winged along the midrib. Blooms August- September.

**Fruit:** The fruiting calyxes are wing-angled, 8-9 mm long (0.3 in). Achene is triangular, shiny, 3-4 mm (0.1-0.15 in) long.

**Life History**

Knotweed spreads rapidly from stout long rhizomes. Seeds are distributed by water in floodplains, transported with fill dirt, and to a lesser extent are wind-blown. Populations escaped from neglected gardens, and discarded cuttings are common urban paths of distribution. Once established, populations are quite persistent and can outcompete existing vegetation.

**Origin and Distribution**

Japanese knotweed, native to Japan, was introduced into the United States prior to 1890. By the turn of the century, it was established in the eastern United States and was reported naturalized around Philadelphia, PA, Schenectady, NY, and Atlantic Highlands, NJ. Knotweed was collected in the Tennessee region in the 1940s and is now found throughout the state. In 1966, it was considered “one of the most persistent and aggressive of all perennial weeds.” Current distribution is from Newfoundland to Ontario, in many parts of the north and southeastern U.S., and west to Minnesota and Iowa.

**Similar Species**

There are several native species of *Polygonum* that resemble Japanese knotweed in the seedling stage. Japanese knotweed is distinguished by greater overall height, and vigorous growth of stout rhizomes. This plant is a popular ornamental, and many culti-

vated varieties are produced by the nursery industry. Varieties may be difficult to distinguish, but most share the same invasive characteristics and will respond to the same treatment as the parent plant.

**Habitat**

Japanese knotweed can tolerate a variety of adverse conditions including full shade, high temperatures, high salinity, and drought. It is found near water sources, in low-lying areas, waste places, utility rights of way, and around old homesites. It can quickly become an invasive pest in natural areas after escaping from cultivated gardens. It poses a significant threat to riparian areas, where it can survive severe floods. It is rapidly colonizing scoured shores and islands.

**Management Recommendations**

**Mechanical Control**

Grubbing: This method is appropriate for small initial populations or environmentally sensitive areas where herbicides cannot be used. Using a pulaski or similar digging tool, remove the entire plant including all roots and runners. Juvenile plants can be hand-pulled depending on soil conditions and root development. Any portions of the root system not removed will potentially resprout. All plant parts, including mature fruit, should be bagged and disposed of in a trash dumpster to prevent reestablishment.

**Herbicidal Control**

Cut Stump Treatment: Use this method in areas where vines are established within or around non-target plants or where vines have grown into the canopy. This treatment remains effective at low temperatures as long as the ground is not frozen.

Glyphosate: Cut the stem 5 cm (2 in) above ground level. Immediately apply a 25% solution of glyphosate and water to the cross-section of the stem. A subsequent foliar application of glyphosate may be required to control new seedlings and resprouts.

Triclopyr: Cut the stem 5 cm (2 in) above ground level. Immediately apply a 25% solution of triclopyr and water to the cross-section of the stem. A subsequent foliar application may be necessary to control new seedlings.

Foliar Spray Method: Use this method to control large populations. It may be necessary to precede foliar applications with stump treatments to reduce the risk of damaging non-target species.

Glyphosate: Apply a 2% solution of glyphosate and water to thoroughly wet all foliage. Do not apply so heavily that herbicide will drip off leaves. The ideal time to spray is after surrounding vegetation has become dormant (October-November) to avoid affecting non-target species. A 0.5% non-ionic surfactant is recommended in order to penetrate the leaf cuticle, and ambient air temperature should be above 65°F.

Triclopyr: Apply a 2% solution of triclopyr and water to thoroughly wet all foliage. Do not apply so heavily that herbicide will drip off leaves. The ideal time

to spray is after surrounding vegetation has become dormant (October-November) to avoid affecting non-target species. A 0.5% non-ionic surfactant is recommended in order to penetrate the leaf cuticle, and ambient air temperature should be above 65°F.

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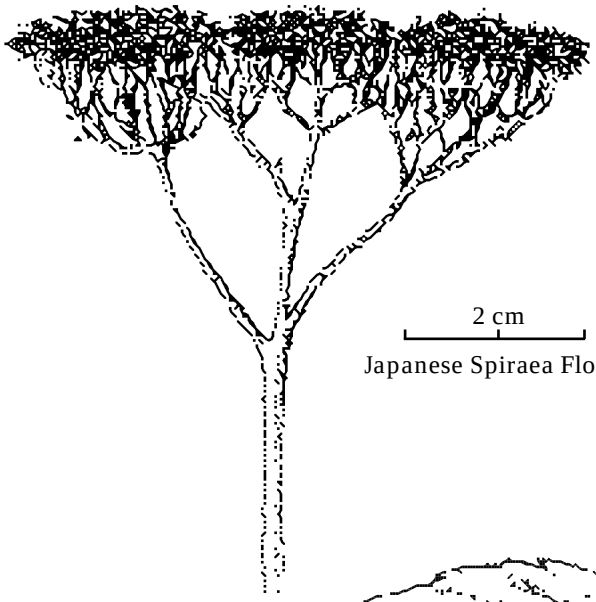
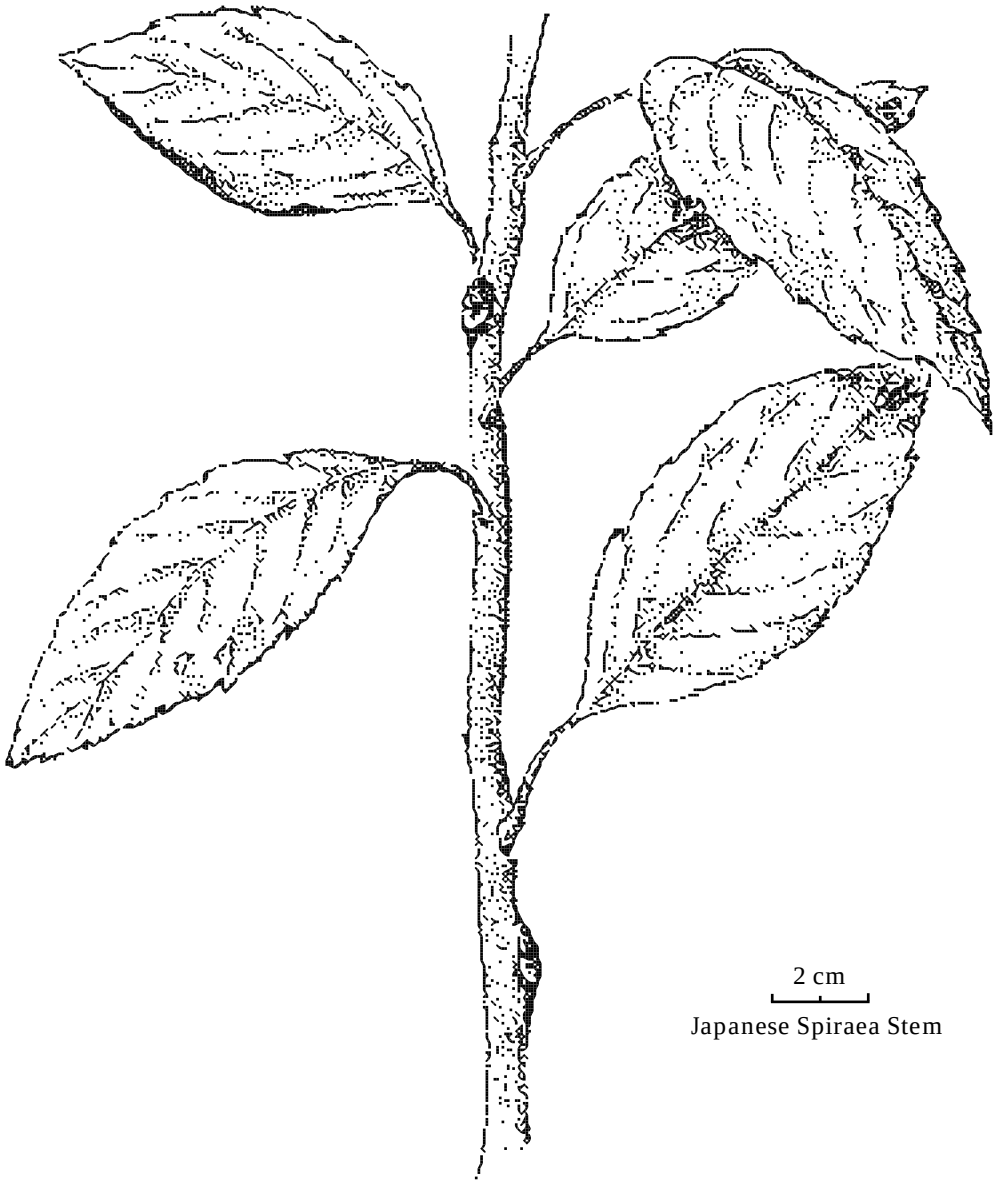


2 cm

Japanese Spiraea Flower



2 cm

Japanese Spiraea Stem

# Japanese Spiraea

*Spiraea japonica* L. f.

Japanese spiraea is one of more than eighty species of spiraea found in the temperate region of the northern hemisphere. Most of the species have been introduced into cultivation and are popular garden shrubs planted for their decorative flowers. It belongs to the Rosaceae (Rose) family.

**Height:** Japanese spiraea is a small shrub with slender erect stems to 2 m (6.5 ft) tall.

**Stem:** Brown to reddish-brown stems are round and glabrous to densely pubescent on branchlets. Buds are very small, rounded to triangular and somewhat flattened.

**Leaves:** The leaves are alternate, lanceolate to lance-ovate, simply or doubly serrate, acute at base, 8-12 cm (3.0-4.5 in) long, 3-4 cm (1.2-1.6 in) wide, and glabrous.

**Flowers:** Inflorescence is a compound corymb with wide spreading branches. Flowers are pale to deep pink, 5 mm (0.2 in) wide, with stamens much longer than the 2-3 mm (0.07-0.11 in) petals. Blooms June-July.

**Fruit:** The 2.2-2.4 mm (0.09-0.1 in) long seeds are borne in a glabrous, smooth, and lustrous capsule. Blooms July-August.

**Life History**

Japanese spiraea is a perennial deciduous shrub. It is adapted to disturbed areas and commonly found along streams and rivers. Each plant produces hundreds of small seeds that are naturally dispersed by water and deposited along stream banks where arboreal competition is limited. Seeds distributed with fill dirt establish new populations that may expand rapidly in the highly disturbed soil of construction sites.

**Origin and Distribution**

Japanese spiraea is native to Japan and was first cultivated in 1870. Introduced as an ornamental landscape plant, spiraea spread from the northeast U.S. and is naturalized in much of the southeast and Midwest, including Tennessee.

**Similar Species**

There are two native species of spiraea that are similar to Japanese spiraea: *S. viginiana* (Britt.) and *S. betulifolia* (Pallas). Both of these species are rare in Tennessee; *S. viginiana* is listed as a threatened species by the U.S. Fish and Wildlife Service. Japanese spiraea is distinguished by dense pubescence on the branchlets and inflorescence, lanceolate leaves, and pink flowers.

**Habitat**

Spiraea will tolerate a wide range of edaphic conditions. It grows well in full sun but may endure partial shade. Ideal habitats include riparian areas, successional fields, roadsides, power line rights of way, and forest edges. Once established, spiraea grows

rapidly forming dense stands that may invade canopy gaps and defoliated areas of adjacent woodlands.

## Management Recommendations

**Mechanical Controls**

Mowing/Cutting: This method is appropriate for small initial populations or environmentally sensitive areas where herbicides cannot be used. Repeated mowing or cutting will control the spread of spiraea, but it may not eradicate it. Stems should be cut at least once per growing season prior to seed production and as close to ground level as possible.

**Herbicidal Controls**

Foliar Spray Method: This method should be considered for large thickets of Japanese spiraea where risk to non-target species is minimal. Air temperature should be above 65°F to ensure absorption of herbicides.

Glyphosate: Apply a 2% solution of glyphosate and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray-drift damage to non-target species. Glyphosate is a non-selective systemic herbicide that may kill partially-sprayed non-target plants.

Triclopyr: Apply a 2% solution of triclopyr and water plus a 0.5% non-ionic surfactant to thoroughly wet all leaves. Use a low pressure and coarse spray pattern to reduce spray-drift damage to non-target species. Triclopyr is a selective herbicide for broadleaf species. In areas where desirable grasses are growing under or around spiraea, triclopyr can be used without non-target damage.

Cut Stump Method: This control method should be considered when treating individual bushes or where the presence of desirable species preclude foliar application. This treatment is effective as long as the ground is not frozen.

Glyphosate: Horizontally cut spiraea stems at or near ground level. Immediately apply a 25% solution of glyphosate and water to the cut stump making sure to cover the entire surface.

Triclopyr: Horizontally cut spiraea stems at or near ground level. Immediately apply a 25% solution of triclopyr and water to the cut stump making sure the entire surface is covered.

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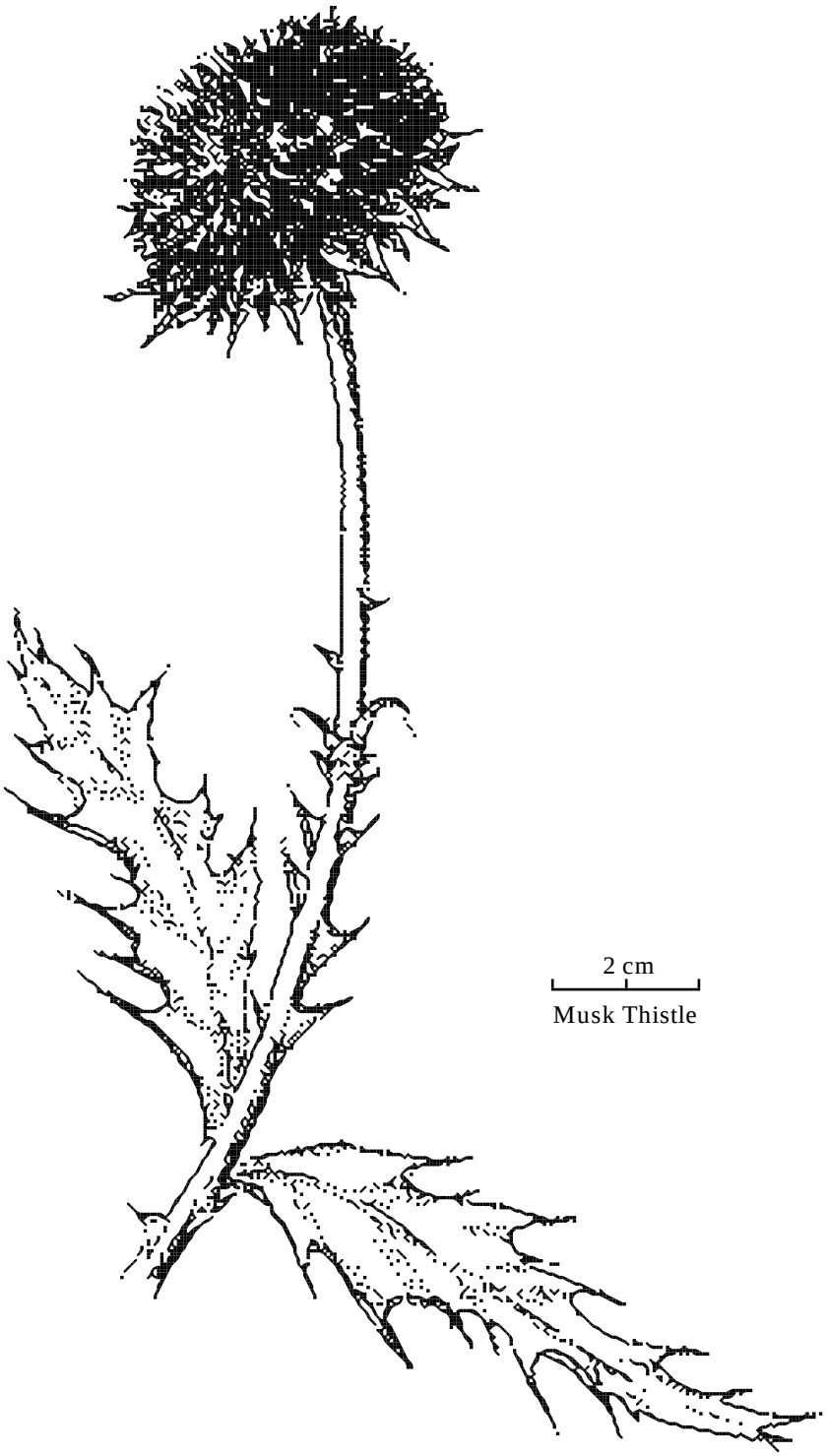


Musk Thistle

# Musk Thistle

*Carduus nutans L.*

Musk thistle is an aggressive biennial plant with large, showy pink flowers on long multi-branched stems. Native to Europe and Asia, it was introduced into the U. S. more than ninety years ago and is declared a noxious weed in many states. It is a member of the Asteraceae (Aster) family.

**Height:** Thistle stems are commonly 0.5-2.0 m (1.5-6 ft) tall, multi-branched and spiny.

**Leaves:** The dark green leaves are coarsely lobed, elliptic to lanceolate, with a smooth waxy surface, and a yellowish to white spine at the tip. Dimensions average 1.5-4.0 cm (0.5-1.5 in) wide, and 5-12 cm (2-5 in) long.

**Flowers:** Disk-shaped terminal flowers are 4-9 cm (1.5-3.5 in) wide, solitary, involucres and corollas are purple, outer bracts squarrose with spines. Flowers will droop to a 90-degree angle from the stem when large, giving musk thistle its common nickname, nodding thistle.

**Seeds:** Each plant may produce thousands of yellowish-brown or straw-colored seeds with attached plumose bristles.

**Life History**

Musk thistle is usually a biennial but may germinate and flower in a single year. Seedlings emerge in mid to late July and develop into a rosette of up to 1.2 m (4 ft) in diameter. Plants overwinter in the rosette stage until they begin to bolt in mid-March. During the bolting stage plants form multi-branched stems to a height of 1.8 m (6 ft) The number of seed heads per plant is site dependent ranging from 241-561 on favorable sites to 1-18 heads on less favorable sites. Flowers emerge in early May to August and may produce 1200 seeds per head and 120,000 seeds per plant. Seed dissemination occurs approximately one month after the flowers form and seeds may be wind blown for miles. Seeds may remain viable in the soil for over ten years.

**Origin and Distribution**

A native of western Europe, musk thistle was introduced into the eastern United States in the early 1900s. It was discovered in Davidson County, Tennessee in 1942 and spread quickly throughout the state. Currently musk thistle is present in forty states. It is widespread on railroad, highway, and power line rights-of-way, which become a large seed source for invasion of crop and pasture lands as well as open natural areas.

**Similar Species**

Musk thistle is similar to Canada thistle (*Cirsium arvense* [L.] Scop.) and bull thistle (*Cirsium vulgare* [Savi.]), both of which are also non-native. There is some evidence of hybridization occurring between musk thistle and non-native plumeless thistle (*Carduus acanthoides* [L.]). Musk thistle is distinguished from other thistles by the usually large disk-shaped flowers.

**Habitat**

Establishment of an extensive population of musk thistle is dependent on the availability of light and water. It can grow from sea level to about 2500 m (8000 ft) and in neutral to acidic soil. It spreads rapidly in disturbed areas and is sensitive to competition. Pasture- land is particularly vulnerable because the drainage is good, and livestock will avoid thistle due to its spiny leaves and stems. Although musk thistle is infrequently found in dense forests, it can impact natural areas by colonizing areas of natural disturbance such as land slides or areas of frequent flooding. Meadows, prairies, grassy balds, and other open areas are susceptible to invasion.

**Management Recommendations**

**Mechanical Controls**

Hand Pulling: This method is most effective on small populations. Hand pulling can be done throughout the year, but is most effective prior to the development of seeds. Flowers or seed heads should be bagged and disposed of to prevent seed dispersal. Minimizing soil disturbance will help prevent germination of seeds already present in the soil.

**Biological Controls**

Two weevils have been introduced as a biological control for musk thistle: thistle head feeding weevil (*Rhinocyllus conicus* Froelich) and the rosette weevil (*Trichosirocalus horridus* Panzer). Although both weevils have been successful, establishment may take several years, thistle populations must be relatively dense, and native thistles may be affected.

**Herbicidal Controls**

Foliar Spray Method: Apply a 2% solution of glyphosate or triclopyr and water plus a 0.5% non-ionic surfactant wetting all leaves and stems. A low pressure and coarse spray pattern will limit drift and damage to non-target species. Treatments should be applied during the rosette stage or prior to flowering.

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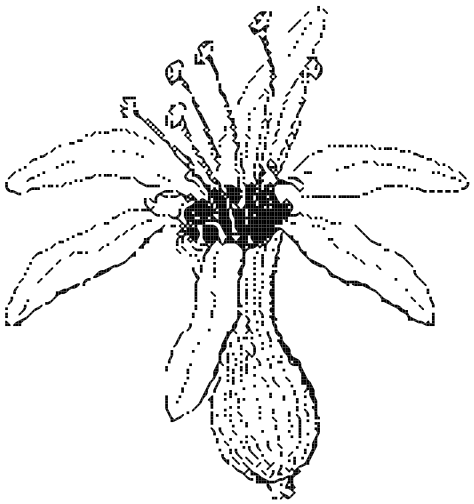
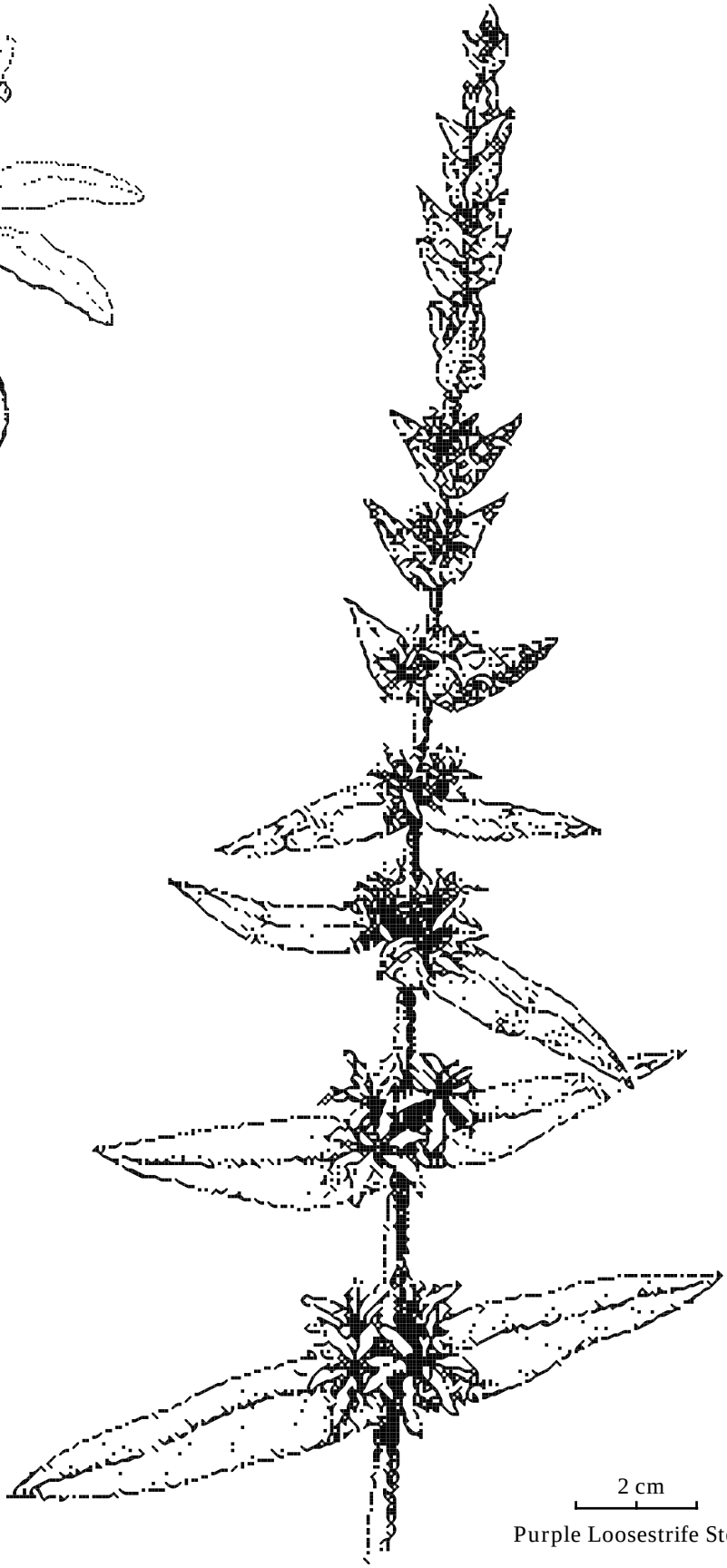


0.5 cm

Purple Loosestrife Flower



2 cm

Purple Loosestrife Stem

# Purple Loosestrife

*Lythrum salicaria* L.

Purple loosestrife (*Lythrum salicaria* L.) is a wetland perennial that forms large, monotypic stands throughout the temperate regions of the U.S. and Canada. This aggressive invader replaces native vegetation, degrades wildlife habitat, and obstructs natural waterways. Also known as Bouquet-violet, it belongs to the Lythraceae (Loosestrife) family.

**Height**: Purple loosestrife grows 1-3 m (3.0-10.0 ft) tall, with an average height of 1.5 m (5 ft). Established plants have 30 to 50 shoots that form wide-topped crowns and dominate the herbaceous canopy.

**Stem**: Stems are pubescent and distinctly four-sided. They may appear woody at base of large plants.

**Leaves**: The entire sessile leaves are primarily opposite or in whorls of three without teeth. Leaves are lanceolate and up to 10 cm (4 in) long and 1.5 cm (0.6 in) wide with an obtuse or cordate leaf base.

**Flowers**: Purple loosestrife has showy, attractive flowers with 5-7 purple petals (occasionally pink or white) occurring in dense compound, terminal bracted spikes that may be 15-20 cm (6-8 in) high. Three forms of the species are distinguished based on the length of the style (up to 7 mm) in the flowers. Blooms have 8-10 stamens. The calyx tube has hirsute lobes 0.5- 0.8 mm (0.02-0.03 in) long which, along with the bracts, are greenish. The self-incompatible, insect-pollinated flowers bloom from June to September and the flower stalks remain standing through the winter. Each plant may bear as many as 3,000 flowers.

**Seeds**: The capsules contain an average of 120 orange, minute seeds (0.06 mg). Each plant may contain up to 900 capsules. Seeds are dispersed from late summer through the winter. Seeds are commonly dispersed by wind, but are also dispersed in water and mud adhering to aquatic wildlife, livestock, and people. Seed germination takes 8-10 weeks. Seeds are long-lived and can remain viable even after 20 months of submergence in water.

**Life History**

Purple loosestrife has a vigorous rootstock that serves as a storage organ, providing resources for growth in spring and regrowth if the plant has been damaged from cuttings. New stems emerge from the perennial roots allowing the plant to establish dense stands within a few years. Each plant has an average of 30 stems which die in late fall but remain standing through winter. Under natural conditions, seedling densities can approach 10,000-20,000 plants / $m^2$ (12,000-24,000 plants / sq. yard) with growth rates exceeding 1 cm / day (0.4 in / day). Plants reproduce primarily by seeds, but also by vegetative cuttings. A single, mature plant can produce more than 2.5 million seeds annually. In addition, plant fragments produced by muskrats and by mechanical clipping can rapidly spread through river and lake systems.

**Origin and Distribution**

Purple loosestrife was introduced to North America from Europe and Asia during the early 1800s as a contaminant of European ship ballasts and as a valued medicinal herb for the treatment of diarrhea, dysentery, bleeding, wounds, ulcers, and sores. For nearly a century it occurred as a pioneer species on the northeastern seaboard. The range then expanded further inland in the 1880s as the construction of inland canals and waterways increased. The continued expansion proceeded with the development and use of road systems, with commercial distribution of the plant for horticultural purposes, and with regional propagation of seed for bee forage. Purple loosestrife reached the upper Midwest by the 1930s. The plant now occurs in scattered locations across most of the U.S. with the heaviest concentrations in the glaciated wetlands of the northeast. Numerous populations have been found in the midsouth area.

**Similar Species**

The native winged loosestrife (*Lythrum alatum* Pursh) most closely resembles purple loosestrife. However, winged loosestrife has alternate leaves, more widely spaced flowers, and is smaller in size (an average of 0.6 m or 2 ft tall) than purple loosestrife. Other species that might easily be confused with purple loosestrife on first glance include fireweed (*Epilobium angustifolium* L.), blue vervain (*Verbena hastata* L.), and blazing star (*Liatris spicata* L. Willd.), although their preferred habitats are considerably drier.

**Habitat**

Purple loosestrife is an aquatic to semiaquatic species occurring in a variety of different shallow water wetlands including marshes, bogs, wet meadows, stream and river banks, shores of lakes and reservoirs, wet pastures, roadside ditches, and disturbed wet soils. Plants thrive under moist soil conditions and in full sun; however, they can survive in up to 50% shade.

**Management Recommendations**

**Mechanical Controls**

Hand Pulling: In areas that contain less than 100 plants, younger plants (1-2 years old) can be hand-pulled. Plants more than 2 years old should be dug out with special care to include the entire rootstock. Removal activities should take place before flowering to ensure that seeds are not dispersed during the disturbance. All plant parts should be carefully bagged, removed from the site, and placed in approved landfills or preferably burned. Any plant fragment that escapes proper disposal could spread purple loosestrife on your control site or along your travel route. In addition, all clothing, boots, and equipment should be properly cleaned to ensure that no seeds are transported. If feasible, native plants should be restored to the control area by seeding or planting. This reestablishment of vegetation will deter new loosestrife seedling development through competition. Do not cut or mow purple loosestrife. These methods will simply increase the spread of plants since they can sprout vegetatively.

**Biological Controls**

Long-term studies on the effectiveness of biological controls are being conducted at the New York Cooperative Wildlife Research Unit at Cornell University. Several phytophagous insects which specifically feed on purple loosestrife in Europe have undergone a series of intensive lab and field testing. Three beetles—two leaf eaters, and one root miner—have been approved for release in the U.S. Experimental importation of

these insects has been made in the northeast. Success of these efforts could pave the way for the use of biological controls to manage purple loosestrife in a permanent, cost-effective, and environmentally sound way. There is significant concern about other native species of the genus *Lythrum* that may also be fed upon, although to a lesser degree, by these insects. Since other control measures may harm a variety of non-target plant species, this non-target feeding may occur at a level which is preferable to alternative control techniques.

**Herbicidal Controls**

Cut Stump Treatment: In areas that contain more than 100 plants, a spot application of a glyphosate herbicide (one that is approved for use in and near water) is recommended. Individual purple loosestrife plants should be cut about 15 cm (6 inches) above the ground. A 20-30% solution of glyphosate and water should be applied directly to the cut surface either by a wick or injection into the stem.

Foliar Spray Method: If purple loosestrife covers a large area, a foliar spray can be applied using a 2% glyphosate solution and water plus 0.5% non-ionic surfactant. To be most effective herbicide should be applied just when plants have begun flowering. Where feasible, flower heads should be cut, bagged, and removed from the site before application to prevent the production of seed. Glyphosate is a non-selective herbicide, and extreme care must be taken to avoid contact with non-target plant species. The restoration of sites depends on these non-target species as they recolonize the area after the purple loosestrife is eliminated.

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2 cm

Climbing Euonymus Flower



2 cm

Climbing Euonymus Stem

# Climbing Euonymus

*Euonymus fortunei* (Turcz.) Hand.-Mazz.

Climbing euonymus, also known as purple winter creeper, Emerald 'n Gold, or Gaiety, is an evergreen vine in the Celastraceae (Staff-tree) family. It forms a dense ground cover or climbs vertical surfaces with the aid of aerial rootlets.

**Height:** Euonymus is an evergreen vine climbing or trailing to 6 m (20 ft).

**Leaves:** The leaves are opposite, dark green, distinctly veined beneath, elliptic, toothed, thick, glossy, and vary from 2.5-6.0 cm (1.0-2.3 in) in length.

**Stem:** Stems are minutely warty and subterete with aerial rootlets or trailing roots.

**Flower:** The inconspicuous clusters of green flowers are borne on a long flower stalk. Blooms May-June.

**Fruit:** Berries are orange to red, globose, and smooth. Matures June-July.

**Life History**

Climbing euonymus spreads rapidly through long branches and lateral shoots. Independent plants originate at short intervals along the vine from rootlets. Vines may aggressively climb rocks, trees, or other supporting structures; established populations appear as a dense mat of vegetation. Inconspicuous green flowers appearing in early spring produce mature fruits that are readily distributed by birds into undisturbed areas. Because euonymus is an evergreen and begins growing before competing vegetation emerges, it outcompetes existing vegetation for available space and resources.

**Origin and Distribution**

A native of China, climbing euonymus was introduced into the U.S. as a landscape ground cover in 1907. It is currently found scattered throughout the eastern U.S. in populated areas, and has begun to invade state parks and other natural areas as well as landscape settings.

**Similar Species**

Climbing euonymus is similar to other *Euonymus* species but can be readily distinguished as a vine rather than an erect shrub or tree. It is often confused with bittersweet (*Celastrus* spp.) which has alternate leaves as opposed to the opposite leaves of euonymus. Very small seedlings may be confused with pipsissewa (*Chimaphila maculata* [L.] Pursh).

**Habitat**

Climbing euonymus continues to be a popular landscape plant due to its rapid growth and its ability to tolerate a variety of environmental conditions including poor soils, heavy shade, and variable pH. It often escapes from neglected gardens or is spread by

birds, other animals, or water. Once established, euonymus can be very persistent and spread into undisturbed forests or high quality riparian areas. Satellite populations may be established in forest openings caused by wind throw or insect defoliation.

## Management Recommendations

### Mechanical Control

Grubbing: This method is appropriate for small initial populations or environmentally sensitive areas where herbicides cannot be used. Using a pulaski or similar digging tool, remove the entire plant, including all roots and runners. Juvenile plants can be hand-pulled depending on soil conditions and root development. Any portions of the root system not removed may resprout. All plant parts, including mature fruit, should be bagged and disposed of in a trash dumpster to prevent reestablishment.

### Herbicidal Control

Cut Stump Treatment: Use this method in areas where vines are established within or around non-target plants, or they have grown into tree canopies or other vertical surfaces.

Glyphosate: Cut the stem 5 cm (2 in) above ground level. Immediately apply a 25% solution of glyphosate and water to the cross-section of the stem. This procedure is effective at temperatures as low as 40°F and may require a subsequent foliar application of glyphosate.

Triclopyr: Cut the stem 5 cm (2 in) above ground level. Immediately apply a 25% solution of triclopyr and water to the cross-section of the stem. This procedure remains effective at low temperatures (<60°F) as long as the ground is not frozen. A subsequent foliar application may be necessary to control new seedlings.

Foliar Spray Method: Use this method to control large populations. It may be necessary to precede foliar applications with stump treatments to reduce the risk of damaging non-target species.

Glyphosate: Apply a 2% solution of glyphosate and water plus a 0.5% non-ionic surfactant to thoroughly wet all foliage. Do not apply so heavily that herbicide will drip off leaves. Glyphosate is a non-selective systemic herbicide that may kill non-target partially-sprayed plants. Ambient air temperature should be above 65°F.

Triclopyr: Apply a 2% solution of triclopyr and water to thoroughly wet all foliage. Do not apply so heavily that herbicide will drip off leaves. The ideal time to spray is after surrounding vegetation has become dormant (October-November) to avoid affecting non-target species. A 0.5% concentration of a non-ionic surfactant is recommended in order to penetrate leaf cuticle. Ambient air temperature should be above 65°F.

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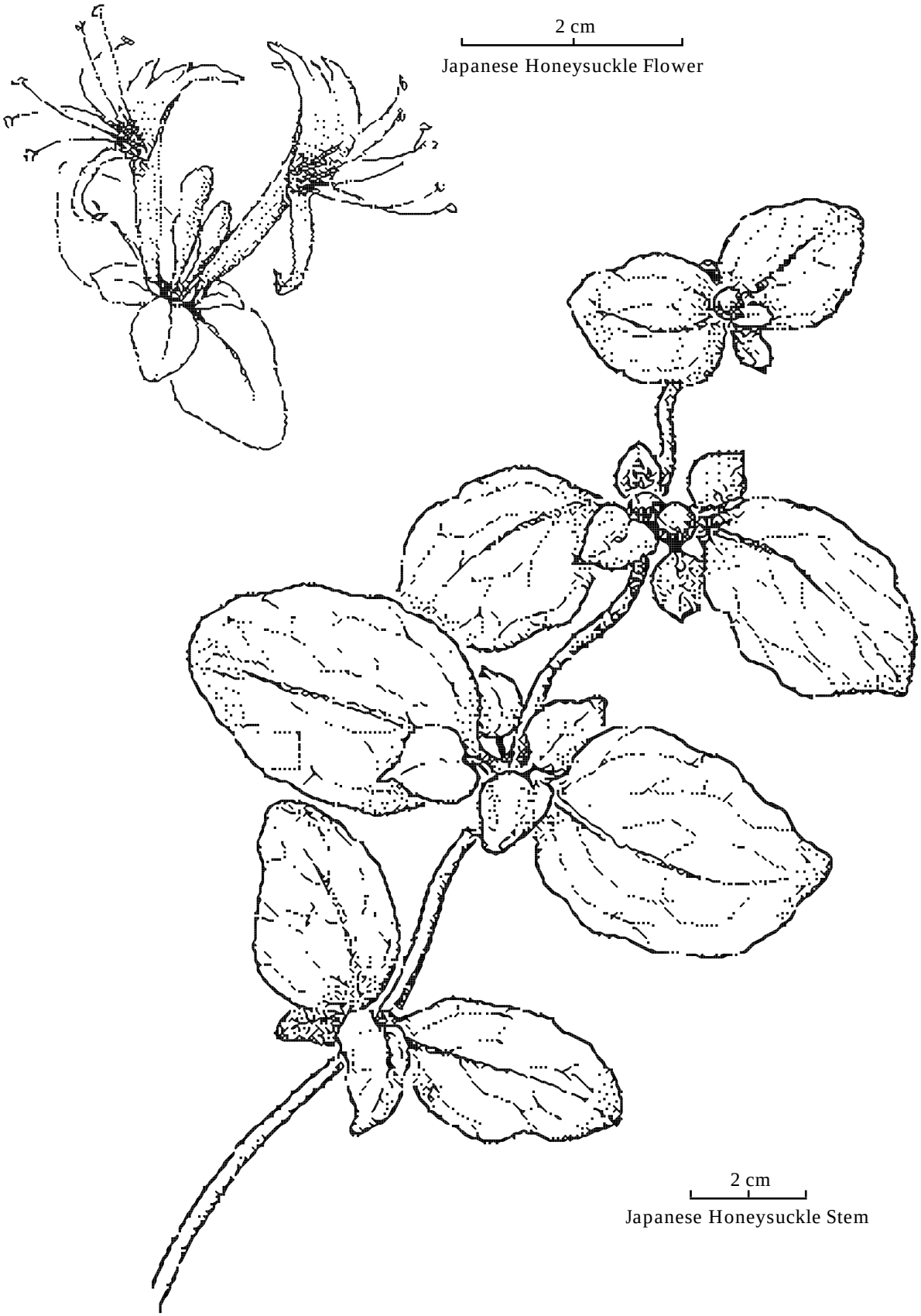
2 cm
Japanese Honeysuckle Flower
2 cm
Japanese Honeysuckle Stem

# Japanese Honeysuckle

*Lonicera japonica* (Thunb.)

Japanese honeysuckle is a perennial climbing or trailing woody vine, introduced from Japan for its value as an ornamental, for erosion control, and for wildlife cover. It became widely established in this country by the early 1900s and has now spread over the eastern and midwestern United States. Japanese honeysuckle is still propagated and promoted as a ground cover in areas where it has not yet become a pest. It belongs to the Caprifoliaceae (Honeysuckle) family.

**Height:** Japanese honeysuckle is a climbing and trailing vine that can reach a total height of 9-12 m (30-40 ft) depending on surrounding vegetation. Annual growth may reach 9 m (30 ft).

**Leaves:** Japanese honeysuckle leaves are evergreen, 3.0-7.5 cm (0.5-3.0 in) long, 1.5-4.5 cm (0.6-1.8 in) wide, ciliate to eciliate, opposite, and ovate. Mature leaves are generally entire although there is a toothed form.

**Stem:** The vines are woody and densely pubescent to glabrous.

**Flowers:** Inflorescence is 0.8-3.0 cm (0.3-1.2 in) long with curved stamens that project from a two-lipped, five-lobed corolla (white or yellow). Flowers are very fragrant and borne in pairs in the axils. Blooms April-June.

**Fruit:** Fruits are small, 5-6 mm (0.19-0.23 in) in diameter, globose to subglobose black berries containing 2-3 seeds each. Matures August-October.

**Seeds:** Seeds are black, lustrous, 3.0-3.3 mm (0.12-0.13 in) long, oval to oblong, and flat to concave on one side and 3-ribbed on the other.

**Life History**

Japanese honeysuckle starts its growing season in early spring when temperatures reach 34-48°F. Vegetative reproduction is through stolons that develop new roots and shoots at short intervals. Japanese honeysuckle flowers prolifically in full sunlight starting in April or May and continuing into June. Seeds, widely dispersed by birds, may germinate in a variety of light conditions and begin photosynthesis almost immediately. Mature plants have relatively shallow root systems that range in depth from 15-30 cm (6-12 in) on moist sites. Although unable to twine around large trees (>15 cm Dbh), honeysuckle vines can attain canopy height by twining around and growing with other vegetation and may girdle the stems or over-top smaller shrubs and trees. Persistent green leaves are able to continue photosynthesis during winter months, contributing to its ability to dominate favorable sites.

**Origin and Distribution**

A native of the Nagasaki area of Japan, Japanese honeysuckle was introduced in 1806 for its delicious fragrance and horticultural uses. By 1919 it had spread from the Gulf

of Mexico to New York. Present distribution extends from Massachusetts to Florida, west to Texas, and north to Illinois and Michigan. Japanese honeysuckle has been identified throughout Tennessee and has reached pest proportions in areas where annual precipitation is at least 100 cm (39 in).

**Similar Species**

Japanese honeysuckle is not easily confused with native twining vine species present in Tennessee. The juvenile stage of native honeysuckle (*Lonicera canadensis* [Bartr.]) resembles the leaf structure of Japanese honeysuckle. Distinguishing characteristics of *L. canadensis* include yellow flowers, shrub-like growth form, and deciduous foliage. It is found only in higher elevations (>3500 ft). Coral honeysuckle (*L. sempervirens* L.) has tubular red flowers in one or more terminal spikes.

**Habitat**

Japanese honeysuckle is associated with disturbance within or along woodlands, roadsides, fence rows, pastures, old fields, and canopy gaps. Once established, it can endure low light levels without noticeable growth and then respond to increased light with vigorous growth. Honeysuckle thrives in fertile, nitrogen-rich soil where an established colony spreads rapidly until nitrogen-poor soil or shade is encountered. As a ground cover it can form dense mats that completely occupy a habitat.

**Management Recommendations**

**Mechanical Control**

Grubbing: This method is appropriate for small initial populations or environmentally sensitive areas where herbicides cannot be used. Using a pulaski or similar digging tool remove the entire plant, including all roots and runners. Juvenile plants can be hand pulled depending on soil conditions and root development. Any portions of the root system not removed may resprout. All plant parts, including mature fruit, should be bagged and disposed of in a trash dumpster to prevent reestablishment.

**Herbicidal Control**

Cut Stump Treatment: Use this method in areas where vines are established within or around non-target plants, or where they have grown into the canopy. This treatment remains effective at low temperatures as long as the ground is not frozen.

Glyphosate: Cut the stem 5 cm (2 in) above ground level. Immediately apply a 25% solution of glyphosate and water to the cross-section of the stem. A subsequent foliar application of glyphosate may be required to control new seedlings and resprouts.

Triclopyr: Cut the stem 5 cm (2 in) above ground level. Immediately apply a 25% solution of triclopyr and water to the cross-section of the stem. A subsequent foliar application may be necessary to control new seedlings.

Foliar Spray Method: Use this method to control large populations. It may be necessary to precede foliar applications with stump treatments to reduce the risk of damaging non-target species.

Glyphosate: Apply a 2% solution of glyphosate and water to thoroughly wet all foliage. Do not apply so heavily that herbicide will drip off leaves. The ideal time to spray is after surrounding vegetation has become dormant (October-November) to avoid affecting non-target species. A 0.5% non-ionic surfactant is recommended in order to penetrate the leaf cuticle. Ambient air temperature should be above 65°F.

Triclopyr: Apply a 2% solution of triclopyr and water to thoroughly wet all foliage. Do not apply so heavily that herbicide will drip off leaves. The ideal time to spray is after surrounding vegetation has become dormant (October-November) to avoid affecting non-target species. A 0.5% non-ionic surfactant is recommended in order to penetrate the leaf cuticle. Ambient air temperature should be above 65°F.

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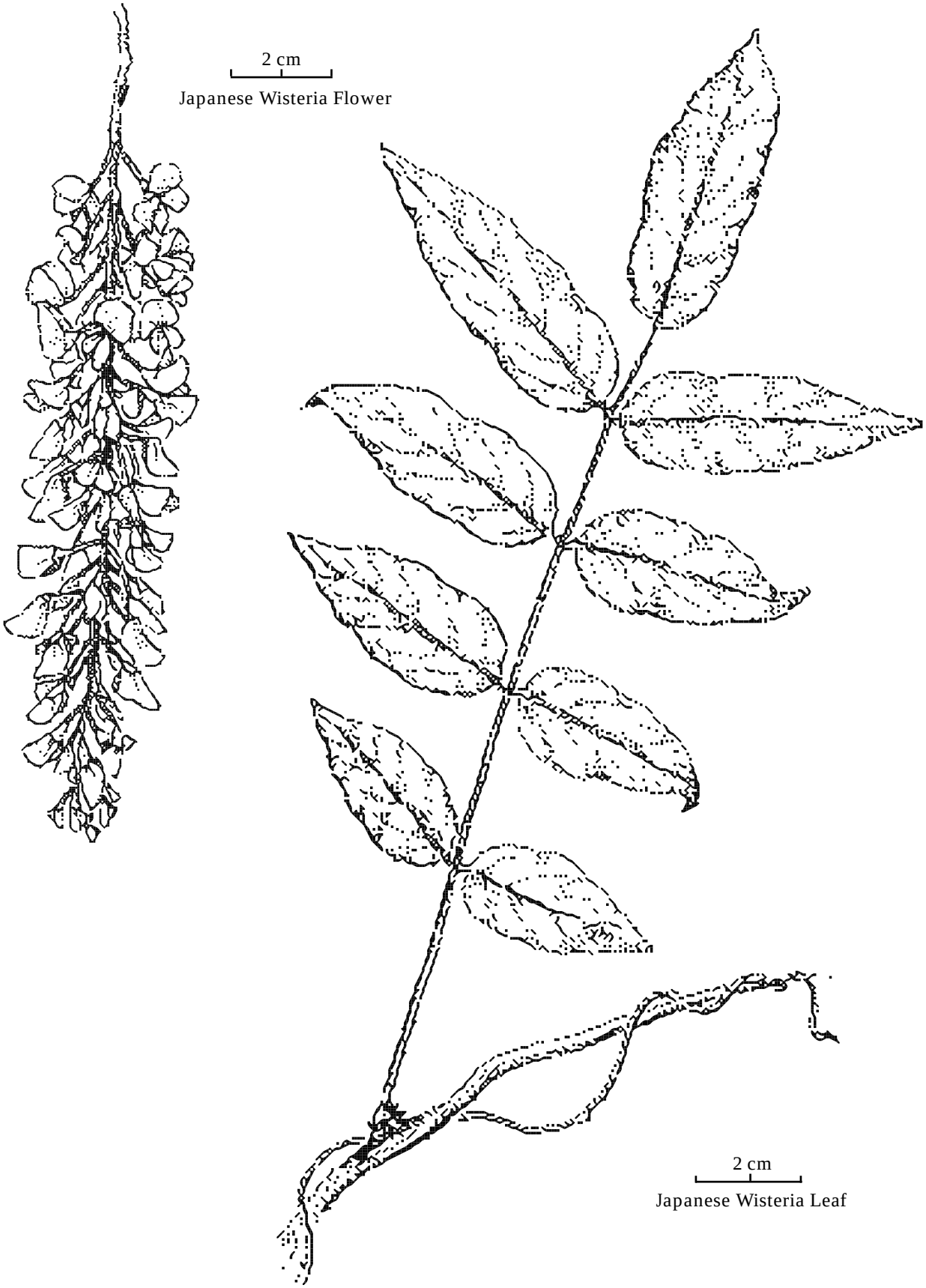
2 cm
Japanese Wisteria Flower
2 cm
Japanese Wisteria Leaf

# Japanese Wisteria

*Wisteria floribunda* (Willd.) DC.

Japanese wisteria is one of several members of its genus that are popular ornamentals. It is hardy and aggressive, capable of forming thickets so dense that little else grows. It constricts the stems of trees and kills them by girdling or over-topping. Wisteria belongs to the Fabaceae (Pea or Bean) family.

**Height:** Wisteria can climb trees and shrubs to 20 m (65 ft).

**Stem:** White-barked wisteria vines twine clockwise around its host. Stems are stout, up to 16 cm (15 in) and woody. Buds are solitary and appressed.

**Leaves:** Alternate, pinnately compound leaves are 20-30 cm (7.8-11.8 in) long with 13-19, ovate-elliptic to oblong, 4-8 cm (1.6-3.1 in) long leaflets.

**Flowers:** Very showy, fragrant pea-like flowers 1.5-2.0 cm (0.5 -0.75 in) long, grow in pendulous racemes 20-50 cm (8-20 in) in length. Flowers are purple, blue-purple, or lilac-blue in color. They have five-toothed calyxes. The two upper teeth are often more or less united and shorter than the others. The standard or banner petal is large and reflexed, while the wing petals are sickle-shaped. Blooms April-July.

**Fruits:** The fruits are flattened pods 10-15 cm (4-6 in) long, narrowed toward the base, and more or less constricted between the seeds. Matures July-November.

**Life History**

Wisteria is a perennial vine that may live for over 50 years. Vegetative reproduction is the primary means of expansion; numerous stolons develop new roots and shoots at short intervals. Wisteria can also produce abundant seeds if conditions are favorable, but flower buds produced in the fall are susceptible to winter kill. In riparian habitats, seeds may be dispersed downstream in water for great distances.

**Origin and Distribution**

Japanese wisteria was introduced from Japan around 1830 as an ornamental. It was popular in the southern U.S. as a decorative addition to porches, gazebos, walls, and gardens. Wisteria is hardy enough to be found in New England, and a few areas farther north.

**Similar Species**

There are 10 species of wisteria; only two are native to the United States while the others are native to Asia. *W. frutescens* (L.) Poir. and *W. macrostachya* (T. & G.) Small. are native to the southeastern United States. It is similar to Japanese wisteria in height, leaf, and flower structure. Japanese wisteria is hardier and more invasive than the native species. Identification must be made carefully, especially with hybrids. One distinctive quality of Japanese wisteria is its fragrant flowers. Consult detailed reference material before taking treatment action.

**Habitat**

Ideal habitat for wisteria is in full sun, but established vines will persist and reproduce in partial shade. Often they climb surrounding vegetation toward sunlight. Twining wisteria vines may reduce the vigor of competing vegetation by strangling the stems or shading the crown. Wisteria tolerates a variety of soil and moisture regimes but prefers loamy, deep, and well-drained soil. Populations often spread from neglected gardens but are commonly found along forest edges, roadsides, ditches, and rights-of-way.

**Management Recommendations**

**Mechanical Control**

Cutting: Cut climbing or trailing vines as close to the root collar as possible. This technique is feasible on small populations, as a pretreatment on large impenetrable sites, in areas where a herbicide cannot be used, or if labor resources are not sufficient to adequately implement herbicidal control. This treatment will prevent seed production and strangulation of surrounding woody vegetation. Wisteria will resprout unless cut so frequently that its root stores are exhausted. Treatment should begin early in the growing season and be repeated at two-week intervals until autumn.

Grubbing: This method is appropriate for small initial populations or environmentally sensitive areas where herbicides cannot be used. Using a pulaski or similar digging tool, remove the entire plant, including all roots and runners. Juvenile plants can be hand pulled depending on soil conditions and root development. Any portions of the root system not removed may resprout. All plant parts, including mature fruit, should be bagged and disposed of in a trash dumpster to prevent reestablishment.

**Herbicidal Control**

Cut Stump Treatment: Use this method in areas where vines are established within or around non-target plants or where vines have grown into the canopy. This treatment is effective as long as the ground is not frozen.

Glyphosate: Cut the stem 5 cm (2 in) above ground level. Immediately apply a 25% solution of glyphosate and water to the cross-section of the stem. This procedure may require a subsequent foliar application of glyphosate.

Triclopyr: Cut the stem 5 cm (2 in) above ground level. Immediately apply a 25% solution of triclopyr and water to the cross-section of the stem. A subsequent foliar application may be necessary to control new seedlings.

Foliar Spray Method: Use this method to control large populations. It may be necessary to precede foliar applications with stump treatments to reduce the risk of damaging non-target species.

Glyphosate: Apply a 2% concentration of glyphosate and water plus a 0.5% nonionic surfactant to thoroughly wet all foliage. Do not apply so heavily that herbicide will drip off leaves. Glyphosate is a non-selective systemic herbicide that may kill non-target partially-sprayed plants. Ambient air temperature should be above 65°F.

Triclopyr: Apply a 2% concentration of triclopyr and water to thoroughly wet all foliage. Do not apply so heavily that herbicide will drip off leaves. A 0.5% concentration of a non-ionic surfactant is recommended in order to penetrate the leaf cuticle. Ambient air temperature should be above 65°F.

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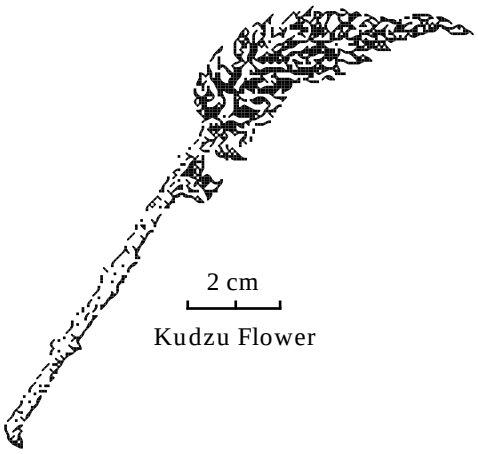
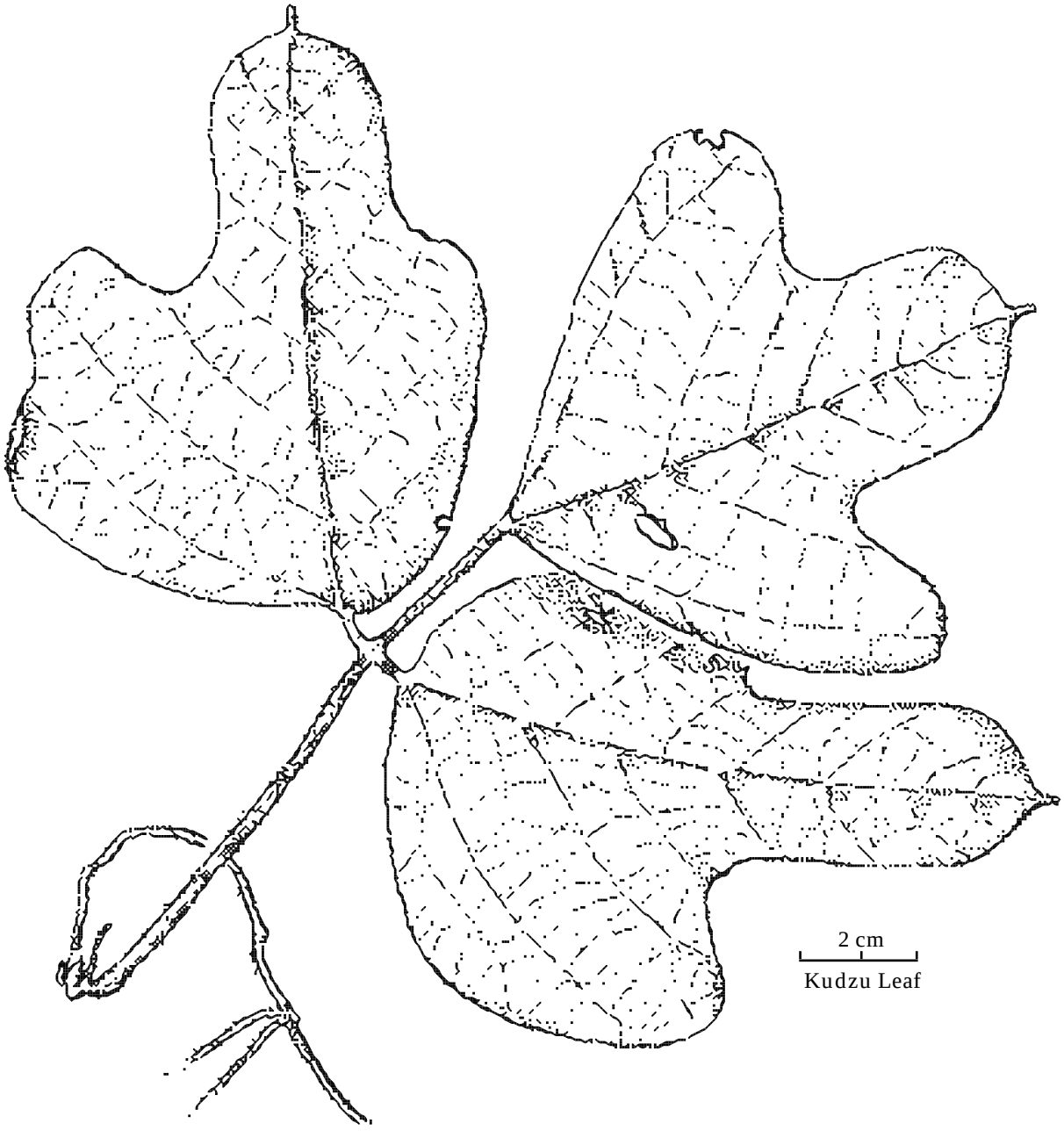


2 cm

Kudzu Flower



2 cm

Kudzu Leaf

# Kudzu

*Pueraria montana* (Lour.) Merr.

This aggressive vine can grow 60 feet per year forming a continuous blanket of foliage. This massive covering often chokes out competing native vegetation that provides food and habitat for native animals. The result is a large-scale alteration of biotic communities. Kudzu is also a problem in forest agriculture and landscaping. It belongs to the Fabaceae (Pea or Bean) family.

**Height:** Trailing or climbing semi-woody, perennial vines reach 30 m (98 ft) in length.

**Roots:** Kudzu roots typically reach a soil depth of 1-3 m (3-9 ft) and are capable of storing large amounts of carbohydrates. Roots are tuberous, up to 17.8 cm (7 in) in diameter.

**Stem:** First year vines are pubescent and may reach 1.3 cm (0.5 in) diameter. Old vines are fibrous, relatively soft, and may reach a diameter of 10 cm (4 in).

**Leaves:** Foliage is alternate and compound (trifoliate) with leaflets up to 10 cm (4 in) across. Each leaflet is entire or deeply 2-3 lobed with hairy margins. Foliage drops after the first fall frost.

**Flowers:** Kudzu plants do not usually flower until their third year. Flowers are purple, fragrant, about 1.3 cm (0.5 in) long, produced in long racemes, and resemble pea flowers in shape. Blooms July-October.

**Fruit:** Three hard seeds are contained in flat, 5 cm (2 in) long, hairy pods. Matures September-October.

**Life History**

Kudzu is a leguminous perennial actively growing from early summer (May) until the first frost. Sexual reproduction is rare, however seeds have been collected in the Great Smoky Mountains National Park and sprouted in a laboratory dish. Kudzu establishes plants by forming roots at nodes where the vines come in contact with the soil. These roots enlarge to form new crowns. Vines grow rapidly— increases of 15 m (50 ft) in a single season are not uncommon. Roots can penetrate the soil to depths of 3 m (9 ft).

**Origin and**

A native of Asia, kudzu was introduced into the United States at the Philadelphia Centennial Exposition in 1876. By 1900 kudzu was available through mail order and sold mainly as an inexpensive livestock forage. The Soil Erosion Service (later renamed the Soil Conservation Service) distributed approximately 85 million seedlings starting in 1933 in an effort to control agricultural erosion. In 1953 the USDA removed kudzu as a cover plant and listed it as a common weed of the South in 1970. It is estimated that kudzu now covers seven million acres in the southeast. Distribution is as far north as Pennsylvania, Illinois, and Connecticut and from east-

ern Texas to central Oklahoma in the west. The largest infestations are found in Mississippi, Alabama, and Georgia.

**Similar Species**

Kudzu may be confused with other three-lobed legumes such as dollar leaf (*Desmodium rotundifolium* [DC.]). Distinguishing features of kudzu include: densely pubescent young stem, ovate/trifoliate leaves, and highly invasive characteristics often seen as large areas of contiguous cover. Hog peanut (*Amphicarpaea bracteata* [L.]) may be mistaken for young kudzu vines, but it does not have pubescent stems or climb extensively into tree crowns.

**Habitat**

Kudzu grows well under a wide range of environmental conditions, although greatest growth is achieved where winters are mild (40-60°F), summer temperatures rise above 80°F, and rainfall is abundant (101+ cm [39 in]). Kudzu can grow in nearly any type of soil (e.g., acid soils, lime soils, lowlands with high water tables, and over heavy subsoil), and where winter soil temperatures remain above -25°F. Large roots allow plants to survive in fairly dry climates and drought conditions. Ideal conditions are moist to well drained and acid to neutral soils (4.5-7.0 pH). New growth may exceed one foot per day . Forest edges or disturbed areas, such as abandoned fields and roadsides, are preferred habitats. Kudzu can persist on the floor of a closed canopy forest; the vines grow up trees toward light and take advantage of any openings.

**Management Recommendations**

**Mechanical Controls**

Grubbing: Using a pulaski or similar digging tool, remove the entire plant, including the taproot. Removed vegetation should be destroyed by burning or bagging. Because many roots exceed 1.8 m, eradication by this method is very difficult and should be considered primarily for small initial incursions.

Cutting: Vines and runners are chopped just above the ground level, and the pieces destroyed. Early in the season, cutting is repeated at two-week intervals, to weaken the crown and prevent resumption of photosynthesis. Later in the season, when the stored energy in the taproot has been reduced, the interval between cuttings can be extended. Cutting does not typically kill roots and should only be used to control the spread of kudzu.

**Herbicidal Control**

Cut Stump Method: Use this method in areas where vines are established within or around non-target plants or where vines have grown into the canopy.

Glyphosate: Cut the stem 5 cm (2 in) above ground level. Immediately apply a 25% solution of glyphosate and water to the cross-section of the stem. This procedure is effective at temperatures as low as 40°F, and may require a subsequent foliar application of glyphosate.

Triclopyr: Cut the stem 5 cm (2 in) above ground level. Immediately apply a 25% solution of triclopyr and water to the cross-section of the stem. This procedure

remains effective at low temperatures (<60°F) as long as the ground is not frozen. A subsequent foliar application may be necessary to control new seedlings.

Foliar Spray Method: Use this method to control large populations. It may be necessary to precede foliar applications with stump treatments to reduce the risk of damaging non-target species. After the stems and leaves have been brought under control (i.e., all above ground portions of the plants have been effectively treated) further treatment should follow the Root Crown Method.

Glyphosate: Apply a 2% concentration of glyphosate and water plus a 0.5% non-ionic surfactant to thoroughly wet all foliage. Do not apply so heavily that herbicide will drip off leaves. Glyphosate is a non-selective systemic herbicide that may kill non-target partially-sprayed plants. Ambient air temperature should be above 65°F.

Triclopyr: Apply a 2% concentration of triclopyr and water to thoroughly wet all foliage. Do not apply so heavily that herbicide will drip off leaves. A 0.5% concentration of a non-ionic surfactant is recommended in order to penetrate leaf cuticle. Ambient air temperature should be above 65°F.

Root Crown Method: Follow the young or resprouting stem of the plant to the root. Dig and cut into the root crown using a pulaski or similar tool. Apply a 50% glyphosate solution or 50% triclopyr solution to the main root crown and any below ground runners.

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2 cm
Oriental Bittersweet Fruit
2 cm
Oriental Bittersweet Stem

# Oriental Bittersweet

*Celastrus orbiculata* Thunb.

Oriental bittersweet is a serious threat to plant communities due to its high reproductive rate, long range dispersal, ability to root sucker, and rapid growth rate. Climbing Oriental bittersweet vines severely damage native vegetation by constricting and girdling stems. Vines can shade, suppress, and ultimately kill native vegetation. Oriental bittersweet has been shown to hybridize with the relatively rare American bittersweet (*Celastrus scandens* L.). Hybridization may lead to the loss of American bittersweet's genetic identity through introgression. Both are members of the Celastraceae (Staff-tree) family.

**Height:** Oriental bittersweet is a deciduous woody vine that may become a spreading, trailing shrub. Maximum height can reach 19 m (60 ft) depending on surrounding vegetation. Vines grow up to 10 cm (4 in) in diameter.

**Leaves:** Leaves are alternate and are variable in size and shape from oblong-obovate to suborbicular. Margins are crenate-serrate and base cuneate to obtuse. Petioles are 1-3 cm (0.4-1.2 in) long.

**Stem:** Stems and branches are round, glabrous, light to dark brown with discernible lenticels.

**Flowers:** Inflorescence is a few-flowered (3-7) axillary cyme. Flowers have 5 sepals and 5 petals, and are greenish-yellow in color. Varieties can be dioecious or monecious. Blooms in May.

**Fruit:** Fruit is green changing to bright yellow upon maturity. The globose fruits are 6-8 mm (0.2-0.3 in) in diameter, three valved with each fruit containing one to three seeds. Matures August-September.

**Life History**

Oriental bittersweet flowers in May in Tennessee. Hymenopterous insects, especially bees, are the primary pollinators, but wind pollination is also successful. Fruit ripens in August through September and remains on the stem into the winter. Seed dispersal is by birds or small mammals. Seedling germination is generally high (up to 95%) and begins in mid to late spring. The highest rate of seed germination is in lower light intensities. Seedlings increase photosynthesis two-fold when exposed to direct sunlight. The plants develop and expand by layering stolons and rootsuckers. Annual growth rate is from 0.3-3.0 m (1-12 ft) with little additional growth after about seven years.

**Origin and Distribution**

Oriental bittersweet is native to Japan, Korea, and northern China. It was introduced into the U.S. in 1860. Naturalized plants were first collected in Connecticut in 1916. Oriental bittersweet has become naturalized in 21 of 33 states in which it is cultivat-

ed. Present distribution is throughout the northeastern and southeastern U.S. extending to the southeastern Great Plains.

**Similar Species**

Oriental bittersweet is similar in appearance to American bittersweet and anyone surveying for Oriental bittersweet should verify identification. Oriental bittersweet differs from American bittersweet by having axillary inflorescences instead of terminal flower clusters. However, inflorescences are sometimes terminal in male Oriental bittersweet plants. A less reliable difference is the color of the outer covering of the fruit. The fruit of Oriental bittersweet is yellow while American bittersweet fruit is orange.

**Habitat**

Oriental bittersweet has a wide range of habitat preferences including roadsides, old homesites, thickets, and alluvial woods. Oriental bittersweet is shade tolerant, readily germinating and growing under a closed forest canopy.

**Management Recommendations**

Since Oriental bittersweet produces numerous seeds, extensive seed reserves can become established in the soil within a year or two. Seeds of Oriental bittersweet remain viable for several years and control actions must continue until seed sources are eliminated.

**Mechanical Control**

Cutting: Cut climbing or trailing vines as close to the root collar as possible. This technique is feasible on small populations; as a pretreatment on large impenetrable sites; in areas where herbicide cannot be used; or if labor resources are not sufficient to adequately implement herbicidal control. This treatment will prevent seed production and strangulation of surrounding woody vegetation. Oriental bittersweet will resprout unless cut so frequently that its root stores are exhausted. Treatment should begin early in the growing season and be repeated at two-week intervals until autumn.

Grubbing: This method is appropriate for small initial populations or environmentally sensitive areas where herbicides cannot be used. Using a pulaski or similar digging tool, remove the entire plant, including all roots and runners. Juvenile plants can be hand pulled depending on soil conditions and root development. Any portions of the root system not removed will potentially resprout. All plant parts, including mature fruit, should be bagged and disposed of in a trash dumpster to prevent reestablishment.

**Herbicidal Control**

Stump Treatment: Use this method in areas where vines are established within or around non-target plants, or where vines have grown into the canopy.

Glyphosate: Cut the stem 5 cm (2 in) above ground level. Immediately apply a 25% solution of glyphosate and water to the cross-section of the stem. This procedure is effective at temperatures (as low as 40°F) and may require a subsequent foliar application of glyphosate.

Triclopyr: Cut the stem 5 cm (2 in) above ground level. Immediately apply a 25% solution of triclopyr and water to the cross-section of the stem This procedure remains effective at low temperatures (<60°F) as long as the ground is not frozen. A subsequent foliar application may be necessary to control new seedlings.

Foliar Spray Method: Use this method to control large populations. It may be necessary to precede foliar applications with stump treatments to reduce the risk of damaging non-target species.

Glyphosate: Apply a 2% solution of glyphosate and water plus 0.5% non-ionic surfactant to thoroughly wet all foliage. Do not apply so heavily that herbicide will drip off leaves. Glyphosate is a non-selective systemic herbicide that may kill non-target partially sprayed plants. Ambient air temperature should be above 65°F.

Triclopyr: Apply a 2% solution of triclopyr and water to thoroughly wet all foliage. Do not apply so heavily that herbicide will drip off leaves. The ideal time to spray is after surrounding native vegetation has become dormant (October-November) to avoid affecting non-target species. A 0.5% concentration of a non-ionic surfactant is recommended in order to penetrate leaf cuticle. Ambient air temperature should be above 65°F.

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**Achene:** A small, dry, hard one-locular, one-seeded closed fruit with a thin pericarp, derived from a one-carpellate ovary.

**Acuminate:** Long-tapering to a pointed apex.

**Adventitious:** Buds or roots that develop without pattern.

**Annual:** Life cycle completed in one year or one season.

**Axil:** The angle found between any two organs or structures.

**Biennial:** Plant with life cycle completed in two years or seasons.

**Bipinnate:** A pinnate leaf with the divisions also being pinnate, twice pinnate.

**Bracts:** A reduced leaf, particularly one subtending a flower as the involucral bracts in Asteraceae.

**Calcareous:** Of the nature of, or containing, lime.

**Calyx:** The usually green, outer whorl or series of whorls surrounding flower petals.

**Cauline:** Pertaining or belonging to an evident stem or axis, as opposed to basal.

**Ciliate:** With hairs arranged on the edge of a flattened structure such as a leaf or petal.

**Compound:** Composed of two or more similar and united parts, as in a compound pistil or leaf.

**Cordate:** With a sinus or rounded lobe at the base.

**Corolla:** The inner, usually colored or otherwise differentiated, whorl or whorls of the perianth.

**Corymb:** Short, broad, more or less flat-topped indeterminate inflorescence, the outer flowers opening first.

**Crenate:** Shallowly round-toothed or teeth obtuse; scalloped.

**Cuneate:** Wedge-shaped; triangular, with the narrow end at the point of attachment, at the bases of certain leaves or petals.

**Cyme:** A broad, flattish determinate inflorescence, the central flowers maturing first.

**Deciduous:** Not persistent or evergreen.

**Decumbent:** Reclining or lying on the ground, but with the end ascending.

**Dioecious:** Having staminate and pistillate flowers on separate plants.

**Drupes:** A fleshy, usually one-seeded indehiscent fruit with seed enclosed in a stony endocarp.

**Eciliate:** Without hairs arranged on the edge of a flattened structure such as a leaf or petal.

**Elliptic:** Having narrow to relatively round ends and being widest at or about the middle, two-dimensional, essentially laminate.

**Entire:** A margin without teeth, lobes or divisions.

**Glabrous:** Without hairs, smooth.

**Glaucous:** Covered with a fine, waxy, removable powder that imparts a whitish or bluish cast to the surface.

**Globose:** Globular or spherical in shape.

**Hirsute:** With rather rough or coarse hairs.

**Hymenopterous:** Pertaining or belonging to an order of insects, Hymenoptera, having four membranous wings, comprising the wasps, bees, ants, etc.

**Inflorescence:** The flowering section of a plant.

**Involucre:** A whorl or collection of bracts surrounding or subtending a flower cluster or a single flower.

**Lanceolate:** Lance-shaped, much longer than wide, widened at or above the base and opening to the apex.

**Lenticels:** A lens-shaped, biconvex spot on the surface of a plant, which serves as a pore.

**Mericarps:** The individual, separated carpels of a schizocarp as in the Apiaceae or the "nutlets" in the Boraginaceae.

**Monoecious:** With staminate and pistillate flowers on the same plant.

**Monotypic:** Having only one representative, as a genus with a single species.

**Non-ionic surfactant:** A surface active agent that reduces the surface tension between it and another liquid not occurring in the form of ions.

**Obtuse:** Blunt, rounded at the end.

**Odd-pinnate:** Pinnately compound and with a terminal leaflet, so that typically there is an odd number of leaflets.

**Ovate:** With an outline like that of a hen's egg, the broader end below the middle, having two dimensions.

**Panicles:** An indeterminate branching raceme; an inflorescence in which the branches of the primary axis are racemose and the flowers pedicellate.

**Pedicel:** The support of a single flower in a cluster, any stalk or stem between sepals and main axis.

**Perennial:** A plant living three or more years duration.

**Perfect flowers:** Bisexual; having both male and female sexual organs.

**Petiole:** The stalk by which a leaf is attached to the stem; leaf stalk.

**Phytophagous:** Herbivorous.

**Pinnate:** With the leaflets or pinnae of a compound leaf placed on either side of the prolongated petiole, feather-like.

**Plumose:** Feathery appearance often from long dense pubescence; the pappus of some Asteraceae.

**Polygamous:** Bearing unisexual and bisexual flowers on the same plant, or different individuals of the same species.

**Pubescent:** Covered with soft, short hairs.

**Raceme:** A simple, elongated, indeterminate inflorescence with pedicelled or stalked flowers.

**Rhizome:** Usually elongate, horizontal underground or subsurface stem, usually rooting at the nodes.

**Samaroid:** Like or as a samara; an indehiscent, usually one-seeded winged fruit, such as a maple or elm.

**Schizocarp:** A fruit that splits between carpels into two or more one-seeded portions, as in the Apiaceae or Boraginaceae.

**Serrate:** With sharp teeth pointing forward.

**Sessile:** Attached by the base without a stalk or stem.

**Silique:** The long slender fruit of certain Brassicaceae, much longer than broad.

**Squarrose:** Abruptly spreading or recurved at some point above the base.

**Suborbicular:** Circular or round on the under side or beneath.

**Surfactant:** Any substance that when dissolved in an aqueous solution reduces its surface tension between it and another liquid.

**Terete:** Cylindrical, usually solid or slightly tapering, and round in cross-section.

**Terminal:** Growing at the tip or end of a branch or stem, as in a bud or inflorescence.

**Tomentose:** Closely covered with down or matted hair.

**Truncate:** Square or broad at the end, not tapered, base or apex essentially straight across.

**Tuberous:** Having a fleshy enlarged portion of a rhizome or stolon with only vestigial scales; true tubers found in the Solanaceae.

**Umbel:** An inflorescence with pedicels or flower stalks or both, nearly equal in length and arising from a common point; umbrella shaped.

**Whorl:** Three or more leaves or flowers at one node in a circle.

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### Foliar Treatments

Foliar applications should be made with a low pressure (20-50 psi) backpack sprayer at rates of one gallon or less per minute. All foliar treatments should be made after full leaf expansion in the spring and before fall colors are visible. Allow herbicide treatments to dry for at least three hours at an air temperature above 60°F to ensure adequate absorption and translocation. In areas that receive significant public use, it may be necessary to close off the treatment area until the herbicide has completely dried.

Use a nonionic surfactant with all herbicide solutions, unless otherwise specified by the manufacturer's label. Surfactants increase the effectiveness of the herbicide by 1) reducing surface tension and ensuring complete foliar coverage, and 2) increasing the rate of absorption through the leaf cuticle.

Apply herbicide with a backpack or similar hand-operated pump sprayer equipped with a flat spray tip or adjustable cone nozzle. Apply herbicide to the leaves and stems of target plants using a consistent back and forth motion. Herbicide should thoroughly cover foliage, but not to the point of run-off. All recommended herbicides require complete foliar coverage to be effective. Applications made while walking backward will reduce the risk of the herbicide wicking onto the applicator's clothing.

### Cut Surface Treatments

Cut surface treatments include hack and squirt, girdle, and cut stump methods. The main advantages to these methods are: 1) they are very economical, 2) there is minimal probability of non-target damage, 3) minimal application time, and 4) they can be used in the winter as long as the ground is not frozen. Backpack sprayers or spray bottles are very effective for all of these methods.

Hack and Squirt Method: Using an axe or similar cutting tool, make uniformly spaced cuts around the base of the stem. The cuts should angle downward, be less than 2.5 cm (1 in) apart, and extend into the sapwood. Apply herbicide to each cut to the point of over flow.

Frill Method: Using an axe or similar cutting tool, make continuous cuts around the base of the stem. The cuts should angle downward, be less than 2.5 cm (1 in) apart, and extend into the sapwood. Apply the recommended herbicide to the entire cut area to the point of over flow.

Cut Stump Method: Horizontally cut stems at or near ground level; all cuts should be level, smooth, and free of debris. Immediately apply the herbicide to the outer 20% (cambial area) of the stump; delayed treatment may reduce the effectiveness of treatment.

### Basal Bark Treatments

Basal bark treatments are effective for controlling woody vines, shrubs, and trees. Treatments can be made any time of year, including the winter months, except when snow or water prevent spraying the basal parts of the stem. Proper plant identification is crucial during the dormant season due to the absence of foliage.

Apply herbicide with a backpack sprayer using low pressure (20-40 psi) with a straight stream or flat fan tip. To control vegetation with a basal stem diameter of less than 7.6 cm (3.0 in) apply specified

herbicide-oil mixture on one side of the basal stem to a height of 15.25 cm (6 in) from the base. Apply herbicide to the point of run-off; within an hour mixture should almost encircle the stem. For stems greater than 7.6 cm (3.0 in) basal diameter or with thick bark, treat both sides of the stem to a basal height of 30.5 cm (12 in) to 61 cm (24 in).

All herbicides should be applied in accordance with specific label instructions, which include personal protective equipment and storage requirements.

| Brand Name & Manufacturer | Generic Name | Application |
|---|---|---|
| Numerous brands & manufacturers | 2,4-D Amine | Dicot-Specific, Foliar |
| Garlon 3A Dow Chemical | Triclopyr triethanolamine salt | Dicot-Specific Foliar, basal bark injection, cut surface |
| Garlon 4 Dow Chemical | Triclopyr butoxyethyl ester injection, cut surface | Dicot-Specific Foliar, basal bark |
| Rodeo Monsanto | Glyphosate | Non-Selective Foliar, cut surfaces Approved for water. |
| Accord Monsanto | Glyphosate | Non-Selective, Foliar, Cut surfaces. Approved for wet areas and near water. |
| RoundUp Monsanto | Glyphosate | Non-Selective, Foliar, Cut surfaces. Cannot be used over water because it contains a surfactant which is not approved for aquatic use. |
| Diquat ICI Agrochemicals | Diquat | Non-Selective Contact herbicide Foliar application (Does not kill roots) |
| Sonar Lily (Elanco) | Fluridone | Non-Selective, Submerged aquatic weeds in contained water body |

With any herbicide use, always read and follow the label instructions. The label is the law. Follow all instructions concerning safety gear requirements and first-aid. With the application of all herbicides, always wear impenetrable rubber gloves and eye protection. Additional personal safety gear may be required for mixing. Use respirators when a respiratory hazard is indicated on the label. If you have any questions, do not hesitate to call the manufacturer. Each herbicide label will contain a phone number for customer inquiries.

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### Linear Measure

| English Unit | Metric Unit |
|---|---|
| 1 inch | 25.4 millimeters<br>2.54 centimeters |
| 1 foot | 30.48 centimeters<br>3.048 decimeters<br>0.3048 meters |
| 1 yard | 0.9144 meter |
| 1 mile | 1609.3 meter<br>1.6093 kilometers |
| 0.03937 inch<br>0.3937 inch<br>3.937 inches | 1 millimeter<br>1 centimeter<br>1 decimeter |
| 39.37 inches<br>3.2808 feet<br>1.0936 yards | 1 meter |
| 3280.8 feet<br>1093.6 yards<br>0.62137 mile | 1 kilometer |

### Liquid Measure

| English Unit | Metric Unit |
|---|---|
| 1 fluid ounce | 29.573 milliliters |
| 1 quart | 9.4635 deciliters<br>0.94635 liter |
| 1 gallon | 3.7854 liters |
| 0.033814 fluid ounce<br>3.3814 fluid ounces | 1 milliliter<br>1 deciliter |
| 33.814 fluid ounces<br>1.0567 quarts<br>0.2617 gallon | 1 liter |