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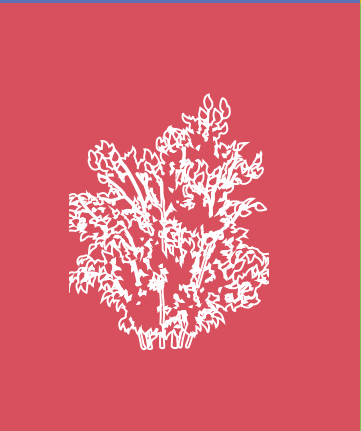
INVASIVE PLANTS FIELD & REFERENCE GUIDE:

An Ecological Perspective of Plant Invaders of Forests & Woodlands






Berberis thunbergii **invading a disturbed forest. USDA Forest Service photo by Cynthia Huebner.**

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An Ecological Perspective of Plant Invaders of Forests & Woodlands

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INTRODUCTION

Purpose of this Field Guide:

There are many field guides available about invasive plants and their identification. The purpose of this field guide is to give a brief scientific synthesis of what is known about the behavior of select invasive species in managed, disturbed, and pristine forested systems. It also provides key information for accurate identification. Such information will be helpful when prioritizing research questions and choosing the best control strategies. Control methods for each species are not provided. The most successful control methods are most often site-specific; overgeneralizing control methods might lead to poor management and frustrating outcomes. This is not to say that the information that is available should not be used; this guide just could not do it justice and still achieve its primary goals.

Four Goals:

1. While there is a great deal of publicly available information about many invasive plants, much of this information lacks corresponding citations for verification. The first goal of this guide is to help provide such information, using mostly peer-reviewed scientific publications and other primary sources. If information about a species provided in other guides or web pages could not be verified by valid sources, it was not included in the species description.
2. Despite the first goal's scientific nature, the second goal is to make this book accessible to a variety of people, including private landowners and managers as well as researchers. This is done by providing simple, cursory descriptions that can then be read about in more detail (if desired) using the corresponding citations. Relevant botanical terms and phrases are defined in the Glossary.
3. The third goal is to emphasize the dynamic nature of invasions and science. Species will be updated, and new ones added from a prioritized list of invaders, as funding and time allow.
4. The last goal is to provide a true-to-form field guide that can be used extensively in field situations. This required the book to have small, weatherproof, interchangeable pages that allow users to organizefor specific field conditions and add new species pages when available.

A Collaborative Effort:

The U.S. Department of Agriculture Forest Service recognizes the threat of invasive plant species to public and private forests is serious. Successful progress in prevention, control, research, and restoration from the negative impacts of such invasions is only possible using a concerted and organized effort. This guide is a collaboration between the Forest Service Eastern Region and Northern Research Station; it was made possible with the guidance and support of Noel Schneeberger, Don Dagnan, John Kyhl, Nancy Berlin, Jan Schultz, Sierra Dawkins, and several botanists (see Acknowledgements).

Guide Organization:

This guide contains at least 30 species of potential invaders threatening forests of various ages—ranging from recently harvested forests or woodlands to old-growth forests. New plants will be added from an evolving list of 50 species.

Species lists are provided by both scientific and common names and will be updated as needed. In lieu of page numbers, this guide is organized by habit type (herb, vine, shrub, or tree) and then by species scientific name (in alphabetical order) to easily accommodate adding new species. Each species description presents only the most common Latin synonyms. Citations are noted in the text with a small number that corresponds to its entry in the species' citations list at the back of the guide (after the Glossary, ordered by habit and species' scientific names). Photograph information is provided at the end of each citations list.

Comments are welcomed and can be made by contacting the Author of Correspondence Cynthia D. Huebner. Additionally, both the Forest Service Eastern Region and Northern Research Station websites will be updated when new species are available.

Acknowledgements:

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Note: Due to the use of non-weatherproof paper, the glossary and citations pages should be removed before taking this booklet outdoors.

HERBS

Aegopodium podagraria – goutweed
Alliaria petiolata – garlic mustard
Cirsium arvense – Canada thistle
Fallopia japonica – Japanese knotweed
Heracleum mantegazzianum – giant hogweed
Imperata cylindrica – cogongrass
Lespedeza cuneata – Chinese lespedeza
Microstegium vimineum – Japanese stiltgrass
Miscanthus sinensis – eulalia
Ranunculus ficaria – lesser celandine
Rumex acetosella – sheep sorrel

VINES

Akebia quinata – chocolate vine
Celastrus orbiculatus – oriental bittersweet
Lonicera japonica – Japanese honeysuckle
Persicaria perfoliata – mile-a-minute weed
Pueraria montana var. *lobata* – kudzu vine
Vinca minor – common periwinkle
Vincetoxicum nigrum – black swallow-wort

SHRUBS

Berberis thunbergii – Japanese barberry
Elaeagnus umbellata – autumn olive
Euonymus alatus – winged burning bush
Ligustrum sinense – Chinese privet
Lonicera maackii – Amur honeysuckle, bush honeysuckle
Rhamnus cathartica – common buckthorn
Rosa multiflora – multiflora rose
Rubus phoenicolasius – wineberry

TREES

Acer platanoides – Norway maple
Ailanthus altissima – tree of heaven
Paulownia tomentosa – princess tree
Pyrus calleryana – Callery pear

SPECIES LIST BY SCIENTIFIC NAME

SPECIES LIST BY COMMON NAME

HERBS

Canada thistle – *Cirsium arvense*
Chinese lespedeza – *Lespedeza cuneata*
Cogongrass – *Imperata cylindrica*
Eulalia – *Miscanthus sinensis*
Garlic mustard – *Alliaria petiolata*
Giant hogweed – *Heracleum mantegazzianum*
Goutweed – *Aegopodium podagraria*
Japanese knotweed – *Fallopia japonica*
Japanese stiltgrass – *Microstegium vimineum*
Lesser celandine – *Ranunculus ficaria*
Sheep sorrel – *Rumex acetosella*

VINES

Black swallow-wort – *Vincetoxicum nigrum*
Chocolate vine – *Akebia quinata*
Common periwinkle – *Vinca minor*
Japanese honeysuckle – *Lonicera japonica*
Kudzu vine – *Pueraria montana* var. *lobata*
Mile-a-minute weed – *Persicaria perfoliata*
Oriental bittersweet – *Celastrus orbiculatus*

SHRUBS

Amur honeysuckle, bush honeysuckle – *Lonicera maackii*
Autumn olive – *Elaeagnus umbellata*
Chinese privet – *Ligustrum sinense*
Common buckthorn – *Rhamnus cathartica*
Japanese barberry – *Berberis thunbergii*
Multiflora rose – *Rosa multiflora*
Wineberry – *Rubus phoenicolasius*
Winged burning bush – *Euonymus alatus*

TREES

Callery pear – *Pyrus calleryana*
Norway maple – *Acer platanoides*
Princess tree – *Paulownia tomentosa*
Tree of heaven – *Ailanthus altissima*

Habit: Erect, branched, rhizomatous, herbaceous perennial; 40-100 cm (16-39 in) tall.[7]

Reproduction: Vegetative by long-lived rhizomes forming clones;[1,10,11] also by seed[19] but recruitment by seed may be rare.[11]

Leaves: Lower mostly biternate with 9 leaflets (some irregular), and petioles longer than blades; leaflets are oblong to ovate, sharply serrate, 3-8 cm (1-3 in) long;[7] upper leaves are smaller, mostly once-ternate[7] with petioles shorter than blades;[13] rachis of leaf not winged.[13]

Stems: Alternate and glabrous.[7,16]

Flowers: Late spring to early summer;[15] dense umbel, 6-12 cm (2¼-4¾ in) wide, 15-25 subequal rays; petals white, no sepals.[7,13]

Fruits/Seeds: Schizocarp not winged or prominently ribbed;[13] 3-4 mm (~⅛ in) long; each fruit usually with two seeds dispersed late summer; morphophysiological dormancy,[18] the underdeveloped embryo requires extended cold period to germinate;[8,9] radicles emerge in Jan., doing best with 116 days at 4-5 °C (39-41 °F) followed by 7 days of 15 °C (59 °F) during day and 5 °C (41 °F) at night, and cotyledons emerge in Mar., doing best with 11 days alternating day/night temperatures of 25/15 °C (77/59 °F);[12] seed bank documented at 15 years.[4]

GOUTWEED

***Aegopodium podagraria* L.**

APIACEAE

HERB

Aegopodium podagraria
GOUTWEED

Habitat: Native to Europe and Northern Asia;[17] moist, partial shade preferred;[7] USDA hardiness zones 4-8, performs best in zone 8 within shade.[15]

Comments: Most horticultural forms have white-margined leaves[7] and may be less aggressive than the invasive wildtype;[5] non-variegated and wild forms have higher rates of photosynthesis in shade but not full sun;[14] in more northern latitudes produces more shoot biomass than in southern latitudes, possibly an adaptation to a shorter growing season; in shady environments depends more on resources shared through rhizome connections,[11] is less apt to produce seeds,[6] and puts more energy into below ground biomass and storage compared to open environments;[3] as common name implies, once used to treat gout, but other medicinal plants possibly more effective.[2]

Similar Native Species: Golden alexander (*Zizia aurea*) but leaves more finely serrate, flowers bright yellow, fruit prominently ribbed.[13]

Habit: Erect biennial herb;[16] second-year stalks up to ~1 m (3 ft).[5,14,16]

Reproduction: By seed;[16] prefers outcrossing but may self.[8]

Leaves: Lower—kidney-shaped, palmate venation, 2-12 cm (¾-4¾ in) long, form a basal rosette in first year that persists through winter; upper—alternate, triangular, toothed.[5,14,16,30]

Stems: One flowering stem per rosette, but up to 6 possible;[5,34] may branch.[5,14,16]

Flowers: Second year, late Apr.-June;[16,30] numerous 5-7 mm (¼ in) diameter, white, 4-petaled; most in cluster at top of stalk (opening from bottom to top), but some in leaf axils;[5,16] open 2-3 days, but produce nectar primarily on first day; pollinated by medium-sized, short-tongued bees and flies that visit 1-2 flowers per plant.[8]

Fruits/Seeds: Narrow capsules (siliques), 4-7 cm (1½-2¾ in) long,[14,16] contain dark brown to black seeds;[5,16] up to 3,000 seeds per plant, animal and water dispersed[5] in late summer; cold and moist stratification required[3,20,28] but potential for scarification plus gibberellic acid to work instead of stratification;[33] germination best in dark, moist conditions at lower temperatures, 1-5 °C (34-41 °F); seed banks could last up to 10 years[29] and may be more likely in drier conditions.[4]

Habitat: Native to Europe; introduced to U.S. in 1868,[22] but molecular evidence suggests multiple introductions;[10] upland or floodplain forest, savannas, roadsides, trail edges, and disturbed areas;[4,36] shade-tolerant,[5] prefers shady, mesic areas with alkaline soils[4,36] but found in high light, xeric areas with acidic soils.[1,4]

GARLIC MUSTARD

***Alliaria petiolata* (M. Bieb.) Cavara & Grande**
[*A. officinalis* Andrz.]
BRASSICACEAE

HERB

Alliaria petiolata
GARLIC MUSTARD

Comments: Nutritious for humans and possibly other animals;[17] may increase soil nutrient availability at invaded sites;[32] rare native butterfly oviposit host but larvae cannot feed;[9,25] wounding increases herbivory defenses,[13] but defensive chemical levels vary among populations from different sites;[6] allelopathy documented[26] (sinigrin, its most prominent glucosinolate, and cyanide[7]) on native plant mycorrhizae (both arbuscular mycorrhizae and ectomycorrhizal fungi);[2,16,31,35,37] phytotoxins decline as populations age[18,19] and are higher in high-density populations than low-density mixed-species populations;[11] susceptible to powdery mildew, but less in drier environments due to increased phytotoxin activity response to water limitation;[11,12] often associated with nonnative earthworms[23] that preferentially consume its seed over native seed;[27] at least two weevils assessed as biocontrol agents;[15] early-seedlings (cotyledon stage) do not compete well with second-year rosettes;[3,21] managing second-year plants may be most efficient.[24]

Similar Native Species: Meadow parsnip, golden alexander, ragwort, violet species (*Thaspium, Zizia, Senecio, Viola* spp.) have similar basal leaves; several mustards (*Brassica* spp.) have similar fruiting structures.[16]






Habit: Herbaceous, clonal perennial ≤2 m (6½ ft) tall; deep, creeping root system[14,16,27] that grows horizontal initially then downward[7] reaching 7 m (22 ft)[35] but most roots ≤30 cm (1 ft); root grows 5-10 cm (2-4 in) before shoot emerges;[11] runners between plants ≤12 m (39 ft).[7]
Reproduction: By seed,[14,16] root suckers,[14,16,22,27] root fragments[22] >5 mm (~¼ in),[19] and stem segments (less likely);[11] imperfectly dioecious (11-15% hermaphrodites in native range); selfed hermaphrodite seed set low compared to outcrossed individuals;[22] despite female-bias in progeny, males maintain an abundant presence, suggesting a greater capacity for males to clone.[26]
Leaves: Alternate; oblong to lanceolate; both surfaces glabrous to short-woolly (more so beneath); spiny margin; most cauline leaves sessile, slightly decurrent at stem,[14,15] variably shaped (wavy-pinnatifid lobed or just toothed).[15]
Stems: Glabrous,[15] grooved,[37] and very leafy.[14,15]
Flowers: Open, branched in ovoid-cylindric discoid heads;[14,15] involucre with weakly spine-tipped bracts ≤2 cm (¾ in) long;[32] pinkish-purplish, sometimes white; plumose pappus[15] surpass corollas in female flowers, but are shorter than corollas in males;[16] fragrance emission highest when pollinator activity highest and lowest when florivore activity highest;[34] female flowers insect pollinated optimally within 50 m (164 ft) of male plants; receptive for ~3 days but longer when pollen levels are low;[26] needs 14-16 hours of light to flower; may flower in one growing season; June-Oct.[11,14]
Fruits/Seeds: Achene 2.5-4 mm (~⅛ in), on larger side when pollen is limiting;[26] produces up to 50 seeds per head,[22] 5300 seeds per plant;[11] abortion rate

CANADA THISTLE

***Cirsium arvense* (L.) Scop.**
[*Carduus arvensis* (L.) Robson;
***Cirsium setosum* (Willd.) Bess. ex Bieb.]**
ASTERACEAE

HERB

high;[26] Aug.-Oct.;[11] ants move seeds and may facilitate recruitment;[1] long-distance wind dispersal possible but rare because pappus separates from achene early;[30] cold stratification required;[3] germination better at depth ≤1 cm and soil moisture 75-100% of field capacity,[25] and best in high light for younger seeds; most germinate first year (seed bank unlikely),[11,38] but some persist 20 years if buried deep enough, 105 cm (~3½ ft);[20,36] stored seed germination rate is 90% at 2 years and 0% at 5 years.[8]

Habitat: Native to Europe, Western Asia, Northern Africa[2]—where also invasive;[35] likely introduced to U.S. from Western Europe in 1600s in contaminated hay or seed and again from Eastern Europe in late 1800s in contaminated cereals;[18] distribution primarily above 37° N latitude in U.S.; growth limited by temperatures >30 °C (86 °F); open areas, roadsides, streambanks, clear-cuts, forest openings, and wet grasslands;[30] seedlings need ≥20% full sunlight to survive.[11]

Comments: Small patches have high extinction rates;[12] population expansion more likely via new clone establishment than growth of existing clones;[21] genetic diversity high for a clonal species,[33] possibly due to multiple introductions[18] with gene flow between populations;[6] not competitive against perennial nonnative grasses;[2,13] allelopathic properties demonstrated;[4,11] some allelopathic compounds are volatile and deter insects, such as aphids;[17] native and nonnative insect seed predation and herbivory high but minimal impacts;[10,11] many native congeners make biological control unlikely;[31] exotic weevil release may impact native thistles;[28] rust fungus *Puccinia punctiformis* may be specific to *C. arvense*[23] since it occurs in every U.S. county the plant is found, but its complex lifecycle may limit its establishment on *C. arvense*;[5] invasive range void of natural enemies may not boost performance;[9] higher CO_2 concentrations correlated with increases in growth and leaf defenses (leaf spine number and length);[39] controls include repeated stubble tillage followed by crop cultivation as well as repeated mowing or cutting (but less effective);[24,29] best to treat just before flowering when root carbon reserves are low.[35]

Similar Native Species: Swamp thistle (*C. muticum*) but biennial with larger flowering heads; Carolina thistle (*C. carolinianum*) but biennial with fewer, narrower cauline leaves, fewer flowers.[16]

Habit: Perennial, herbaceous shrub; ≥3 m (9 ft) tall;[10,11,26,28] shoots survive one season, rhizomes survive decades; in native habitat forms circular clonal stands that senesce from center.[1]

Reproduction: Mainly vegetative from fragments of rhizome or shoot;[4,7,10,25] by seeds,[9,10,11,26] dioecious[9,11] or gynodioecious.[4,10]

Leaves: Simple, alternate; broadly ovate with abruptly pointed tip, truncate base;[9,11] 8-15 cm (3⅛-6 in) long, 5-12 cm (2-4¾ in) wide; tubular, membranous ocrea.[4,9]

Stems: Round, sometimes ridged;[11] glaucous, often mottled;[9] hollow internodes,[10] swollen nodes.[9,26]

Flowers: Mid- to late summer; small, 2-3 mm (⅛ in);[4] 1,000s/plant;[10] greenish-white,[9,11,26] narrow racemes or panicles at middle/upper nodes;[9,11,26] fly and bee pollinated; copious nectar[4] that bees transform into a dark, quality honey.[3,23]

Fruits/Seeds: Fruits 3-winged, 8-9 mm (¼-½ in); seeds 3-4 mm (⅛ in), dark, glossy;[9,11,26] germination rate 61-95% in light at room temperature; no apparent cold stratification required;[10] dispersed by wind[16] and possibly water (rhizome and shoot fragments); House Sparrows, possibly other birds, eat the seeds.[4]

Habitat: Native to Asia; introduced to U.S. mid- to late 1800s;[10] disturbed and riparian areas, roadsides, woodlands; shade-intolerant;[4] native substrate volcanic[17] with low pH, but grows in a variety of soil types and pH levels; prefers wet habitats;[4] seedling survival depends

JAPANESE KNOTWEED

***Fallopia japonica* (Houtt.) Ronse Decr. [*Polygonum cuspidatum* Sieb. & Zucc.; *Reynoutria japonica* Houtt.]**

POLYGONACEAE

HERB

on water, adults tolerate drier conditions;[16] some populations show salt tolerance;[27] USDA hardiness zones 4-8.[8]

Comments: Tetraploid, hexaploid, or octoploid;[15] polyploidy may increase genetic diversity;[13] native soil biota may facilitate knotweed invasion;[21] increases K, Mg, P, Cu, Mn, and Zn, which may enhance nutrient cycling rates and soil fertility,[6] but N mineralization rates not enhanced;[2] potential allelopathy;[22] cross with *F. sachalinensis* (also a nonnative invasive) results in viable, fertile hybrid *F.* × *bohemica*[4,14] that shows chemical weapons diversification[22] and hybrid vigor;[20] *F. japonica* used as substitute for natural estrogen, treatment for skin disorders, hepatitis, and inflammation;[18] use as biofuel being considered;[29] grazed by sheep, cattle, horses;[4] exhibits significant guttation;[19] *F. japonica* var. *compactum* also escapes;[4] *Aphalara itadori* (knotweed psyllid) released as biocontrol in Canada,[5,30] trial basis in U.S.

Similar Native Species: Virginia knotweed (*Persicaria virginiana*) but smaller, not shrubby, ocreae with marginal bristles, inflorescence slender spike.[11,26]

Habit: Perennial or biennial (less common) herb with a deep, 40-65 cm (16-26 in), branching tap root.[18]

Reproduction: Seeds; immature umbels may produce some viable seed;[16] monocarpic[6,18] though some perennials may survive after flowering[18] and even with immature umbels[16] cut stems may re-sprout.[18]

Leaves: Alternate;[6,17,18] pinnately-lobed with 2 side segments and a third terminal segment;[6] large, up to 3 m (9-10 ft) long; gradual decrease in size approaching top of plant;[17] pubescent underside;[17] petiole hollow[12] with enlarged sheath.[6]

Stems: Often purple-mottled; 2-5 m (6-16 ft) tall, up to 10 cm (4 in) diameter; hollow and ridged;[6,17,18] covered with stiff, brittle whitish hairs (also on petioles and peduncles).[12]

Flowers: Compound umbels each with 50-150 white rays;[6,18] up to 1.5 m (4-5 ft) diameter; most plants flower in third or fourth year;[4,18] flowers earlier in invaded range than native range, but flowers later (fifth year) in managed sites (pastures) than unmanaged sites for both invaded and native ranges;[13] June-Aug.;[17,18] stem damage may produce weak flowers;[18] self-compatible, outcrossing, protandrous hermaphrodite; pollinated by a variety of insects, mostly bees and flies; self-pollination may occur between different umbels of same plant.[7,18]

Fruits/Seeds: Fruit elliptic, ridged, winged, 8-15 mm (⅜-¾ in) long schizocarp on an elongate stalk; splits

GIANT HOGWEED

Heracleum mantegazzianum **Sommier & Levier**

APIACEAE

HERB

into 2 single-seeded halves; shed Aug.-Oct.;[6,17,18] possible >100,000 seeds per plant;[18] water, wind, or human dispersed, mostly within 10 m (33 ft) of mother plant;[4,14,18] germination appears to require moisture and cold stratification[15,18] and occurs in light or dark; may remain dormant in soil 5-6 years before germinating;[1] viability 2-15 years.[18]

Habitat: Native to Caucasus region, Southwest Asia;[18] introduced in U.S. as an ornamental;[4] open abandoned areas, roadsides, disturbed woodlands, and streambanks;[4,17] may invade a range of habitats,[5,20] but possible preference for open, mesic, and seasonally cold environments;[15,18] can survive temperatures as low as -17 °C (-31 °F).[12]

Comments: May increase soil pH and phosphorus;[11] sap has secondary compounds (furanocoumarins) that may cause severe burns, blistering, and rashes on humans with sun exposure;[5,18] some toxic compounds (e.g., isobutyl isobutyrate, isoamyl butyrate, and xanthotoxin) also present;[8,19] some of these substances inhibit insect herbivory by generalists but not by specialists,[3] while others have antibacterial properties;[19] leaves and seeds may contain allelopathic compounds;[2] root exudates may contain non-furanocoumarin allelopathic compounds with phytotoxic effects that may differ by maternal line[9,10] and are not novel but similar to those of a native congener and other species;[9] cattle, sheep, goat, pig, mollusc, and snail grazing is common; fungal pathogens noted;[18] the putative hybrid between *H. mantegazzianum* and *H. sphondylium* (native to U.K.) with low fertility is rare in the U.K.[7,14]

Similar Native Species: Cow parsnip (*H. lanatum*) but stem reaches only 3 m (10 ft)[6] and umbels usually have 15-30 rays.

Habit: Perennial, rhizomatous, warm-season grass reaching 1.5 m (5 ft) in height.[27,30]
Reproduction: By seed, outcrosses via wind pollination;[37] vegetatively by rhizomes;[27] older rhizomes may be primary form of reproduction;[3,13] rhizome fragments weighing as little as 0.1 g (<0.004 oz) can produce a new plant.[3]
Leaves: About 5 mm (¼ in) wide with serrated margins; midvein offset from center;[13,27,35] sheath and ligule may be pubescent;[20] aside from flower stalks, most plant height is leaf material;[27] 'Red Baron' variety has bright red leaves.[35]
Stems: Culm nodes have silky hairs; most stem tissue is underground as rhizomes in top 15-40 cm (6-16 in) of soil but as deep as 1.2 m (4 ft);[20] rhizomes from a single plant up to 12 m (39 ft) long;[37] rhizomes are covered with brownish scale leaves;[27] a band of sclerenchymatous fibers just below epidermis protects stem tissue from desiccation and damage; culms may develop 3-4 weeks after seedling first forms, rhizomes may develop from seedling 4-12 weeks after germination.[27,37]
Flowers: Cylindrical, spike-like panicle, ~10-60 cm (4-24 in) long, 0.5-2.5 cm (¼-1 in) wide; spikelets, surrounded by silky hairs, have 2 florets—upper is fertile with 2 orange-brown stamens, 2 purplish-brown stigma lobes[27] and lower is infertile; disturbances and added N stimulate flowering;[27] 'Red Baron' variety may[5] or may not flower;[34,35] late winter to early spring in U.S., later in the Mediterranean region, and possibly year-round in more tropical environments.[20]
Fruits/Seeds: Seeds small, ≤1.3 mm (0.05 in);[23] may produce >3000 seed per plant;[27] plumed seed wind dispersed as far as 24 km (15 mi), especially as clumps over open areas,[27] but most seed travels ≤15 m (49 ft);[20,27] higher light increases germination rates;[27] seed bank unlikely, possibly due to lack of dormancy and rapid decline in seed viability.[10,27]

COGONGRASS

***Imperata cylindrica* (L.) Raeusch.**
[*I. arundinacea* Cirillo; *Lagurus cylindricus* L.]
POACEAE

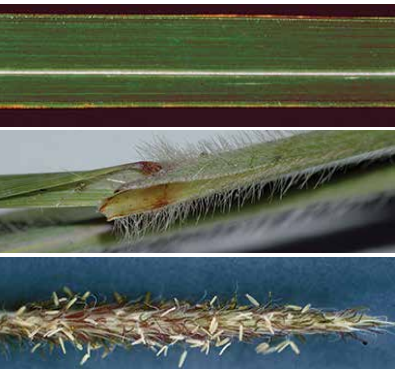
HERB

Imperata cylindrica
COGONGRASS

Habitat: Native to Southeast Asia where it is a nuisance yet important for fire-maintained grasslands and savannas;[27,32] accidentally introduced to AL, in 1912 as packing material; intentionally introduced to MS, in 1921 as forage; cosmopolitan in tropical and subtropical regions; on every continent except Antarctica;[27] adapted best to disturbed areas in full or partial sun[27] but disturbance not required;[23] some populations salt tolerant;[16] USDA hardiness zones 4-13.[38]

Comments: C_4 photosynthesis; genets grow slower than ramets but are more likely to invade disturbed areas, while ramets are more competitive in areas with established populations;[37] light increases rhizome sprouting; shading reduces rhizome growth[34] and suppresses growth[19,36] but plants persist in forest understories;[22] may form mycorrhizal associations, giving it an advantage in infertile soils;[27] outcompetes other plants for P, especially legumes;[4,33] competes better for N than native species;[11] leaves accumulate silicates; has allelopathic compounds that may inhibit plant growth[15,21,24,27,29] or be used as an herbicide;[2,8,39] its sharp rhizomes may penetrate and damage belowground organs of other plants;[19] harbors an endophytic fungus that produces cytotoxic substances;[12] potential bioremediation use as a heavy metal hyperaccumulator (e.g., iron[1] and lead[31]); leaf powder may absorb heavy metals (copper,[18] lead,[17] and nickel[25]); pollen used to induce wheat haploids;[9] leaf extracts treat hypertension;[28] rhizome extracts have neuroprotective properties;[40] lacks genetic diversity[7] in native and invaded ranges;[6] not genetically distinct from less aggressive *I. brasiliensis* (1 stamen, not 2) that invaded pine rockland habitats of FL; further genetic comparisons with *I. brasiliensis* in native Brazil and Argentina needed.[26]

Similar Native Species: Arctic reedgrass (*Calamagrostis coarctata*) but florets awned, seeds not plumed.[14]



Habit: Shrubby, deciduous, perennial, herbaceous legume; somewhat woody base; 1.5 m (5 ft) tall.[12]
Reproduction: By seed through mixed-mating system with chasmogamous (CH) flowers primarily insect-pollinated and cleistogamous (CL) flowers selfed;[1] clonal by vegetative buds on stem base and by rhizomes.[6,30]
Leaves: Numerous; trifoliate; petioles 1.5-5 mm (~1⁄16-¼ in) long;[12] leaflets wedge-shaped or linear-cuneate, 10-27 mm (⅜-1 in) long and both truncate and mucronate; underside with silky, gray pubescence.[12,25]
Stems: Wand-like, slender, erect branches with longitudinal grooves; hairy on angles (or ridges) between grooves.[12]
Flowers: July-Oct.; CH small 7-9 mm (¼-⅜ in), whitish with purple or pink veins; CL inconspicuous, about half size of CH; 1-3 axillary for both CH and CL;[6,25] CH typically open in morning and senesce after one day;[28] *L. cuneata* CH attract more pollinators than associated native *Lespedeza* spp. CH in the same area;[31] delayed self-pollination of CH more likely when pollinators are limited.[30]
Fruits/Seeds: Fruit is oval loment, 2-3 mm (1⁄16-⅛ in) long;[12,25] CH seeds and seedlings larger than CL seeds and seedlings;[7] most CH seed outcrossed but not all; progeny derived from CH seed produce 40% more seed than progeny from CL seed;[9] seeds may germinate throughout growing season;[29] scarification required for germination;[6] fire stimulates germination;[6,29] seed leachate may prevent germination under high seed densities;[17] seeds potentially viable >50 years;[6] seed bank ≥30 years.[5,28]
Habitat: Native to East Asia; first introduced to the U.S. in NC, from Japan in 1896[9,24] with a second introduction in 1924 to VA;[11] planted over large regions in U.S. in the 1930s and 1940s for erosion control;[9,10] also included in

CHINESE LESPEDEZA

***Lespedeza cuneata* (Dum. Cours.) G. Don.**
FABACEAE

HERB

a reclamation seed mix for coal mine spoils;[5,28] old fields, prairies, oak savannas, woodlands, forest openings, and disturbed open areas.[11]

Comments: Populations today likely a mixture of 3 cultivars;[2,14] tissue high in condensed tannins deters foraging by cattle (and possibly other ruminants) by reducing protein digestion; polyethylene glycol (PEG) supplements in cattle's diet bind with tannins to improve digestion and increase consumption;[23] late season grazing by sheep (not affected by tannins) possible;[22] increased herbivory reduces number of seeds produced resulting in fewer CH than CL seeds,[26] however, tends to experience less herbivory and produce more CH seed than native *Lespedeza* spp.;[27,28] appears more competitive under low soil fertility conditions as a N-fixer;[3,16] also facilitates its invasion by increasing abundance of available rhizobia in the invaded area;[8] associations with several rhizobial genera formed in native range,[13] but limited to fewer genera in introduced range; forms less diverse rhizobial associations than native *Lespedeza* spp.;[4] despite lower diversity of rhizobia, has higher shoot and root biomass than competing native species;[18] may put more energy into root biomass in low-N soils;[15] few nematodes attack in invaded range due to high tannin content; nematodes associated with increases in nodules;[19] lower rhizobial diversity related to lack of nematodes;[4] hybridization with native *Lespedeza* spp. unlikely due to differences in chromosome numbers (*L. cuneata* n=19 and native *Lespedeza* spp. n=10);[6] some evidence of allelopathy;[20,21] evolved since 1930s to become more aggressive but with fewer defenses—switched from constitutive to inducible defense strategy.[2]

Similar Native Species: Virginia lespedeza (*L. virginica*) but leaflets strigose above and below,[12] flowers purple or violet.



Habit: Reclining, loosely branching annual; grows to 1 m (3 ft).[10,13,18,25]

Reproduction: Seeds;[10,13,25] may root at lower nodes.[15]

Leaves: Lanceolate, tapering at both ends; 5-10 mm (~¼-⅜ in) wide, 3-8 cm (~1-3 in) long; pale green; midvein offset from center; a silvery line runs over the mid-vein on upper surface; sheath collar ciliate.[13,23,25]

Stems: Reclining and branching growth to upright; nodes glabrous and swollen.[8,10,23]

Flowers: Late summer/early fall; terminal spike-like, branching inflorescence; up to 7 cm (2¾ in) long with paired, hairy spikelets; one form has one of the two lemmas awned, another form both lemmas are awnless;[9] has both cleistogamous (CL) and chasmogamous (CH) flowers;[27] all flowering during drought is more likely under high light conditions;[12] more CH flowers on plants grown in high light;[1,5] shade populations potentially highly selfed.[12]

Fruits/Seeds: Ellipsoid grain 2.8-3.0 mm (⅛ in) long; may produce abundant seed infrequently;[12] seeds mature and are dispersed in late fall[25] when they appear to be dormant; water and animal dispersed;[23] cold stratification improves germination but is not required;[12,17] CH seed more viable than CL seed;[17] seed bank ≥3 years.[1,12]

Habitat: Native to tropical Asia;[13,25,26] introduced to the U.S. in 1919;[9] shade-tolerant;[19] prefers shade (closed canopy forests, especially riparian areas) but found in

JAPANESE STILTGRASS

***Microstegium vimineum* (Trin.) A. Camus**
[*Andropogon vimineus* (Trin.);
***Eulalia viminea* (Trin.) Kuntze]**
POACEAE

HERB

high light areas (roadsides, ditches, forest borders, and fields);[24] plants are larger in open areas;[5] may prefer bare or disturbed ground lacking competition with other plants.[1,18,24,29]

Comments: C_4 photosynthesis;[2,3,19] efficient use of sunflecks;[14] lower capacity to photosynthesize in high light;[28] its litter forms thick thatch that may prevent establishment of natives and itself;[12] may alter soil conditions by increasing pH, nitrification, and nitrates;[1,8] association with nonnative earthworms possibly due to increased litter decomposition or an agricultural connection;[20,21] arbuscular mycorrhizal fungi associations that enhance P uptake and *M. vimineum* growth;[22] initial establishment correlated with high native species diversity;[16] older populations less likely to persist and compete with natives;[7,11] genetically distinct populations are indicative of selection and adaptation to new environments;[6,30] two *Bipolaris* spp. of fungus infect and can kill this species; efficacy varies by species of *Bipolaris* and stiltgrass population making biocontrol use unlikely.[4,19]

Similar Native Species: White cut grass/Virginia cut grass (*Leersia virginica*) but perennial, hairy nodes, and earlier flowers (early/mid-summer).[23]




Habit: Tufted, perennial, warm-season, ornamental grass[2,14,40] with 0.9-1.2 m (3-4 ft) spread; like other tussock grasses, "fairy-ring" patches (center shoots of clump die back due to intraspecific competition) are common.[39]
Reproduction: By seed,[7] self-incompatible;[8,20,36,39] vegetatively via rhizomes possible.[28]
Leaves: Up to 2 m (6½ ft) long and about 1 cm (~¼-½ in) wide; scabrous margins.[14]
Stems: Aboveground stems solid;[3] rhizomes up to 4.7 cm (~2 in)[28] and as deep as 10 cm (4 in),[45] and may survive 4-5 years as separated propagules.[22]
Flowers: Flowering date varies with latitude (higher latitudes up to 2 months earlier than lower latitudes); June-Oct.;[39] simple raceme forms a fan-shaped panicle, 20-25 cm (8-10 in) long;[40] paired spikelets, one short- and the other long-pedicelled; glumes 3-4 mm (⅛-3⁄16 in) long with a ring of long silky hairs radiating beneath; upper fertile lemma has an awn 6 mm (¼ in) long, lower lemma is sterile without an awn.[14]
Fruits/Seeds: July-Nov.;[39] each plant produces estimated 1051 seeds[19] that disperse up to 400 m (¼ mi);[31,32] seed bank in native range may last 50 years;[39,43] related *M. sacchariflorus* does not appear to produce a seed bank in its invasive range;[17] germination occurs without pretreatment[18] but percentages may increase with day/night temperatures of 30/20 °C (86/68 °F) or day temperatures of 32-36 °C (90-97 °F).[1,28]
Habitat: Native to Japan, Korea, China, Taiwan, and Russia;[39] introduced to U.S. from Japan in late 1800s,[2,13] escapes from cultivation first noted in 1913;[5] pioneer species in native range, dominates heavily disturbed volcanic sites[42] and clear-cut tracts[30]—more so if succession stalled by management (e.g., frequent fire);

EULALIA

***Miscanthus sinensis* Andersson**

POACEAE

HERB

can grow in wide variety of environments;[34] tolerates non-fertile soils, cold temperatures, heavy metals, and low soil pH;[39] USDA hardiness zones 5-9.[40]

Comments: Continues to be a popular landscape grass;[31,44] at least 24 cultivars;[40] variegated variety *M. sinensis* var. *zebrinus* may also escape;[2,35] most roots in top 60 cm (2 ft) of soil but may extend down to 120 cm (4 ft);[45] C_4 photosynthesis;[38] potential use as bioenergy crop; vegetation decomposes slowly;[27] grows larger in higher light environments, though survives in shade[21,25] where plant size and vigor may not be decreased;[11] invaded range shade tolerance not greater than native Japan;[25] grazed by livestock in native range;[39,41] documented associations of arbuscular mycorrhizae in native populations;[37] genotype response varies with different environments;[9] U.S. populations have high genetic diversity similar to populations in Japan;[33] genome is large—two subgenomes originated from a tetraploid;[23] in native range diploid *M. sinensis* naturally hybridizes with tetraploid *M. sacchariflorus* to form sterile triploid *M.* × *giganteus*;[16,29] both *M. sacchariflorus* and the hybrid likely spread via rhizome propagules;[24] *M. sinensis* is easier to propagate while *M.* × *giganteus* is less likely to become invasive[15,31,32] unless fertile varieties are developed; a fertile cultivar of *M.* × *giganteus* is in development as alternative to costly vegetative plantings used for biofuel crops, increasing its invasive potential;[26] genome doubling overcomes triploid sterility of *M.* × *giganteus*;[6] *M. sacchariflorus*[14] and *M.* × *giganteus* less cold[12] and drought[10] tolerant than *M. sinensis,* and their lemmas are awnless; *M. sacchariflorus* reaches heights of 2.5 m (8¼ ft) with hollow or solid stems[3] and *M.* × *giganteus* reaches heights of 3.5 m (11½ ft) with hollow stems;[3] two aphids known to cause severe damage to some grass crops were found on *M.* × *giganteus* indicating potential to be a host.[4]

Similar Native Species: Silver plume grass (*Saccharum alopecuroides*) but leaves densely pilose at base, margins not scabrous, can be longer/wider; panicles narrower.[14]

Habit: Erect (diploid type) to reclining (tetraploid type), perennial herb and geophyte;[17,21] 30 cm (12 in) or less in height;[7,8,17,21] spring ephemeral.[3,9]
Reproduction: By seed and vegetatively by tuberous, adventitious roots; clonal; usually hermaphroditic,[21] though female flowers documented and more rarely male flowers; ssp. *bulbifera* (tetraploid) can produce bulbils, but may produce less seed; ssp. *ficaria* (diploid) and other subspecies do not produce bulbils but produce tubers and seed; preferentially outcrosses, but self-pollination possible with lower seed viability.[13,19]
Leaves: Long-petioled with sheathing bases;[21] blade 5-50 mm (¼-2 in) long and wide, fleshy, glabrous, shiny, dark green,[7,21] sometimes with whitish mottling or black blotches;[21] cordate to oblong cordate, shape variable; entire, toothed, or wavy margin;[7,8,17] rosette of 2-4 basal leaves; 1-2 pairs of opposite, cauline leaves may have some lobing.[21]
Stems: Glabrous and fleshy;[7,21] short internodes;[8] aerial bulblets may be at each node, usually in tetraploids; may branch;[21] first developmental stem is a spear shoot (one apparent cotyledon; second is enclosed in the first).[18]
Flowers: Terminal and solitary on each stem, 2-3 cm (~1 in) diameter; 3-4 green sepals fall off early; 8-12 bright, shiny (on inside) yellow petals fade to white; 5-72 stamens and carpels;[21] produces nectar; pollinated by short-tongued insects (bees, small beetles, and flies); flowering more likely on plants under high light with large tubers;[21] Mar.-May.[3,21]
Fruits/Seeds: Fruit is beakless, glabrous, or pubescent achene, 2.5-4 mm (1-1½ in) long;[2,7,8,17] 10-15 achenes per flower;[2] May to early June;[21] evidence seed dispersed by deer (in excrement) and ants in native environment;[10,12] about 60% of diploid seed is viable; about 2% of tetraploid seed is viable due to low pollen viability; germinates in both light and dark; requires warm then cold stratification; germination optimal at 5 or 11 °C (41

LESSER CELANDINE

***Ranunculus ficaria* L.**
[*Ficaria verna* Huds; *F. ranunculoides* Moench]
RANUNCULACEAE

HERB

or 52 °F) day and 4 or 9 °C (39 or 48 °F) night;[1,21] seed bank undocumented in the literature at this time.

Habitat: Introduced from Europe (Norway/Russia to the Mediterranean/Portugal)[21] to Eastern U.S. in mid-1700s;[3] shade-tolerant; flowers and fruits before forest leaf out;[12] tolerates dry conditions, but prefers wetter conditions in spring; often associated with seasonally wet sites; possible preference for alkaline soils; in native England most common in mixed deciduous forests; diploid is associated with undisturbed, deciduous woodlands and permanent pastures; tetraploid is associated with disturbed ground;[21] vegetative growth is less susceptible to dry conditions than flowering is.[24]

Comments: Plants with larger tubers develop faster; vesicular-arbuscular mycorrhizal association present;[21] at least 9 cultivars;[7] possibly 100 varieties and 5 subspecies;[4] the 5 subspecies have been confirmed in the U.S., with ssp. *calthifolius* (leaves crowded at base, few on short stems) having widest distribution;[16] ssp. *ficaria* and ssp. *bulbifera* are also thought to predominate;[11,21] fragmentation of root tubers results in extensive vegetative propagation;[21] native plants growing near *R. ficaria* have increased pollinator visitation rates, but not seed production;[14] possible allelopathic properties, but relatively weak;[5,6] used medicinally as an anti-inflammatory, astringent, and antibiotic,[23] but documented to cause acute hepatitis if ingested;[20] contains several flavonoid compounds;[22] documented reduction in its abundance in areas with increased soil acidification over 30 years.[15]

Similar Native Species: Marsh marigold (*Caltha palustris*) but leaves larger and lighter green, stems hollow, flowers petaloid (petal-like sepals only) and multiple per stem, follicle fruit.[6]






Habit: Perennial herb up to 40 cm (16 in) tall,[18] male plants shorter than female.[32]
Reproduction: By seed[13,40] and vegetatively by root sprouts producing clones;[27] dioecious;[13,18,40] most genet populations at a 1:1 sex ratio, ramet populations often female-biased;[33,38] seedlings unlikely to flower first year; overwintering ramets likely make up most of any cohort.[54]
Leaves: Hastate with 2 divergent basal lobes or linear-spatulate;[13,18,40] primarily a basal rosette with some alternate and petioled cauline leaves of same shape;[40] glaucous-green; thin; bitter, slightly acid taste.[32]
Stems: Erect or bending.[40]
Flowers: A panicle of small, reddish yellow-green flowers[40,50] on jointed pedicels;[13] May-Sept.,[50] male plants flower first;[33] tendency for more flowering males; wind pollinated.[32]
Fruits/Seeds: Triangular achene, June-Oct;[13] seeds may require scarification; warm stratification required; tend not to germinate first year;[32] optimum germination at 15 °C (59 °F) or a fluctuating 20/30 °C (68/86 °F), higher rates in light;[2,4,51] adding heat (~80-100 °C; 176-212 °F) and drying then wetting increases germination; adding fire[19] and N may promote germination;[21] potential seed bank of 5[20,21,41] to 26 years;[17,34] less viable seed production as plants age.[9]
Habitat: Native to Eurasia; preference for disturbed, open habitats[36] (plants relatively smaller than those in shade), but found in forest gaps[10] and closed canopy forests (plants relatively larger);[12] acidic soils high in exchangeable phosphate;[48] calcifuge; unable to

SHEEP SORREL

***Rumex acetosella* L. [*Acetosella acetosella* (L.) Small; *A. tenuifolia* (Wallr.) Á. Löve]**
POLYGONACEAE

HERB

solubilize phosphate and iron;[45,49] avoids Al^{3+} (aluminum ion) toxicity by exuding oxalic acid;[42] may survive in serpentine soils by excluding heavy metals;[44,53] distribution associated with N deposition;[3] typically non-mycorrhizal;[14,36] population may increase if soil symbiotic fungi decreases;[37] more competitive in areas with high light and nutrients;[10] sensitive to flooding,[1] but drought-tolerant;[11] males more drought-tolerant than females, depending on age.[22,23,55]

Comments: North American (NA) populations primarily hexaploids[12] (subspecies *angiocarpus*); diploids, tetraploids and octoploids also found; genetic variation high, but NA populations less diverse than European populations;[30] ovaries, stamens, seed, and pollen increase in size as ploidy level increases; hybridization between ploidy types occurs, but offspring usually sterile;[32] not palatable to livestock;[6] females initially smaller than males, but often equal or larger at end of growing season;[28,38] males have higher reproductive cost than females at certain stages,[33] but overall cost to females is higher;[29] females respond more rapidly and positively to rich environments;[22] males allocate more biomass to belowground organs;[16] associated with appreciable amounts of N-fixation, presumably by rhizosphere bacteria;[43] cytokinins may trigger femaleness;[5,25] resource translocation among ramets unlikely;[27] older populations (≥4 years) allocate greater overall resources to vegetative propagation;[7,8,9] fossil pollen deposits used as a disturbance or human-settlement indicator;[35,39,47] documented 50% reduced yield of strawberry crops associated with this species;[52] often found growing in low-bush blueberry fields; eaten in salad;[24] traditionally used to treat gastrointestinal problems, inflammation, and fevers;[46] shows resistance to the herbicide hexazinone;[26,31] fairly widespread in sub-Antarctic islands.[15]

Similar Native Species: Wild sorrel (*R. hastatulus*) but achene has wing-like valves; arrowhead violet (*Viola sagittata*) but leaves all basal and flowers violet-purple.[18]

Habit: Semi-evergreen to evergreen; high-climbing, woody twining vine;[5] size depends on support structure, may grow 7-12 m (23-39 ft) tall,[13] ≥6-12 m (20-39 ft) horizontally; stoloniferous (allows colonization of large areas), can be groundcover.[2]

Reproduction: By seed, monoecious but self-incompatible—must be cross-pollinated to set fruit;[5,6] vegetatively by stolons.[2]

Leaves: Alternate;[5,16] palmately compound—5 oval leaflets, 3.5-8 cm (1¼-3 in) long;[1,2,16] notched tips;[1] bluish-green above, glaucous beneath; leaf out as early as Mar.; new leaves may be purple-tinged.[2]

Stems: Green becomes brown; glabrous, heavily lenticelled; leaf scars much raised.[2]

Flowers: No petals, 3 fleshy sepals; fragrant (slightly vanilla, spicy);[1,2,3,19] appear with leaves between Mar.[2] and May;[16] drooping,[19] axillary racemes, ~13 cm (5 in) long;[1] lower raceme flowers female,[5] purplish-brown, ~2-3 cm (~1 in) wide[2,5,16] with 5-9 purple pistils; upper are male,[5] pale pink, sepals slightly reflexed,[2,19] 6 mm (~¼ in) wide with 6 deep purple stamens;[6] female to male ratio approximately 1:4 or 1:5; female flowers open 1-2 days before males but produce no nectar—pollinators unrewarded;[6,7] distinctive flower sizes for sexes increases pollinator efficiency where solitary bees, the primary pollinators, visit a plant's larger female flowers first followed by many more of its male flowers,[6] this sequence reduces pollen transfer between flowers of the same plant.[8]

Fruits/Seeds: Fleshy, sausage-shaped pod, about 5-10 cm (2-4 in) long, glaucous-gray to purple-violet; soft, juicy

CHOCOLATE VINE

***Akebia quinata* (Houtt.) Decne.**

LARDIZABALACEAE

VINE

texture with delicate, sweet flavor that tastes like a mixture of banana, lychee, and passion fruit;[14] splits lengthwise showing pulpy, white core with black seeds[2,19] (~200/pod) when fruit matures, Sep.-Oct.;[8] mammals and birds disperse seeds (found in feces) as well as ants;[15] refrigerating 14 days at 5 °C (41 °F) improves germination; seeds viable 2-3 years in cold storage;[22] seed bank longevity unknown.

Habitat: Native to Eastern Asia[5] (i.e., central China, Korea, and Japan); introduced to U.S. in 1845;[2] hardy, grows in sun or shade, moist or dry soils, and low or high pH;[3] responds negatively to root disturbance;[19] thrives in partial shade with well-drained, moist loamy soil in native range;[13] USDA hardiness zones 4-8.[2,3]

Comments: Three known cultivars, one has white flowers and fruit;[2] fruit production limited by proximity to another *A. quinata*;[3] high fruit crop potential in native region[14] but it is overharvested there;[13] extracts may have diuretic, analgesic,[9] antioxidant,[11,17] and neuroprotective[21] activities; used to treat urinary disorders, inflammation,[10] obesity, high blood lipid concentrations,[20] and skin aging;[18] powdery mildew symptoms exhibited;[4] chloroplast genome defined.[12]

Similar Native Species: Virginia creeper (*Parthenocissus quinquefolia*) but leaves toothed and pointed, flowers small yellowish-green, fruit purplish-black berries ≤6 mm (~¼ in) wide.[5,16]

Habit: Deciduous; woody twining vine;[7] up to 18 m (59 ft) long.[3,5,10]

Reproduction: By seeds; vegetatively[7] by root suckers.[4]

Leaves: Alternate; entire with shallow teeth; 5-12.5 cm (2-5 in) long; shape varies but length usually less than twice width and rounded with abruptly pointed tip.[3,7]

Stems: Light brown;[3] up to 5-10 cm (2-4 in) diameter.[3,5,10]

Flowers: Few whitish-greenish flowers in short axillary inflorescences subtended by a longer leaf;[7] May-June;[23] dioecious with some perfect flowers,[7] occasionally monoecious;[4,9] insect or wind pollinated.[1,29]

Fruits/Seeds: Fruit adjacent to vegetative bud; matures late summer/early fall; yellowish outer skin covers red fleshy aril containing 3-6 seeds;[4] may remain on vines through winter, though most drop by early winter;[8] seeds dispersed by humans, birds (131 m, 430 ft),[24] or small mammals;[4] wildlife typically ingest in winter; germination rates of de-fleshed seed higher than ingestion-scarified seed;[8] no apparent seed bank.[27]

Habitat: Native to Japan, China, and Korea—where not considered a forest species;[25] introduced to U.S. as early as 1860;[8] open areas; early/late-successional forests;[4,25] possible mesic soil preference;[12,17] benefits from additional support at high densities;[15] USDA hardiness zones 4-7.[3]

Comments: Presence may improve soil fertility by increasing soil pH, K, Ca, and Mg levels, but P may remain limiting;[16] forms endomycorrhizal fungi associations that may help in P limited soils;[14,18] germinates best in shade, but prolific growth may require light;[8,21] very low root pressure but conducts

ORIENTAL BITTERSWEET

Celastrus orbiculatus **Thunb.**

CELASTRACEAE

VINE

water at rates equal to native vines with high root pressure; despite evident embolism, keeps leaves ~1 month after first frost; greater secondary growth rates than native grape species;[26] may facilitate grapevine growth;[6] may be weakly allopathic;[2,13] "sit and wait" invasion strategy;[8] may impede photosynthesis and damage structure of host species;[4,19] produces a sparingly fertile hybrid with native *C. scandens*[28] that is more vigorous than this native;[22] unidirectional hybridization—pollen flows from male invader to female native—result is poor seed set and offspring with infertile pollen, ensuring wasted native female reproductive effort;[30] evidence of medicinal properties that treat rheumatoid arthritis,[20] reverse cancer cell resistance to treatment drugs,[11] and inhibit growth of cancer cells.[31]

Similar Native Species: American bittersweet (*C. scandens*) but leaf length typically more than twice width, inflorescences terminal and not next to a vegetative bud.[9,23]

Habit: Perennial, semi-evergreen to evergreen[3,5,9] vine that trails or climbs to 7 m (23 ft).[21]
Reproduction: Vegetatively by stem cuttings;[1] by seed;[3,11,13,31,43] obligatory outcrosser, but may be pollinator limited.[1,5,22,32]
Leaves: Opposite, entire, oblong, 4-8 cm (1½-3⅛ in) long; base round/triangular; may have lobes or teeth; lower surface often lighter green than upper; surfaces may have a few hairs.[5,9,21]
Stems: Pubescent, reddish/light-brown when young;[9,13,21] becomes hollow, brownish, and glabrous with age;[23] climber internodes shorter than trailer internodes.[38]
Flowers: May-June;[21,22,31] may flower again Sept.-Oct. in Southern States;[23] paired at each node;[21] tubular, 2.5-3.8 cm (1-1½ in) long with 2 reflexed lips, stamens extend beyond lips; white, cream, or pink[13,21]—yellows with age;[21,31] fragrant,[28] pubescent inside[11] with glandular hairs bearing nectar;[32] open at dusk, maximizes visits from diurnal (bees) and nocturnal (moths) pollinators; nocturnal pollinators disperse pollen further;[28] may be best adapted for hawkmoths[22,29] that are attracted to rhythmic linalool emission (highest first midnight of 2-day flowering period[29]); diurnal bee pollinators remove more pollen but transfer it less efficiently (due to high pollen consumption) than hawkmoths.[28]
Fruits/Seeds: Sept.-Oct.;[21,31] black, glossy fruit 0.6 cm (¼ in) diameter[13,21] with 4-10 brown-black seeds;[21] dispersed by deer, rabbits, bobwhites, turkeys,[10] and other birds;[21] germinates best with cold, moist stratification; germination rates high, seed bank potential therefore low;[12,16] viability may be low;[15] after 3 years viability reduced to <1%.[41]

JAPANESE HONEYSUCKLE

***Lonicera japonica* Thunb.**
[*Nintooa japonica* (Thunb.) Sweet]
CAPRIFOLIACEAE

VINE

Lonicera japonica
JAPANESE HONEYSUCKLE

Habitat: Native to Eastern Asia;[13] introduced to the U.S. in 1806[23,24,36] for horticultural purposes and soil stabilization;[21] escaped cultivation between 1860 and the 1890s;[23] woods, fields, disturbed areas, roadsides, bottomlands, and fence rows;[13,31,37] tolerates shade but most growth in full sun; rarely flowers in low light;[33] not as shade tolerant as some associated native vines;[4] sensitive to dry conditions;[2] responds positively to increase in CO_2;[34] USDA hardiness zones 4-9.[9]

Comments: Has 6-12 cultivars or horticultural varieties;[9,23] most common invasive variety in North America is *halliana* (green leaves, white flowers);[23] diploid but with a tetraploid cultivar;[26] tetraploids may exhibit increased leaf thickness and drought tolerance compared to diploids;[26,27] less genetic diversity[35] and greater annual carbon gain[37] than *L. sempervirens* (native vine); forage for deer[40,44] but *L. sempervirens* preferred; herbivory increases growth;[36] impacts on native host plant (reduced lower leaf N, photosynthesis, and growth) primarily due to root competition;[6,7,8] may have allelopathic effects on some tree species;[42] several medicinal properties[39] including anti-inflammatory[25] and anti-bacterial/viral;[17] potential use to treat diabetes[14] and myocardial infarction[20] and prevent food-borne diseases and food spoilage;[30] shows tolerance to cadmium—potential hyperaccumulator with possible uses in phytoremediation;[18,19] possible insecticidal applications.[45]

Similar Native Species: Trumpet honeysuckle (*L. sempervirens*) but leaves glaucous (both surfaces), terminal leaves connate, flowers terminal.[13,31]



Habit: Annual climbing vine with shallow, fibrous roots;[6,29] ascends 6-8 m (20-26 ft);[19,29] climbs on other plants;[21] may behave as a perennial (with a tap root) in subtropical climates.[21,29]

Reproduction: By seed;[21] as perennial, may root at nodes.[29]

Leaves: Alternate, simple, triangular; entire, glaucous, and glabrous; recurved prickles on lower veins and petioles;[8] bright to pale green color (sometimes reddish when young); 3-8 cm (1⅛-3⅛ in) long and 5-9 cm (2-3½ in) wide; peltate;[4,6] perfoliate ocrea.[3,4,6,18,21]

Stems: Wiry, slender, and armed with small, recurved prickles;[3,17] becomes reddish with age.[17,29]

Flowers: Small, 1.5 mm (1⁄16 in);[29] 10-15 per terminal or axillary spike-like racemes, 1-2 cm (⅜-¾ in) long; greenish-white to pink;[6,21] blooms early summer to fall;[8,13] perfect, primarily self-pollinates with some outcrossing.[15]

Fruits/Seeds: Perianth persistent, 3-5 mm (⅛-¼ in), thickening to a fleshy, berry-like, iridescent blue covering;[6,21] contains one seed[24] that is a round, shiny black achene;[21,29] each plant may produce 50-100 seeds;[14] buoyant;[3,21] water-, bird-, small mammal-, and human-dispersed,[13,21,29] July-Nov.;[18,21] germinates mid-Mar.-Apr.;[13] cold stratification may be required in colder environments[1,17] but is detrimental in warmer areas; scarification may promote germination;[17] most seed germinate within 2-3 years,[13] but seeds may persist in seed bank for ≥6 years;[10] seed from immature fruit still 35% viable.[23]

MILE-A-MINUTE WEED

***Persicaria perfoliata* (L.) H. Gross**
[*Polygonum perfoliatum* L.; *Ampelygonum perfoliatum* (L.) Roberty & Vautier[18]]
POLYGONACEAE

VINE

Persicaria perfoliata

MILE-A-MINUTE WEED

Habitat: Native to Eastern Asia;[3,6,13] introduced to the U.S. in 1890s[19] near Portland, OR, with no local spread;[25] found in PA in mid-1930s; along streams, in floodplains,[21] at roadsides, and in disturbed sites (harvested forests) and open woodlands;[16,20] possible preference for moist soils;[8] growth more vigorous (thicker stems and nodes) in full sun.[9]

Comments: Easily spread in nursery stock;[8] relatively shade-tolerant compared to native congeners;[8] performs better in open areas;[18] numerous native insects feed on it with little effect;[18,27] the weevil *Rhinoncomimus latipes* is an effective biocontrol,[28] reducing the vines' reproductive potential by 37%;[22] first released in the U.S. in 2004,[2] this biocontrol agent's herbivory impact is greater in full sun[9] and with adequate soil moisture;[2] adding a pre-emergent herbicide to biocontrol release results in an 80% reduction in *P. perfoliata* cover;[12] lowest temperature threshold for weevil development estimated at 10.2 °C (50 °F) with about 358 degree days needed from egg to adult;[11] sheep grazing reduces cover of *P. perfoliata* by 19% and significantly reduces flowering;[5] has anticarcinogenic compounds;[26] used in Eastern Asia as a medicinal plant for over 300 years.[7]

Similar Native Species: *P. sagittatum* and *P. arifolium* but leaves not glaucous, peltate, or triangular and ocreae not perfoliate.[8,20,21]

Habit: Perennial, twining vine[3] that trails or climbs to 30 m (98 ft);[6,12,25] legume with symbiotic nitrogen-fixing bacteria.[9]
Reproduction: Tubers, root suckers,[19] and runners that root at nodes;[9,19] by seed;[6,9,12] successful seed production rare in cold climates;[20,25] stem cutting propagation not successful.[20]
Leaves: Alternate, trifoliate, up to 18 cm (7-8 in) long with long petioles; dark green; pubescent underside; leaflets with smooth or lobed margin, middle leaflet usually has 3 shallow lobes and equal base, side leaflets have 1-2 lobes and unequal bases.[6,12,25]
Stems: Up to 2.5 cm (1 in) diameter but can be 10 cm (4 in);[19] brownish; young stems with tan/bronze hairs;[6,12,19,25] may grow 30 cm (12 in)/day; dieback in fall/winter;[19] some overwinter.[37]
Flowers: Up to 2.5 cm (1 in) wide; papilionaceous, reddish-purple, upper petal base yellow;[5,19] on elongate, branching racemes to 20 cm (8 in) long emerging from leaf axils; grape scented;[6,12,19,25] May-Nov. on vertically growing plants[9] in direct sunlight.[19]
Fruits/Seeds: Early/late fall; flat, pubescent pod 4-5 cm (1½-2 in) long;[12,19] seeds kidney shaped, 3-4 mm (⅛-3⁄16 in);[39] germination at 15-35 °C (59-95 °F), in light or dark, and best after scarification[32] (mechanical[36] or sulfuric acid[33]); cold stratification not required;[33] mammal and bird dispersed.[9]
Habitat: Native to China, Eastern Asia;[14,25] introduced to the U.S. in late 1800s;[14] forest edges, roadsides, old fields, and disturbed areas; shade-intolerant[3] but found in forests;[7,8] shading reduces shoot and root growth,[9,35]

KUDZU VINE

***Pueraria montana* var. *lobata* (Willd.) Maesen & S.M. Almeida ex Sanjappa & Predeep**
[*P. lobata* (Willd.) Ohwi.]
FABACEAE

VINE

but less for shoots at the expense of the roots;[11] not tolerant of cold;[4] tolerant of compacted, nutrient-poor soils,[34] though phosphorus is limiting;[18] older plants with deep roots are more drought tolerant;[30] positive growth response to increasing CO_2.[28]

Comments: Though not established in all niches of U.S. with climate like its native range, exists where climate is different from its native range, suggesting spread likely and continued expansion into new climates possible;[2] potentially allelopathic; leaf and root extracts reduce germination of lettuce and radish, but stem and seed extracts do not;[22] phytotoxic properties retained in soil beyond litter decomposition;[23] invaded soils show substantial increases in net N mineralization and nitrification as well as increases in nitric oxide emissions;[13] isoprene emission possible ozone source;[29] in areas with extensive kudzu invasion, there is a direct increase in the number of high ozone events;[13] simulated herbivory (removal of 50% of leaves and root drilling) has no effect on above ground biomass, but 75% damage shows some reduction in biomass;[10] high genetic diversity but low population differentiation in U.S. suggests multiple introductions from different sources and subsequent gene exchange;[16,21,31] continental U.S. has subject variety, Hawaii has *P. montana* var. *chinensis*; variety hybridization occurs;[15] potential carbohydrate production from southern populations rivals maize and sugar cane—being considered as a biofuel;[26] uses include soil enhancer in South American humid tropics,[27] erosion control,[19,25] feed,[5,18] fiber,[38] ornamental plantings,[14] and starch source;[1] treatment for alcoholism,[17,24] colds, asthma, diarrhea, fever, and anemia.[30]

Similar Native Species: Boykin's clusterpea (*Dioclea multiflora*), but fruit is 2-winged along upper suture, flower is smaller.[12]

Habit: Prostrate, low-growing, mat-forming perennial vine ≤15 cm (6 in) tall;[17] herbaceous, evergreen groundcover.[16,21]
Reproduction: Primarily vegetatively, also by seed;[20] cross-fertilization best for seed set, self-fertilization rare.[11]
Leaves: Opposite, simple; egg-shaped, 1-3.5 cm (~½-1½ in) long and 1-2 cm (~½-¾ in) wide; tip blunt to pointed; margin smooth; upper surface shiny, smooth, dark green with lighter green central vein;[10,17] sometimes variegated;[21] lower surface also smooth, but pale; petioles 1-3 cm (~½-1¼ in) long; petioles and leaves exude milky juice when broken;[8,10,12,17] new leaves form just after onset of flowering in early spring and overwinter.[16]
Stems: Smooth, green, shiny;[17] somewhat woody;[12] will root at nodes;[19,21] flowering stems erect.[19]
Flowers: Hermaphroditic;[11] solitary in axils;[19] lilac to blue (sometimes white); about 2.5 cm (1 in) wide; 5 petals[10,17,19] with truncate lobes;[10] pedicel 1-3 cm (~½-1¼ in) long;[17] Mar.-June;[10] double-flowered varieties exist and correlate with plants transplanted to a sunny environment.[26]
Fruits/Seeds: Dry, abruptly beaked capsule (follicle) 2-2.5 cm (¾-1 in) long, splits on 2 sides;[10,17] fruit seldom set on cultivated plants;[8] seed thought to be ant-dispersed (may limit dispersal range);[15] described as having no active dispersal mechanism.[13]
Habitat: Native of Europe[12,17,19] and Western Asia[8,20] where it is considered a late-successional forest interior species;[13] prefers partial shade to shade and acid to neutral, well-drained soils;[21] can be slow to establish in full sun, but can spread rapidly in response to

COMMON PERIWINKLE

Vinca minor L.

APOCYNACEAE

VINE

more favorable conditions;[9] found along roadsides and in fields,[17,19] cemeteries,[17] woods,[19] and forest understories;[20] USDA hardiness zones 3-8.[8]

Comments: Older native populations have lower genetic diversity than more recent populations in same native range, suggesting different origins;[3] at least 29 cultivars, which differ in flower color and leaf variegation;[8] *V. major*, a similar species that may have invasive tendencies, is hardy in zones 6-9[8] and is a taller, coarser groundcover[21] with small, short hairs (cilia) along its leaf margins;[12] *V. minor* cold-tolerant;[16] adjusts its ability to respond to higher light levels via thermal dissipation of excess energy using the pigment zeaxanthin;[5,6] exhibits higher photosynthetic rates in shade than sun in winter and accumulates carbohydrates, which may contribute to its cold tolerance;[1] mycorrhizae colonize roots, but whether association is obligate or mutually beneficial is unclear;[18] negative impacts on spider abundance and composition;[2] may suffer from leaf spots, stem lesions, root rot, canker, dieback, and cucumber mosaic virus;[8] deer may consume in spring, autumn, and winter, but not preferred;[22] produces the allelochemical vincamine (an alkaloid) but its toxicity to other organisms is uncertain, possible effects on tree seedlings;[4,7] fungal endophytes may enhance growth and production of vincamine;[25] vincamine is used as a cerebral vasodilator (widens blood vessels);[14,23] late fall herbicide application may effectively reduce its cover.[24]

Similar Native Species: Star chickweed (*Stellaria pubera*) but not evergreen and much less mat-forming, flowers smaller and white; partridgeberry (*Mitchella repens*), but leaves smaller and rounder, flowers white, fruit scarlet or white berry.[12]

Habit: Herbaceous milkweed; perennial, twining, and climbing vine;[11,13,21] clonal;[16] broken tissue exudes milky juice.[11,13,21]

Reproduction: By seed[13,16] and deep (50 cm, 20 in) rhizomes; monoecious,[6,24] selfing possible.[7,16]

Leaves: Opposite, entire, oblong to ovate, 5-10 cm (2-4 in) long; acuminate; round or subcordate base; petiole short;[5,11,13,21] glabrous, but veins and margin may have short curved hairs.

Stems: Glabrous or with short curved hairs; twining;[16] height typically 1-2 m (3-6½ ft).[16]

Flowers: May-Sep.;[13,21] small (6-8 mm, ~¼ in), 6-10 form an umbel-like cyme;[13,16,21] cymes located at every node except the bottom 3-4;[16] corolla purple-black, 5 fleshy lobes with tiny hairs;[13,21] corona inconspicuous;[13] peduncles 1-3 cm (⅜-1¼ in) long;[22] open 6-8 days; nectar smells of rotting fruit, strongest mid-day; pollinated primarily by flies.[16]

Fruits/Seeds: Smooth, slender follicle 4-7 cm (1½-2¾ in) long;[13,16,21] each contains many comose seeds that are released in fall when fruit splits lengthwise; primarily wind-dispersed,[13,16] most seed falls within a few meters of parent;[3] seed of vines growing at greater heights may travel 72 m (236 ft);[9] polyembryonic;[6,22] no dormancy or stratification required; seed viability of selfed and open-pollinated flowers not significantly different;[6,24] 30-50% germination rate; seeds germinate in spring or fall,[16] most in the first year; seed bank >3 years unlikely.[8,20]

Habitat: Introduced from Mediterranean Europe;[16] earliest records in U.S. from Ipswich, MA, in 1854;

BLACK SWALLOW-WORT

***Vincetoxicum nigrum* (L.) Moench**
[*Cynanchum louiseae* Kartesz & Gandhi; *C. nigrum* (L.) Pers.]
ASCLEPIADACEAE

VINE

disturbed areas, roadsides, fence rows, old fields, barrens, and woodlands; prefers calcareous soils,[22] but tolerates wide range of soil pH;[17] tolerates drier soils, full sun, and closed canopy forests; seed production lower in shaded sites;[5,19,24] forms monospecific populations under all light conditions,[6] but prefers higher light.[1]

Comments: Diploid and tetraploid races exist;[22] *V. hirundinaria* (yellowish, white flowers) is native to Eurasia[13,15] and less common in U.S.; related nonnative *V. rossicum* (lighter colored flowers with longer peduncles[22]) from Ukraine and Russia is also invasive—its seed are lighter and travel further than *V. nigrum* seeds,[9] and it is most abundant in the lower Great Lakes Basin,[22] forms monospecific populations,[2] and reduces arbuscular mycorrhizal fungi activity;[14] monarch butterfly oviposit on both *V. nigrum* and *V. rossicum*, but larvae unlikely to survive,[4,18] preferring its native host plant;[7,18] presence of both species reduces invertebrate and vertebrate diversity;[6,10] both species produce the phytotoxin -(-) antofine that has inhibitory effects at high concentration levels;[12] leaf-feeding moth *Hypena opulenta* approved as a biocontrol.[23,25]

Similar Native Species: Sandvine (*C. laeve*) but leaves cordate, flowers smaller white to green, corona lobes evident and erect; maroon Carolina milkvine (*Matelea carolinensis*) but leaves cordate, flowers larger, fruit covered in small, sharp projections.[5,13]

Habit: Spiny, deciduous shrub; ≤2.5 m (8 ft) tall and wide.[3,8,12]
Reproduction: Seeds;[8] by stump or stem sprouts.[3,24]
Leaves: Alternate, simple, clusters at each node;[3,12] entire, spatulate; 1.25-2 cm (½-¾ in) long; bright green above, lighter below;[3,7,8] fall color red to purple depending on cultivar;[3] appear before tree canopy leaf out and remain after canopy leaf abscission.[24]
Stems: Numerous; may senesce and be replaced every few years;[5,24] stems/shrubs mortality independent of *B. thunbergii's* population density;[5,24] reddish-brown, older stems gray; inner bark yellow;[12,25] angled or grooved, glabrous; usually stiff, single spines at nodes ~1.25 cm (½ in) long.[3,25]
Flowers: Apr.-May:[3,8,12] small, 6 petals, yellow, stalked; 1-4 form umbel-like clusters at nodes; nectaries on both sides of each of 6 stamens; anthers have a tripping mechanism; pollinated by bees[20]—first visit removes >50% of the sticky pollen;[13] perfect, may self- or cross-pollinate.[3]
Fruits/Seeds: Early–late summer; oblong to round berry, 1-1.25 cm (⅜-½ in); bright red, dry, 1-seeded;[7,8,12] high to intermediate light levels maximize production;[24] fruit removal may be highest in low light;[24] may remain on shrub through winter;[3] >90% fruit falls ≤1 m (3 ft) from shrub but mapped up to 80 m (262 ft) away; dispersed by birds (not a preferred food[24]), including turkey and grouse, as well as deer;[4] cold stratification and alternating temperatures improve germination;[2,22,24] seed bank possibly lacking or short-lived.[1]
Habitat: Introduced to U.S. from Japan between 1864 and 1879;[3,24] full sun to full shade; most soil types and habitats—dry ridgetops to wetlands, roadsides to closed canopy forests.[5,21]

JAPANESE BARBERRY
Berberis thunbergii DC.
BERBERIDACEAE

SHRUB

Berberis thunbergii
JAPANESE BARBERRY

Comments: At least 47 cultivars;[3] related *B. julianae* (evergreen, toothed leaves), escaping in several states, has invasive tendency;[9] *B. thunbergii* var. *atropurpurea* is among the most invasive—producing more seeds with a higher germination rate emerging into seedlings with greater vigor than other common cultivars,[14] yet most escaped populations are genetically distinct from var. *atropurpurea*;[17] feral var. *atropurpurea* descendants can be found[19] but may be highly inbred[18] and may be green in high-shade areas such as closed-canopy forests;[15,16] may alter soil conditions to its benefit by increasing pH, nitrification, and nitrate;[6] nonnative earthworm association possibly with increased litter decomposition or an agricultural connection;[10,11] positive association between the abundance of questing blacklegged ticks (deer tick, *Ixodes scapularis*) and higher incidences of Lyme disease, likely due to increase relative humidity in dense *B. thunbergii* thickets;[28,29] deer herbivory minimal,[4] but rabbits cause severe winter damage;[26] growth minimal in low light—seedling survival drops from 90% in intermediate-high light to 40% in low light, but survivors persist;[24] directed burning with a propane torch is effective control if done twice per growing season.[27]

Similar Native Species: American barberry (*B. canadensis*) but leaves toothed, spines usually 3-pronged.[23]

Habit: Deciduous shrub or small tree up to 6 m (18 ft) tall and 9 m (27 ft) wide.[6,11,15,18]

Reproduction: Primarily by seed;[11] also by stump or root sprouting; cuttings for 'Ellagood' cultivar.[23]

Leaves: Alternate, simple; oval, entire, wavy; gray-green above, silvery-scaly underside appears to shimmer;[11,15,18] young leaves may be silvery on both sides.[6]

Stems: Twigs silvery or golden brown; often thorny;[11,15,18] brownish scales give speckled appearance.[6,15]

Flowers: Clusters of 1-8 at leaf axils; tubular; 4 of each petals and stamens;[15,18] cream to light yellow,[15] exterior silvery-scaly; fragrant; Apr.-June.[11,15,18]

Fruits/Seeds: Fruit 6-8 mm (~¼ in); silvery with brown scales when immature, ripens to speckled red[11,15,18] or yellow;[9] Sept.-Nov.;[15,18] fleshy, edible (bitter to semi-sweet);[15] high in lycopene;[9] 1-seeded;[11,15,18] seed dispersed by birds (but not a preferred food[21]) and water;[14] cold stratification improves germination—optimized by alternating day/night temperatures of 20-30/10 °C (68-86/50 °F);[2] persistent seed bank possible considering related nonnative *E. angustifolia* seeds remain viable for 3 years in the lab and have a dormancy period;[13] despite its abundance (compared to 31 years ago), one study found no *E. umbellata* seeds in the seed bank.[5]

Habitat: Native to Asia; open woods, forest edges, roadsides, riparian areas, fencerows, meadows, pastures, sand dunes, mine spoils, and other disturbed

AUTUMN OLIVE

***Elaeagnus umbellata* Thunb.**

ELAEAGNACEAE

SHRUB

areas;[5,14,15,18,21] possibly shade-tolerant; tolerant of infertile and dry soils, as well as drought and salt;[7] acidic soils may reduce seedling survival;[4] USDA hardiness zones 4-8.[6]

Comments: At least 5 cultivars;[23] leaves have high N;[3] forms N-fixing actinorhizal root nodules[22] with actinomycete *Frankia* bacteria;[12] increases soil N,[1] which may benefit black walnut,[10] or harm an ecosystem by changing the soil nutrient properties native species were adapted to and possibly leading to increased exotic plant species invasions,[1] though these outcomes are unconfirmed; infection by N-fixing bacteria may induce defense-related genes;[19] allelopathic potential[17] but weak compared to other known allelopathic invasive species;[20] can maintain C-assimilation while under water stress;[16] may tolerate fire temperature up to 500 °C.[8]

Similar Native Species: Silverberry (*E. commutata*) but leaves shorter, egg-shaped with both sides scaly, silver-brown; stems thornless.[11]

Habit: Deciduous[14,20,26] shrub typically 2.5 m (8 ft) tall[14,26] but possibly 7 m (23 ft) with equal spread;[8,20] cultivar dictates size;[8] tends to grow slowly with short spurts.[8]

Reproduction: By seeds,[14,20,26] primarily outcrosses;[3] by stem cuttings, plant hormone IBA improves success;[6,8,27] and possibly by root suckers;[23] nursery industry mainly propagates with cuttings,[9] but spread most likely by seed.

Leaves: Opposite, subsessile; elliptic to obovate, ≤8 cm (3⅛ in) long; sharply serrulate; upper surface dark green, turn bright red in autumn; may be downy beneath.[8,20]

Stems: Opposite; 2-4 conspicuous corky wings[8,14,20,26] run the stem length[27] serving no apparent function;[2] 'Compactus' cultivar corky wings may be less pronounced or absent.[7]

Flowers: Small, 6-8 mm (~¼ in) wide; inconspicuous yellow-green; 4 petals,[8,20] very short stamens opposite petals;[14] perfect;[14] Apr.-June.[8,20]

Fruits/Seeds: Fruit smooth, purplish; 1-4-lobed capsule[14,20] containing 3-5 locules each with 1-6 seeds; fruit matures Sept.-Oct. with lobes splitting to reveal orange aril;[14,20,26] releases seeds through Jan.;[23] birds disperse seeds;[8] germination may require cold moist stratification for 1-3 months[8] or sequence of cold moist to warm moist back to cold moist;[3,25] prolonged dormancy regulated by abscisic acid;[29] seed bank likely but longevity unknown.[8]

Habitat: Indigenous to Northeast Asia and central China;[8,14,26] escaped cultivation and established in open areas, such as prairies[1] and woodlands;[8,10,11,12,13,24] appears

WINGED BURNING BUSH

***Euonymus alatus* (Thunb.) Siebold**

CELASTRACEAE

SHRUB

to prefer sunny conditions, though does well in deep shade without affecting fall's red foliage; may dominate mature forest understory;[10] prefers well-drained soils, sensitive to drought; USDA hardiness zones 4-9[8] but possibly prefers more northern zones due to seed dormancy requirements.[16]

Comments: Extensive use in ornamental plantings; ≥10 cultivars,[8] 'Compactus' among most popular;[7,8] some cultivars may produce fewer seeds at lower survival rates, but still enough to be considered invasive;[3,25] triploid plants, which are likely infertile, were produced via endosperm culture;[28] transgenic plants (created using *Agrobacterium tumefaciens*) that yield fruit but no or nonviable pollen or seed are in development;[4] if these triploid and transgenic plants are proven sterile, they may be less invasive; possible medicinal applications include cytotoxic activity against tumor cells[19,22] and treatments for inflammation,[18] stomachaches,[15] and diabetes;[5] minimally affected by a few pathogens, (e.g., two-spotted spider mites[8,21] and nematodes[8]); *Whetzelinia sclerotiorum* fungus may cause dieback; overwinter host of black bean aphid (*Aphis fabae*).[17,30]

Similar Native Species: Wahoo (*E. atropurpureus*) but autumn leaf color is yellow; strawberry bush (*E. americanus*) but flowers are 5-merous.[14]

Habit: Semi-deciduous (northern latitudes) to evergreen (southern latitudes);[4,5] opposite-branching shrub or tree, grows to 6 m (20 ft)[4] but possibly up to 10 m (33 ft) tall[19] and 4.5 m (15 ft) wide;[5] shrubs likely composed of 1-3 ramets.[14]

Reproduction: By seed[4,14,23] and vegetatively via root suckering.[4,14,22]

Leaves: Opposite, simple, elliptic-oblong; 2.5-7.6 cm (1-3 in) long and 1.3-2.5 cm (½-1 in) wide; margin smooth; dark dull green above; midrib pubescent below; petiole ~3 mm (⅛ in) long.[4]

Stems: Pubescent, gray-yellow.[4]

Flowers: Small, cream to white on pedicels, stamens exserted slightly beyond or equal to corolla lobes;[12] axillary and terminal open/diffuse panicles,[15] 5-7.5 cm (2-3 in) long;[5] may produce up to 270 flowers per ramet;[14] early Apr.-May;[3,12] hermaphroditic; primarily pollinated by insects in Lepidoptera Order, such as moths.[3]

Fruits/Seeds: Dull, waxy, purple-black fruit,[5] ~5 mm (¼ in) diameter;[24] fleshy part is dry and fibrous; persists through winter;[5] usually 1 seed (but up to 4)[6,17] ~3 mm (⅛ in) long and 2 mm (~1⁄16 in) wide;[24] one ramet produces up to 46 seeds;[14] estimated 1,300 seeds/m^2 of its canopy;[23] if small mammals ingest the fruit, seed rarely survives intact;[24] when birds ingest the fruit they disperse seed;[5,25] deer consume the fruit[19] and may disperse seed; 60 days of cold stratification improves germination;[1] higher germination rates may occur for seeds in shallowly-buried intact fruit than buried or

CHINESE PRIVET

***Ligustrum sinense* Lour. [*L. villosum* May]**

OLEACEAE

SHRUB

surface sown bare seeds; >95% of seeds persist <12 months—seed bank formation unlikely.[16]

Habitat: Native to China, Laos, and Vietnam;[5,14] introduced to the U.S. in 1852;[4,5] naturalization noted as early as 1933;[18,26] found in open areas as well as forest interiors[14] with light levels down to 5% full sunlight;[2] invades limestone cedar glade/woodland ecosystems that contain several endemic species;[14] may withstand short-term flooding because it can form lenticels and adventitious roots;[2] associated with lower elevations, shallow slopes, moist less acidic to alkaline soils,[8,21] and nonnative earthworms.[11] USDA hardiness zones 6-10.[4,5]

Comments: At least 5 cultivars,[4,26] variegated cultivars tend to produce fewer seed;[4,5,10,26] plant height and leaf area increase in response to lower light levels, unlike an associated native shrub species; low-light conditions decrease flowers to 65 and fruits to 12 per ramet;[14] a fall/winter food source for deer in GA, when acorns are scarce;[19] removal from riparian forests increases butterfly[9] and beetle[20] abundance; forms arbuscular mycorrhizae associations, presence of *L. sinense* may increase their abundance;[7] litter is high in N, low in lignin and cellulose, and rapidly decomposed;[13] genus has several potentially invasive species, including more northern-zoned *L. obtusifolium*[17] that has little published about it; no native *Ligustrum* spp. in North America may make it a good candidate for biocontrol—a lace bug, *Leptoypha hospita*, may be most promising option.[27,28]

Similar Native Species: Fringe tree (*Chionanthus virginicus*) but leaves are larger, flower petals have long linear lobes, panicles droop, and fruit is blue; coralberry (*Symphoricarpos orbiculatus*) but flowers are in small axillary clusters and fruit is red.[6]

Habit: Deciduous shrub ≤5 m (16 ft) tall/wide.[12,16,24,31,38]
Reproduction: By seed; main stem may re-sprout, cut young stems and bare roots may root.[12,16,44]
Leaves: Opposite; inverted egg-shaped, broadest in middle, tapering at both ends, tip abruptly pointed, 3.5-8.5 cm (1½-3½ in) long; entire with short ciliate; upper surface dark green, underside paler, both surfaces have hairs on veins;[6,16,24] petiole short, pubescent;[16,24,38] leaf out before and senescence later than many woody, native deciduous species.[11,24]
Stems: Grayish-brown; short hairs when young, broad ridges and grooves (appears striped) on older stems; internodes hollow; nodes and young stems may have white-tan pith.[12,24]
Flowers: May-June, 5-8-year-old plants;[10] usually 2 at a node; 15-20 mm (½-¾ in) long;[16,24] 2-lipped, anthers longer than lips;[24] pedicels shorter than petioles;[24,38] white ages to yellow;[16,24,38] nectar mostly sucrose, attracts primarily bees; ~21,000 flowers/shrub, ~34 g (1.2 oz) sugar/day/shrub;[42] moderate shade strongly reduces flower production.[41]
Fruits/Seeds: Bright red at maturity in late summer to fall;[24,38] pulpy berry with 1-6 seeds (pers. obs.); moderate shade strongly reduces fruit set, number, and mass as well as seed number and size[3,17] but forest interior shrubs still produce fruit;[25] seeds may require cold, warm, or no stratification—inconsistencies may be cultivar-dependent (Rem-Red requires cold, Cling-Red does not);[44] optimal germination at 25 or 15 °C (77 or 59 °F) in light;[3,21] 54-81% germinate with warm, moist conditions in light (30-55% in dark); seed bank unlikely or limited;[20,29,30] birds disperse (e.g., American robin, but cedar waxwings' digestion destroys seed) into suitable habitats[2] but don't prefer the lipid-poor fruit ;[23,46] deer ingest fruit and defecate some viable seed (less than seed directly off shrubs);[7] small mammals consume seeds despite bitter seed coat but not a significant part

AMUR HONEYSUCKLE
Lonicera maackii (Rupr.) Herder
CAPRIFOLIACEAE

SHRUB

of their diet;[47,48] greater seed predation than associated native species in some cases.[33]

Habitat: Native to Eurasia; introduced to U.S. in late 1850s;[12,28] urban areas, old fields, floodplains, disturbed ground, upland/lowland forests (early/late successional), wood edges, and roadsides;[24,38] higher growth rates and fitness in high light;[22,28,29,32] USDA hardiness zones 3-8.[12]

Comments: Allelopathic impact on native seed germination and possible facilitation of self-germination,[8,13] some co-occurring native shrubs have similar allelopathic effects;[34] removal increases survival/fecundity of associated natives;[18,19,35] litter decays 2-4 times faster and releases nitrogen faster than sugar maple litter;[15,43] lower soil moisture[37] and higher transpiration rates[5] may make water more limiting at invaded sites; preferential American robin nesting despite higher predation rates (nests lower) compared to native shrubs;[40] other birds experience lower nest survival in early spring and fewer fledglings than with other shrub species;[39] serves as cover for several rodent species on cloudless nights;[14] exposure to fruit and flower sediment reduces survival and growth of some stream macroinvertebrates;[9] its plant extracts more likely to kill some insect[8] and tadpole species than a water control;[45] presence increases spider abundance in forests;[27] invaded plots have greater richness and abundance of some insects compared to uninvaded plots with same shrub diversity;[26] deer prefer invaded sites leading to increases in lone star ticks (*Amblyomma americanum*) carrying ehrlichiosis at these sites;[1] honeysuckle leaf blight (*Insolibasidium deformans*) impacts may be increasing;[4] a density-dependent effect of fungal seed pathogens may explain greater seed bank decline compared to associated native species seed bank in an invaded site;[36] cross with *L. tatarica* forms *L.* × *bella*.[12]

Similar Native Species: Fly honeysuckle (*L. canadensis*) but smaller size, leaves not abruptly pointed, flowers not strongly bilabiate.[16]



Habit: Deciduous shrub or tree to 8 m (24 ft) tall and wide;[5,6,10,26] tree-like under closed canopies, shrub-like in open conditions.[3]
Reproduction: Primarily by seeds; dioecious,[6,10,26] with some hermaphroditic flowers found on some shrubs;[6] may sucker from base; can sprout from stumps.[11]
Leaves: Opposite, some alternate; elliptic to oblong/obovate, 3-7 cm (1¼-2¾ in) long—twice as long as wide; often abruptly pointed with rounded teeth (each with a gland[21,29]) on the margin;[10,26] pinnately veined, lateral veins curve upward;[10,21,26] upper surface dark green, lower light green;[5,10,21] yellow-brown in fall;[5,11] young leaves downy beneath;[11] early leaf out,[13] late senescence; leaf lifespan exceeds that of native shrubs by 58 days.[1,5,13]
Stems: Opposite (or nearly) at right angles to trunk;[11] some end in a short thorn;[5,10,11,21,26] grayish/yellowish-brown; glabrous,[5,21] trunk becomes scaly with age.[21,29]
Flowers: Male 2-40 per cluster with 4 yellowish-greenish petals and sepals, 4 stamens; female 2-30 per cluster, usually without petals—if present linear and yellowish-brown, 4 green sepals shorter than those in males,[10,11,21,24] 4 vestigial stamens; Apr.-June,[21] appear with leaves;[10,26] females at 6:1 ratio to males; honey-scented calyx tube with nectarial lining; insect pollinated (bees and flies).[11]
Fruits/Seeds: Fruit glossy black at maturity in late summer/early fall; 0.5 cm (¼ in) diameter drupe contains 3-4 seeds;[5,6,10,11,26] most fruit falls beneath females; seed bird-dispersed, including migratory birds,[30] but not a preferred food source (even in native habitat);[11] premature dispersal limited due to presence of emodin which deters feeding;[33] cold stratification may[2] or may not[1] be required; optimal germination at 20 or 30 °C (68 or 86 °F);[2] may germinate in the dark;[11] germination rates high, around 85%;[1] seed longevity at least 2 years; dormancy and seed bank unclear.[1,11,18]

COMMON BUCKTHORN
Rhamnus cathartica **L.**
RHAMNACEAE

SHRUB

Rhamnus cathartica
COMMON BUCKTHORN

Habitat: Native of Eurasia; introduced to U.S. in 1880s as a hedge plant;[1,37] may have been imported earlier as a medicinal;[20] calcareous soils in native habitat;[1,11] tolerates various soil conditions;[1] open/shaded areas, roadsides, woodlands, riverbanks (not flooded[7]), pastures,[1,17,26,32] mature forests;[13] USDA hardiness zone 3-7.[5]
Comments: Seedling establishment more likely on ground with little herb cover;[9] deer may browse it and may prefer it over native *Juniperus virginiana*,[36] though deer are less likely to be found in sites invaded by *R. cathartica* than non-invaded sites;[34] mice consume the seed;[11] voles consume the seedlings;[9] alternate host for oat crown/leaf rust[22] and overwintering host of soybean aphid;[25,35] associated with arbuscular mycorrhizae;[11] early leaf out more important than late senescence for carbon gain;[13] growth rates higher in light;[14] photosynthesizes at higher rate and shows greater fecundity than related native *R. caroliniana*;[31] leaves decompose faster than natives and are high in N;[15] presence may increase soil N, N mineralization rates, and pH;[16] associated with nonnative earthworms;[27] may be allelopathic;[19] fruit exudate inhibits seed germination more than leaf exudate, with no effect from bark or root;[28] contains compounds with antibacterial and anti-yeast activity;[12] a bark and fruit syrup used since the Middle Ages has purgative properties;[24] treating a single stem with herbicide can kill entire shrub;[23] no noted cultivars in the U.S., but 7-8 varieties documented in its native range;[24] microsatellite primers developed;[4] a fertile and vigorous hybrid (e.g., with *R. utilis*, Chinese buckthorn) documented in the U.S.[8]
Similar Native Species: Carolina buckthorn (*R. caroliniana*) but perfect flowers in parts of 5, leaves alternate.[10,26]



Habit: Perennial, deciduous shrub up to 5 m (16 ft) tall and wide; long, slender, arching branches.[13,18,19]

Reproduction: By seed;[13,19] may self-fertilize (less likely) or outcross [also with other roses, e.g., *R. wichuraiana* (nonnative tetraploid)]; male-donor-tetraploid crosses have larger fruit, more seeds;[20] asexual reproduction (agamospermy or seed formation without fertilization) documented but rare; self-fertilization not likely within a flower, but possible among flowers on the same plant, especially for cultivars with higher ploidy levels than diploid;[33] vegetatively by stem sprouts,[13,19] shallow root sprouts, and layering (rooting cane tips that touch the ground);[29] colonial.[19]

Leaves: Alternate, pinnately compound with 5-11 elliptic to obovate leaflets 2.5 cm (1 in) long with fine teeth;[19,29,41] underside of leaflets with hairs and paler than upper surface;[29,41] base of leaves have a fringed stipule.[19,29,41]

Stems: Flexible, green-red; rigid, recurved thorns with wide base;[29] thornless cultivar exists.[5,9]

Flowers: May-June;[18,19,29] white or slightly pink, 1-4 cm (⅜-1½ in) wide; numerous, arranged in terminal panicles; pollinated by generalists like syrphid flies.[26]

Fruits/Seeds: Clustered, hard, maturing to red; 5-7 mm (¼ in) wide, egg-shaped; glossy, smooth; Sept.-Oct.,[13,29] lasting into winter;[13] yellowish seeds;[29] dispersed by turkeys, deer mice,[49] and birds (some migratory),[36,38] though migratory birds[46] and rodents[44] show a preference for native fruit over nonnative (including *R. multiflora*) if both are present; few of the seeds ingested and most expelled after about 25 minutes, allowing for dispersal;[30] cold stratification required;[2,5] scarification with sulfuric acid increases germination

MULTIFLORA ROSE

***Rosa multiflora* Thunb. [*Rosa cathayensis* (Rehder & E.H. Wilson) L.H. Bailey]**

ROSACEAE

SHRUB

rate;[52] germinates best in light (~60%); <10% germinate in dark;[50] optimum germination at 10-20 °C (50-68 °F)[51] or 5 °C (41 °F),[2,51] but requires more time at the colder temperature;[51] seed bank[31] active up to 20 years.[27,32]

Habitat: Introduced to the U.S. from Asia ~1886;[32] promoted in 1930s and '40s by government agencies as a 'living fence,' soil stabilizer, and wildlife food/cover;[11,15,22] streambanks, pastures, roadsides,[11] forest canopy gaps, disturbed areas, and mature forests;[23,41] tolerates a variety of soils,[13,34,43] but prefers more alkaline and fertile soils;[24] USDA hardiness zones 5-8.[13]

Comments: Shrubs located on the forest edge or in canopy gaps have greater density and fecundity than those under a forest canopy;[14] used as rootstock for other roses[42,45] but not best choice for longevity and flower production;[28] repeated herbivory lethal;[4,32] large genome for a diploid in its native range;[37] in native-range pink flowers, obligate outcrossers, and diploid,[10,48] whereas introduced plants have predominantly white flowers, show some self-compatibility, and may have different ploidy levels;[33] in native range, rose rosette disease (also affects other cultivated and native roses[6,17]) may be lethal;[12,16,22] the mite *Phyllocoptes fructiphilus* likely the primary agent of rose rosette disease;[25] *R. multiflora* cryptic virus also associated with rose rosette disease;[35] responds well to mycorrhizal inoculation;[7,8,40] preferential nest site for veeries,[21] other birds,[47] and mammals such as rabbits;[3] abundance may decline while forest succession progresses;[1] ≥3 cultivars;[13] 371 rose species considered its progeny;[39] hip extracts have anti-inflammatory and pain-killing properties.[53]

Similar Native Species: Pasture rose (*R. carolina*) and smooth rose (*R. blanda*) but stipule not fringed.[19]

Habit: Perennial, deciduous shrub with arching canes.[10]

Reproduction: By seed, mostly self-pollinated,[13] but likely also pollinated by insects; vegetatively via rhizomatous growth and tip rooting.[14]

Leaves: Compound with 3 leaflets; terminal one ovate, rounded at the base, and sharply short-acuminate; lateral leaves are similar shape but smaller; all have dense white tomentose underneath; petioles covered with dense, long [3-5 mm (⅛-¼ in)], glandular, purple hairs.[10,15]

Stems: Up to 2 m (6 ft) long; primocanes do not flower; floricanes produce flowers and fruit in second year and then alternate years; covered in dense, long, glandular, purple hairs; armed with a few bristle-like prickles;[10] arching canes prone to layering.[12]

Flowers: Second year, June;[13] hermaphroditic with glandular, hairy sepals and white to pale pink petals that are much shorter than sepals; form cymose panicles.[7,10,15]

Fruits/Seeds: Orange-red raspberry, 1 cm (⅜ in) long; July;[12,15] seeds likely bird and deer dispersed;[16] germinate in spring, light does not appear to be required;[11] seed bank possible; after 26 years of cold storage 8% germinated.[5]

Habitat: Native to Japan, China, and Korea; introduced to U.S. as breeding stock for blackberry and raspberry cultivars in 1890;[13] found on edges of forests, streams, and wetlands as well as in open woodlands; apparent preference for mesic conditions.[13]

WINEBERRY

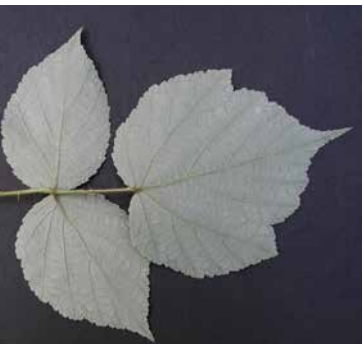
***Rubus phoenicolasius* Maxim.**

ROSACEAE

SHRUB

Comments: Higher leaf N concentrations than native *Rubus* spp.;[13] light and litter and/or soil disturbance ensure growth of seedlings and adults, making gaps important for establishment in forests; larger gaps necessary for spread, because only stems >1 m (3 ft) begin layering and stems this length most likely to occur in larger gaps [>290 m^2 (0.07 acre)];[11] reproduction more likely under conditions that ensure floricane growth[8,9,11] (e.g., larger gaps in closed canopy forests or open, young forests);[14] survival is possible in closed canopy forests, growth can occur in light levels as low as 5% full sunlight;[11] less herbivory than native congener *R. occidentalis*;[17] wild host of raspberry mosaic virus (aphid *Amphorophora rubi* vector) that can spread to native *Rubus* spp., such as *R. occidentalis*;[6] leaf spot disease (fungus *Sphaerulina tirolensis*) observed;[1] low genetic diversity compared to related native *Rubus*;[14] extended leaf phenology;[3] associated with lower temperatures compared to native shrubs, impacting ectotherm habitat use;[4] higher N requirement than many natives.[2]

Similar Native Species: American red raspberry (*R. idaeus* subsp. *strigosus*) but leaves narrower and pinnately compound, stems glaucous (not reddish or purple) with some bristles and glands.[9]




Habit: Deciduous tree reaches 30 m (98 ft) tall.[2,6]

Reproduction: Seeds primarily;[6] can be propagated vegetatively (but uncommon in nature) from roots[16] and cuttings.[2,16]

Leaves: Opposite; wider than long, broad base ≤18 cm (7 in) wide; 5-7 lobes, smooth, few teeth; petioles with milky juice most noted when base broken;[4,6] green to bronze with fall color tending to bright yellow.[2]

Stems: Trunk with widely spreading branches (cultivars vary, some with narrow canopies), bark relatively smooth, with shallow furrows;[4] twigs olive-brown; leaf scars meet to form sharp angle; leaf buds are plump, fleshy, and green to maroon.[2]

Flowers: Yellow-green, perfect; stalked, loose clusters form corymbs;[4] appear before[2] or with leaves in spring.

Fruits/Seeds: Samaras with 2 near horizontal (~180° divergent) wings[4] appear late spring through summer; seeds wind-dispersed with low fall rates, dispersal distance estimated at 50 m (164 ft);[12] 90-120 days cold stratification;[1,2] germinates best at 10 °C (50 °F);[10] seed bank potential.[9]

Habitat: Introduced to U.S. from Europe in 1756;[18] planted extensively in urban and suburban areas;[2] escaped to roadsides and waste places, in hedgerows and roadside thickets;[4] also spreading into early[6] and some late-successional forests;[11,17,18] shade tolerant;[13,18] withstands sandy, clayey, acidic, and calcareous soils as well as ozone and sulfur dioxide; somewhat drought resistant; USDA hardiness zones 4-7.[2]

NORWAY MAPLE

Acer platanoides **L.**

ACERACEAE

TREE

Acer platanoides
NORWAY MAPLE

Comments: Leaves remain on trees through late autumn; root system tends to be shallow[2,13]—investing more in foliage than stem and roots may reduce competitiveness in drier, open environments;[13] its leaf litter may increase soil fertility (high Ca, Mg, K, and N)[14]—this may benefit some associated native seedlings[7,8] and facilitate its own survival/growth;[15] regenerates prolifically under its own canopy[11,18] while this shade inhibits some associated native tree seedling survival/growth,[3,5,15] which may reduce overall plant diversity;[11,18] at least 36 cultivars; over-planted in urban areas despite issues with splitting bark and susceptibility to wilt, anthracnose, tar spot, and leaf scorch.[2]

Similar Native Species: Sugar maple (*A. saccharum*) but petioles without milky juice, leaf scars do not meet, and samara wings <180° angle.[2,4,6]

Habit: Deciduous tree, height up to 30 m (98 ft).[5]

Reproduction: By seed and vegetatively via root suckers;[9] able to produce many viable seeds, even trees over a century old.[30]

Leaves: Pinnately compound, ≤1 m (3 ft) long with 11-41 leaflets that have a "thumb" or tooth (sometimes more than one) at their base; each tooth has a gland.[9]

Stems: Bark gray and smooth; younger twigs covered with light brown to reddish-brown pubescence; thick, slightly enlarged tips; may grow 2 m (7 ft) in a season.[5]

Flowers: Dioecious but hermaphrodites exist;[9] June-July; as early as 6 weeks after germination but adult trees are the norm;[7] pollinated by variety of insects, including bees.[4]

Fruits/Seeds: Samara, 2 wings at 180° and one central seed, sets late summer; >300,000 seeds per tree documented;[2,30] seeds may remain on tree through winter;[5,15] wind[18] and water[19] dispersed ≥100 m;[20] cold stratification not required but improves germination;[12] seed bank thought unlikely,[18] but may be up to 5 years,[26] found in an urban forest seed bank.[17]

Habitat: Native to China; several introductions to U.S. since 1784;[8] poor or rich soil, shallow to steep slopes, urban areas, open fields, woodlands, closed canopy forests; often associated with disturbed habitats;[13,15] tolerates several air pollutants;[11,22,25] USDA hardiness zones 4-8.[5]

TREE OF HEAVEN

***Ailanthus altissima* (Mill.) Swingle**
[*A. glandulosa* Desf.]
SIMAROUBACEAE

TREE

Ailanthus altissima
TREE OF HEAVEN

Comments: More dependent on clonal growth in shady conditions;[18] ≥5 cultivars;[5] drought-resistant seedlings;[27] preferred host for spotted lanternfly (*Lycorma delicatula*) whose fitness decreases with other host plants;[28] increased density of *A. altissima* associated with decreased soil microbial activity, litter detritivores (mites, springtails), and predatory beetles, but also associated with increased earthworms and dung-eating beetles;[23] proximity associated with increased available soil nutrients;[29] crushed leaves, stems, and roots smell of rancid peanut butter; allelopathic properties[14] but previous exposure reduces impact severity;[21] may inhibit nodule formation of nitrogen-fixing species;[1] quassinoid compounds may deter some insect herbivory[10] and frugivory[24] but seeds and tissue may be consumed by deer, mice, and voles,[3,6,24] and preferred by some invertebrates;[3] *Verticillium nonalfalfae* (verticillium wilt) is potential biocontrol.[16]

Similar Native Species: Sumacs (*Rhus glabra, R. typhina*) and walnuts (*Juglans nigra, J. cinerea*) but crushed leaves or broken stems without same odor, fruits not samaras.[9]

Habit: Deciduous tree, 15-20 m (45-60 ft) tall.[6,10] short-lived, possibly only 60-70 years.[9,16]
Reproduction: Seed; can propagate by root cuttings.[4]
Leaves: Opposite or whorled, simple;[4,17] broadly cordate-ovate, 15-25 cm (6-10 in) in size (possibly larger) with 3-5 shallow lobes; entire; underside hairy to tomentose–stellate or branched hairs;[6] topside pubescent;[4] long petioled.[6]
Stems: Opposite or whorled;[6] chambered pith; heavily lenticelled, pubescent when young; olive-brown.[4]
Flowers: Apr.-May, before leaves;[4] showy, terminal panicles of 5-7 cm (2-3 in) foxglove shaped flowers; blue or violet[4,6] with darker spots and yellow stripes inside; vanilla-scented; flower buds light brown, pubescent spheres that overwinter but may not survive harsh winters.[4]
Fruits/Seeds: Woody, pointed capsules, 3-4 cm (1¼-1½ in) long; seed-bearing at 8-10 years;[2] about 2000 seed per capsule;[8] large tree may produce 20 million seed/year;[4] seeds flattened and winged,[6] wind-dispersed;[10] require light to germinate;[13] no dormancy;[4] typically viable <2-3 years;[3,25] significant seed bank unlikely.[7]
Habitat: Native to western and central China; introduced to the U.S. in 1834;[4,11] in native range prefers alkaline soils and moist to semi-dry open forests;[18] found in newly disturbed[8] and urban areas;[5] tolerates high soil acidity, low soil fertility, and drought; may also colonize rocky cliffs and scoured riparian areas;[15] relatively cold intolerant; USDA hardiness zones 6-9.[4]

PRINCESS TREE

***Paulownia tomentosa* (Thunb.) Steud.**
[*P. imperialis* Siebold & Zucc.]
SCROPHULARIACEAE

TREE

Paulownia tomentosa
PRINCESS TREE

Comments: At least 3 cultivars;[4] invasive potential questioned by some;[24] fast growing,[8] possibly 2.7-3.3 m (8-10 ft) per year;[4] very susceptible to deer herbivory;[13] can re-sprout at early age, even in low light, making it tolerant of fire and deer browsing;[14,22] liquid smoke may reduce amount of time needed in light for germination;[22] endomycorrhizal associations present;[1] <1% occurrence on reclaimed mine lands despite preference for highly disturbed sites,[12,21] but successfully planted on strip mines in some areas;[4] one of many host plants for brown marmorated stink bug (*Halyomorpha halys*);[23] wood in high demand (also for related *P. elongata*) to make rice pots, bowls, spoons, coffins, air crates, furniture, and musical instruments;[4,20] contains several phenolic compounds with antioxidant activity.[19]

Similar Native Species: Cigar tree (*Catalpa speciosa*) but leaves not lobed; pith not chambered; flowers white or yellowish spotted with purple; fruit a long, pendulous capsule.[4,6]

Habit: Tree, 9-16 m (~30-50 ft) tall with a 6-11 m (~20-35 ft) spread; moderately conical when young, but broadens with time (at 15-20 years trees may split in half).[6]

Reproduction: By seed; self-incompatible;[25] clones developed via grafting, but poorly managed rootstocks may break free, flower, cross with the scion, and produce seed;[5] reproduction begins as early as 3 years.[1,23]

Leaves: Broadly ovate to elliptical, about 4-9 cm (~1½-3½ in) long;[23] glossy, dark green in summer switching to glossy shades of scarlet and purple in fall; glabrous with crenate margins;[6,19] petioles 2.2-4.5 cm (~⅞-1¾ in) long; narrow stipules about 2 cm (~¾ in) long.[23]

Stems: Bark shiny brown when young and grayer, slightly ridged, and furrowed when mature; stems alternate, may have ridges from the base of leaf scar; terminal buds and stem tips are white and woolly, but gradually become smooth, shiny brown.[6,23]

Flowers: About 2 cm (~¾ in) wide with 5 white petals; 5-12 flowers form a 7.6 cm (3 in) wide corymb;[23] malodorous in full bloom, Mar.-Apr.[6,19]

Fruits/Seeds: Fruit is small, round, 1-1.5 cm (~⅜-⅝ in) diameter; brown to yellow-brown, russet-dotted with 1-4 seeds;[6,23] seeds likely bird-dispersed;[23] cold stratification at 0-2 °C (~32-36 °F) for 60-90 days required;[6] germination rates and seed bank potential unknown.

Habitat: Native to Korea, China,[6] and Taiwan;[23] introduced into U.S. cultivation in 1908 at Harvard University's Arnold Arboretum;[23] common urban street tree; escaped into disturbed open areas and woodlots;[23] USDA hardiness zones 5-8(9).[6,7]

CALLERY PEAR

***Pyrus calleryana* Decne. [*P. koehnei* C.K. Schneid.]**

ROSACEAE

TREE

Pyrus calleryana
CALLERY PEAR

Comments: Unfortunately still a valued street tree by some[9,14,18] because of its early-flowering[3] and tolerance to pollution and water stress,[22] even though reduced use is recommended;[16] has a gene (PcPCS1) associated with the synthesis of phytochelatins that detoxify heavy metals, this gene is a candidate for heavy metal bioremediation via recombinant bacteria;[15] at least 25 cultivars,[3,4,6] of which Bradford and Chanticleer may be the most common in the U.S.; wild species is thorny,[7] but not true of most cultivars; escapees from cultivation are often thorny;[4,6,23] may cross with other *Pyrus* species [e.g., *P. communis* (European) and *P. betulaefolia* (Asian)];[23,24] intraspecific hybridization occurs among genetically distinct cultivars, produces viable seed;[3,4] lack of morphological differences among cultivars increases likelihood genetically distinct cultivars will be planted near each other, leading to intraspecific hybridization;[4] hybrids have no inherent fitness advantage;[11] most cultivars are diploids (n=34), but 4 are triploids (n=51);[26] some cultivars suffer from large limb or whole tree failure;[8,14] spraying flowers with Ethephon prevents fruit formation;[6] may suffer from canker and tip dieback disease caused by the bacterium *Pseudomonas syringae*;[21] has secondary metabolites (e.g., 3,4-dihydroxybenzyl alcohol, known as calleryanin[2]), which may protect it from Japanese beetles (*Popillia japonica*)[13] and wood-boring Asian longhorned beetles (*Anoplophora glabripennis*);[17] resistant to root-knot nematodes;[20] the Bradford cultivar was bred for resistance to fireblight, but other cultivars (e.g., Aristocrat) are prone to this disease;[6] *P. calleryana* var. *dimorphylla* is endangered and endemic to central Japan.[12]

Similar Native Species: Sweet crabapple (*Malus coronaria* var. *coronaria*) but leaves serrate and may have lobes, flowers pink fading to white, fruit greenish; hawthorn (*Crataegus crus-galli*) but leaves serrate, sometimes with lobes, fruit dull green to red not russet-dotted.[10]

INVASIVE PLANTS FIELD & REFERENCE GUIDE:

An Ecological Perspective of Plant Invaders of Forests & Woodlands

Glossary of Terms

Citations and Photograph Information
(Listed by Habit and Alphabetically by Species Scientific Name)

GLOSSARY

Abscission: detachment of plant parts, typically dead leaves and ripe fruit.

Achene: dry fruit that is usually one-seeded and closed at maturity.

Acidic: pH less than 7; releases protons (hydrogen ions, H+) in water.

Actinorhizal: symbiotic relationship of N-fixing bacteria with plant roots; less common than rhizobia.

Acuminate: gradually tapering to a narrow tip or sharp point.

Adventitious: growing from mature tissue of a different type, as in roots developing on a stem.

Alkaline: pH higher than 7; releases hydroxyl ions (OH-) in water.

Allelopathic: ability to inhibit the growth of another plant species using toxic chemical substances.

Annual: a plant that completes its life cycle in 1 year—germinating from seed, flowering, setting seed, and dying in one growing season.

Anther: enlarged terminal pollen-bearing portion of the stamen.

Apex: highest point, often in reference to a shoot or root.

Aril: fleshy, often brightly colored, tissue covering some seeds.

Asexual: reproduction without union of gametes [in plants, without the union of sperm in pollen and egg in the ovule]; includes vegetative and clonal growth.

Awn: bristle-like structure; often associated with grass flowers.

Axillary: the point where the leaf base or petiole meets the stem.

Basal: leaves form a circle at the base of the plant, forming a rosette.

Beak: extension of style on achene, may be straight or curved; used to differentiate some *Ranunculus* species.

Biennial: grows vegetatively for the first year, then flowers and dies the next.

Bilabiate: 2-lipped (petals of a flower); bilaterally symmetrical in shape.

Biternate: borne in threes twice.

Blade: the expanded, terminal portion of a flat plant organ, such as a leaf.

Bract: a modified or reduced leaf-like structure located at the base of a flower or inflorescence.

Bulbil (Bulblet): bulb-like structure produced at the base of a plant (underground), in the leaf axis (above ground) or in place of flowers (both above and below ground).

C: chemical symbol for carbon.

C_4: photosynthetic pathway that uses CO_2 more efficiently (at a higher energy cost) by allowing storage of CO_2 in bundle sheath cells and reducing photorespiration; there is less need for gas exchange and open stomates; C_4 plants originated in the tropics and are well adapted to high light, high temperatures, and low moisture.

Ca: chemical symbol for calcium.

Calcifuge: plant not usually found in calcareous soil (chalk, limestone, calcium carbonate).

Carpel: part of the pistil containing the ovules, which produce seed once fertilized.

Cauline: arising from the stem located above the soil surface, not basal.

Chasmogamous (CH) flower: open; may outcross.

Ciliate: fringed with hairs.

Cleistogamous (CL) flower: closed; must self-fertilize.

Clonal: producing vegetative offshoots that can survive on their own from the same parent.

Collar: the leaf margin at the intersection of blade and sheath surrounding the stem.

Comose: having a tuft of long, soft/silky hairs, especially on a seed.

Compound: two or more similar parts of the same structure (such as flowers or leaflets).

Congener: belonging to the same genus.

Connate: united or fused parts.

Constitutive: inherent.

Cordate: shaped like a stylized heart, with the notch at the base.

GLOSSARY

Corolla: all the petals of a flower, collectively.

Corona: a set of petal-like structures or appendages from corolla base between the corolla and the stamens; floral characteristic of Asclepiadaceae.

Corymb: a flat-topped inflorescence with outer flowers on longer pedicels compared to the inner flowers; central flower is the youngest.

Cotyledons: leaves of the embryonic plant within a seed that first appear upon germination.

Crenate: toothed along the margin, the teeth rounded.

Cu: chemical symbol for copper.

Culm: the aerial stem of a grass or sedge.

Cultivar: a variety of a plant species occurring only under cultivation (though they may escape into the wild).

Cuneate: wedge shaped (or triangular), narrowing to the point of attachment.

Cyme (Cymose): a flat- or round-topped (or scorpioid) inflorescence where the central (or upper) flowers are older and the outer (or lower) flowers are youngest.

Cytokinins: class of plant hormones that promote cell division.

Deciduous: leaves shed each year.

Decurrent: wing or margin (as on a leaf petiole) continuing downward on a stem.

Dioecious: male and female unisexual flowers on separate plants.

Diploid: having two complete chromosome sets (2n).

Discoid: in Asteraceae, having disk flowers that make up all or part of the flowering head; disk flowers are tubular in shape with both male and female parts or are just functionally male; the central flowers in a sunflower head; compare to ray flowers in Asteraceae.

Dormancy (for seeds): arrested growth, requiring either further embryo development or an environmental cue for germination to occur.

Drupe: fleshy, one-seeded fruit with a stony inner layer.

Ectomycorrhiza: mycorrhizae that form a sheath around roots, unlike endomycorrhiza, which penetrate roots.

Embolism: filling of vascular tissue (vessels and tracheids) with air after water columns rupture (cavitation); such air pockets prevent the flow of water.

Evergreen: with leaves that persist for more than one growing season.

Fecundity: ability to reproduce; number of offspring produced.

Fertilization: two reproductive haploid cell nuclei (each with one chromosome set or 1n) fuse together forming a zygote (with two sets of chromosomes or 2n).

Field capacity: water remaining in soil after it was thoroughly saturated and allowed to drain freely.

Flavonoid: any group of aromatic compounds, including common pigments such as anthocyanins and flavones; antioxidant that may reduce cancer or other health risks.

Floret: an individual flower of definite cluster; often used to describe individual flowers of grass inflorescence.

Floricane: flowering stem (second year) of *Rubus* spp.

Florivory: consumption of flowers.

Follicle: a dry fruit derived from a single carpel that opens at maturity along the seed-bearing suture.

Frugivory: consumption of fruit.

Fruit: the mature ovary of a plant containing seeds.

Generalist: an organism seeking a broad range of resources, such as in pollination of flowers or herbivory by insects.

Genet: the genetic individual; may be composed of several individuals (or ramets) but only one genetically distinct organism; a clone.

Geophyte: a perennial plant that bears its perennating buds below the soil surface.

Germination: beginning or resumption of growth (usually in reference to a seed).

Glabrous: smooth, no hairs.

Glaucous: waxy, bluish green; possibly removable residue imparting a whitish or bluish cast to the surface.

Glume: one pair of outer bracts found at the base of a grass spikelet.

Grain: dry, one-seeded fruit, characteristic of grasses.

Guttation: water expelled from leaf tissue, often along the margins, caused by root water pressure.

GLOSSARY

Gynodioecious: female flowers and perfect flowers on separate plants.

Habit: general look or growth form of a plant.

Haploid: having a single set of unpaired chromosomes.

Hastate: shaped like an arrow but with diverging basal lobes.

Head (Capitulum): short dense inflorescence of sessile or subsessile flowers crowded closely together on a peduncle, giving it the appearance of a single flower as in the composite family (e.g., daisies or dandelions).

Herbivory: consumption of live plant tissue.

Hermaphrodite: one flower having both functional sexes; same as perfect.

Hexaploid: having 6 complete chromosome sets (6n).

Hybrid vigor: enhanced or improved function or fitness resulting from cross of two different species, heterosis.

Inducible: capable of being activated or expressed.

Inflorescence: a flower cluster.

Internode: section of stem between two nodes.

Involucre: leafy bracts enclosing multiple flowers, often in Asteraceae.

K: chemical symbol for potassium.

Layering: arching canes that touch ground and root at the tips, producing new ramets; a characteristic of some *Rubus* and *Rosa* species.

Leaf scar: scar left on a twig from a fallen leaf.

Legume: a fruit of the Fabaceae (pea) family composed of a single carpel but several seeds, dehiscing on both sutures.

Lemma: one of a pair of bracts that subtends the floret of grasses; found between the inner palea and the outer glumes.

Lenticel: a slightly raised area on the bark of a stem or root consisting of unsuberized (lacking suberin, lignin) cells that allow for gas exchange.

Liana: climbing, woody vine.

Ligule: flattened part of the ray-corolla in the Asteraceae or the appendage on the adaxial (inner, toward the stem or axis) side of a leaf at the junction of the blade and sheath in grasses and sedges.

Limiting: scarce resource, e.g., N limiting means nitrogen is scarce.

Linalool: a fragrant liquid alcohol.

Lip: one of two segments or sets of lobes of a bilabiate (two lipped) corolla or calyx.

Lobe: projecting segment of an organ, such as a leaf, that is too large to be called a tooth, but with adjoining sinuses (indentations between) usually extending less than half-way to the base.

Locule: seed-containing cavity of an ovary or fruit.

Loment: a legume composed of one-seeded joints.

Lycopene: red carotenoid pigment; an antioxidant; commonly found in tomatoes.

Merosity (n-merous): the number of component parts in a distinct whorl of a plant structure.

Mericarp: individual carpel of a schizocarp fruit.

Mesic: wet or moist.

Mg: chemical symbol for magnesium.

Mn: chemical symbol for manganese.

Monocarpic: flowering and fruiting once, then dying; also called semelparous; opposite is polycarpic or iteroparous, where organisms reproduce more than once before dying.

Monoecious: male and female unisexual flowers contained on one plant.

Morphophysiological dormancy: seeds with an underdeveloped embryo that also require particular conditions in order to induce germination (break dormancy).

Mucronate: tipped with a sharp, slender point.

Mycorrhiza: a fungus and plant root mutually beneficial association (symbiosis); mycorrhizae is plural.

N: chemical symbol for nitrogen (all forms).

Native: plant species naturally occurring in a given range, not introduced to an area by humans.

Nectaries: glands that secrete nectar.

Nitrate (NO_3-): one of the preferred forms of nitrogen for uptake by plants.

GLOSSARY

Nitrification: oxidation of ammonium ions (NH_4+) or ammonia (NH_3) to nitrate (NO_3-) by free-living soil bacteria.

Nitrogen fixation: conversion of gaseous nitrogen (N_2) into nitrogen compounds by free-living and symbiotic bacteria; more appropriately call dinitrogen fixation.

Node: place of attachment of leaf to stem.

Nodule: swellings on the roots of legumes and other plants inhabited by nitrogen-fixing bacteria.

Oblong: sides parallel with ends rounded; longer than broad.

Obovate: egg-shaped but connected at the narrow end.

Ocrea: stipular stem sheath above the leaf base; ocreae is plural.

Octoploid: having 8 complete chromosome sets (8n).

Outcrosser: an individual (i.e., plant) that may be fertilized by another individual of the same species (but not of the same clone), receiving new genetic material.

Oviposit: lay an egg or eggs (often in reference to insects).

P: chemical symbol for phosphorus.

Palea: one of a pair of bracts that subtends a grass floret inside the glumes.

Palmate: radiating out from a central axis.

Panicle: a branching inflorescence with pedicled flowers; flowers mature at the base first, then upwards.

Papilionaceous: butterfly-shaped; common in pea or bean flowers.

Pappus: typical of the Asteraceae; modified calyx composed of bristles, scales, awns, or hairs, located at each achene apex.

Pedicel: stalk that bears a single flower.

Peduncle: stalk of an inflorescence or single flower or fruit.

Peltate: petiole attached at or near the middle of the underside of a leaf, but not going through the leaf.

Perennial: living 2 years or longer.

Perfect: bisexual, having both male and female reproductive organs; usually referring to flowers.

Perfoliate: leaf surrounds the stem or petiole; stem or petiole goes through the leaf blade.

Perianth: petals and sepals of a flower collectively; most often used when petals and sepals look very similar.

Pers. Obs.: personal observation.

Petiole: leaf stalk.

pH: measure of acidity and alkalinity that is the negative logarithm of the effective hydrogen ion concentration.

Pilose: sparsely beset with straight spreading hairs.

Pinnate: arranged on opposite sides of a central axis, i.e., a column of leaflets or veins on each side.

Pinnatifid: more or less deeply cut in a pinnate fashion.

Pistil: the female organ of the flower, composed of one or more carpels, differentiated into ovary, style, and stigma.

Plumose: feathery, arranged in pinnate lateral bristles or dense, long pubescence.

Pollination: pollen transferred from an anther to a stigma (or archegonium neck of gymnosperms); may lead to fertilization.

Polyembryonic: seeds with multiple embryos that produce multiple seedlings.

Polyploidy: having three or more complete chromosome sets.

Prickle: sharp outgrowth from the epidermis or bark.

Primocane: the first-year cane of *Rubus* spp. non-flowering.

Propagule: seed, spores, or vegetative structures (bud, stem, root sucker) that can be used to produce another plant.

Protandrous: with male reproductive organs maturing prior to those of the female (pollen dispersing before female structure is receptive).

Pubescent: with hairs.

Raceme: unbranching, prolonged inflorescence producing stalked flowers, maturing from the base upward or outward.

Rachis: a main axis, such as that of a compound leaf or inflorescence.

GLOSSARY

Radicle: pertaining to the root, the first root upon germination.

Ramet: physiologically separate (at least potentially) individual of a genet (clone).

Ray (Asteraceae): ligule or ligule (lip-like extension) bearing flower; the outer flowers in a sunflower head.

Recruitment: the process in which seeds establish in an area and grow into new mature individuals.

Recurved: curved backwards.

Reflexed: bent backwards.

Rhizobia: N-fixing bacteria (*Rhizobium* and *Bradyrhizobium*) often associated with legumes.

Rhizomatous: with rhizomes (underground stems that can send up new shoots).

Rootstock: same as rhizome or an underground stem that can send up new shoots.

Rosette: radiating cluster of leaves at ground level.

Samara: closed, dry fruit with wings.

Scabrous: rough to the touch often due to short stiff hairs.

Scarification: seed coat degradation that often facilitates germination.

Scion: a young shoot of a plant, especially one cut for grafting or rooting.

Schizocarp: a fruit that splits into separate carpels at maturity.

Sclerenchymatous: Composed of strengthening tissue with thick-walled, lignified cells that are nearly or completely without living contents at maturity.

Secondary growth: cell division in the cambium and lateral meristems that results in an increase in girth rather than in height.

Seed: fertilized ovule with a hard coat, embryo, and sometimes endosperm (food storage for embryo).

Seed bank: seeds present in the soil and persisting for various time periods (longer than one season).

Self-compatible: individual that is capable of fertilizing itself.

Selfed: self-fertilized.

Senescence: life cycle stage from full maturity to death; can be used to describe a whole plant or parts of a plant (such as the leaves).

Sepal: member of the outer-most set of floral leaves, typically green or leafy-looking.

Serrulate: having sharp, forward pointing teeth on leaf margins.

Sessile: attached directly by the base, without a stalk.

Shade intolerant: grows well or preferentially in high light conditions and less well in low light conditions.

Shade tolerant: grows well or preferentially in low light conditions.

Sheath: leaf base surrounding the stem.

Silique: dry fruit, splitting with each half or valve separating from the other and leaving a central thin septum.

Simple: only one, or not divided.

Spatulate: spatula-shaped; with rounded, broad top portion and narrowing to the base.

Specialist: an organism seeking a specific resource (narrow range), such as in pollination of flowers, herbivory, or frugivory by insects.

Spike: unbranched inflorescence with sessile flowers.

Spikelet: a small, prolonged spike subtended by two bracts (in grasses and sedges).

Spring ephemeral: plants that flower and reproduce before leaf-out in early spring, taking advantage of the higher light levels, and that persist in a resting state during the summer until the following winter, when root tubers begin to elongate.

Stamen: male sex organ of a flower that produces pollen; composed of anther and filament.

Stipule: basal appendage associated with leaves, typically borne in pairs at the base of the petiole.

Stock: a plant part united with another plant part (the scion) of the same or a different species and supplying mostly underground parts; uniting stocks to scions is grafting.

GLOSSARY

Stoloniferous: producing stolons or elongate, creeping stems on the surface of the ground that can take root to form new plants.

Stomates: openings in plant epidermal tissue used for gas exchange in photosynthesis but may also be a source of water loss.

Stratification: seed exposure to different (often colder) temperatures to promote germination.

Strigose: with straight, appressed hairs that point generally in the same direction.

Style: slender stalk that connects stigma(s) to the ovary.

Subcordate: not quite heart shaped (stylized, see cordate).

Subsessile: not quite completely without stalks, nearly sessile.

Successional: directional pattern of plant community regeneration or colonization, i.e., going from bare ground or old field to young forest (early successional) to mature forest (late successional).

Sucker: root or stem offshoot emerging from beneath the soil to produce a new plant.

Suture: the line or seam where a mature fruit splits.

Terminal: at the top or apex of a structure (such as shoot).

Ternate: borne in threes.

Tetraploid: having 4 complete chromosome sets (4n).

Tomentose: covered with densely matted, woolly hairs.

Truncate: straight or flat-based as if cut off.

Tuber: in the case of lesser celandine, a tuberous root; true definition is the thickened part of a rhizome serving in food storage and possibly reproduction.

Umbel: a flat-topped or rounded inflorescence with flowers having equal length pedicles arising from a single point.

Variety (var.): in the taxonomic hierarchy, a lower than species division being either equivalent to subspecies level or less; naturally formed (not cultivated).

Vegetative: propagation using asexual means; potentially forming clones.

Venation: vein pattern found in leaves.

Vesicular-arbuscular mycorrhizae: an association (often mutualistic) between a fungus and a plant root in which the fungus enters the host cells and may also extend widely into the surrounding soil; fungus benefits by using plant photosynthates; plant benefits because the fungus increases uptake of nutrients, like phosphorus.

Viability: possibility of survival (i.e., of a seed to form a plant).

Whorled: ring of three or more similar structures, such as leaves, radiating from the same node or common point.

Xeric: dry.

Zn: chemical symbol for zinc.

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Photograph Information:
Plant [UGA5446542]; Leaf [UGA5446614]; Inflorescence [UGA5446521]: Leslie J. Mehrhoff, University of Connecticut. Photographs reproduced from www.invasive.org.

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Photograph Information:
Plant [UGA5451931]; Flowers [UGA5451802]; Seed [UGA5451822]: Leslie J. Mehrhoff, University of Connecticut. Basal leaves [UGA0580063]: Jil M. Swearingen, USDI National Park Service. Mature fruit [UGA1237102]: Britt Slattery, U.S. Fish and Wildlife Service. Photographs reproduced from www.invasive.org.

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Photograph Information:
Plant [UGA5515718]: Rob Routledge, Sault College. Flowers [UGA5451403]: Leslie J. Mehrhoff, University of Connecticut. Fruit [UGA5385910]: Jan Samanek, Phytosanitary Administration. Photographs reproduced from www.invasive.org.

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Photograph Information:
Leaves [UGA1237056]: Jack Ranney, University of Tennessee. Truncate leaves [UGA1539050]: James H. Miller, USDA Forest Service. Flowers with leaves [UGA1237059]: Britt Slattery, U.S. Fish and Wildlife Service. Fruit [UGA5452615]: Leslie Mehrhoff, University of Connecticut. Photographs reproduced from www.invasive.org.

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Leaves [UGA1460060]: Donna R. Ellis, University of Connecticut. Inflorescence [UGA1151039]: Terry English, USDA APHIS PPQ. Seeds [UGA1237083]: USDA APHIS PPQ Archives. Photographs reproduced from www.invasive.org.

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Photograph Information:
Plant [UGA5483689]; Leaf [UGA5483594]; Leaf sheath with hairless node [UGA5483715]; Florets with awns [UGA5483949]: Leslie J. Mehrhoff, University of Connecticut. Flowering/fruiting head [UGA5474657]: Chris Evans, University of Illinois. Photographs reproduced from www.invasive.org.

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Photograph Information:
Flowering plant [UGA5456379]; Variegated leaves [UGA5456366]: Leslie J. Mehrhoff, University of Connecticut. Flowers [2307210]: James Miller, USDA Forest Service. Photographs reproduced from www.invasive.org.

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Photograph Information:
Leaves [UGA5510133]; Population [UGA5455709]; Flowers [UGA2308044]; Bulbils [UGA5455811]; Tubers [UGA5510149]: Leslie J. Mehrhoff, University of Connecticut. Photographs reproduced from www.invasive.org.

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Leaves [UGA5456641]; Flowers [UGA5456550]; Close-up female flower [UGA5456622]; Fruit [UGA5456606]: Leslie J. Mehrhoff, University of Connecticut. Photographs reproduced from www.invasive.org.

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Leaves/flowers [UGA1237099]; Flower [UGA1237106]: Dan Tenaglia, Missouriplants.com. Leaves [UGA1237099]: Chris Evans, University of Georgia. Photographs reproduced from www.invasive.org.

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Photograph Information:
Plant/leaves [UGA5452116]; Fruit [UGA5452245]; Seed [UGA5452239]: Leslie J. Mehrhoff, University of Connecticut. Flower/leaves [UGA5571478]: Ansel Oommen, Bugwood.org. Photographs reproduced from www.invasive.org.

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Plant [UGA0580076]: Jil Swearingen, USDI National Park Service. Leaves and flowers [UGA5270035]: Leslie J. Mehrhoff, University of Connecticut. Fruit [UGA1237080]: Barry Rice, sarracenia.com. Photographs reproduced from www.invasive.org.

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Photograph Information:
Shrub with flowers [UGA5455510]; Leaves with flowers [UGA5455374]; Fruits [UGA5455411]: Leslie J. Mehrhoff, University of Connecticut. Stem with thorn [UGA2307059]: James H. Miller, USDA Forest Service. Flower [UGA5476902]: Chris Evans, University of Illinois. Photographs reproduced from www.invasive.org.

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Photograph Information:
Fall foliage [UGA5457793]; Flowers and leaves [UGA5457575]; Fruit, leaves, winged stems [UGA5510235]: Leslie Mehrhoff, University of Connecticut. Photographs reproduced from www.invasive.org.

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Photograph Information:
Leaves [UGA5079012]: Troy Evans, Great Smoky Mountains National Park. Flowers [UGA2188053]: Chris Evans, University of Illinois. Fruit [UGA5408393]: Karan A. Rawlins, University of Georgia. Photographs reproduced from www.invasive.org.

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Photograph Information:
Leaves and flowers [UGA5447967]: Leslie J. Mehrhoff, University of Connecticut. Hollow stem [UGA5560555]: Chris Evans, University of Illinois. Flowers [UGA5402910]: Annemarie Smith, Ohio Department of Natural Resources, Division of Forestry. Fruit [UGA1237034]: Chuck Bargeron, University of Georgia. Photographs reproduced from www.invasive.org.

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Leaves [UGA0008306]: Paul Wray, Iowa State University. Thorn [UGA5456183]; Fruit [UGA5274026]: Leslie J. Mehrhoff, University of Connecticut. Flowers [UGA5399725]: Robert Vidéki, Doronicum Kft. Photographs reproduced from www.invasive.org.

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Photograph Information:
Leaf [UGA5449995]; Flowers [UGA5449984]: Leslie J. Mehrhoff, University of Connecticut. Fringed stipule [UGA2307111]; Fruit [UGA2307113]: James H. Miller, Forest Service, U.S. Department of Agriculture. Photographs reproduced from www.invasive.org.

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Photograph Information:
Plant [UGA5449869]; Leaf [UGA5449906]; Stem [UGA5449892]; Flower [UGA5449865]; Fruit [UGA5449913]: Leslie J. Mehrhoff, University of Connecticut. Photographs reproduced from www.invasive.org.

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Photograph Information:
Leaf [UGA0008373]; Flowers [UGA0008102]; Samara [UGA0008225]: Paul Wray, Iowa State University. Photographs reproduced from www.invasive.org.

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Photograph Information:
Leaves [UGA0016005]; Leaflet close up [UGA2307007]; Twig with mature fruit [UGA2307009]: James H. Miller, USDA Forest Service. Fruit/seed (reddish color is cultivar dependent) [UGA1150029]: Chuck Bargeron, University of Georgia. Photographs reproduced from www.invasive.org.

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Photograph Information:
Trees [UGA1237040]: Chuck Bargeron, University of Georgia. Leaves [UGA5552391]: Nancy Loewenstein, Auburn University. Stem [UGA5403433]: Annemarie Smith, ODNR Division of Forestry. Flower Buds [UGA5453636]; Flowers [UGA5453605], [UGA5453548]; Immature Fruit [UGA5453537]; Mature Fruit [UGA5391711]: Barry Rice, sarracenia.com. Photographs reproduced from www.invasive.org.

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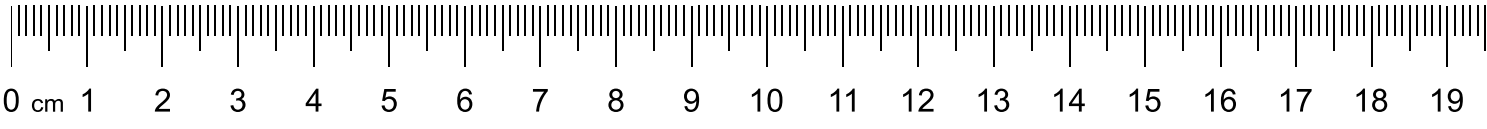
Photograph Information:
Tree in bloom [UGA2308070]; Flowers [UGA2308072]: Dan Tenaglia, Missouriplants.com; Leaves [UGA2308098]; Fruit/leaves [UGA2308100]: Chuck Bargeron, University of Georgia. Photographs reproduced from www.invasive.org.

NOTES/DRAWINGS



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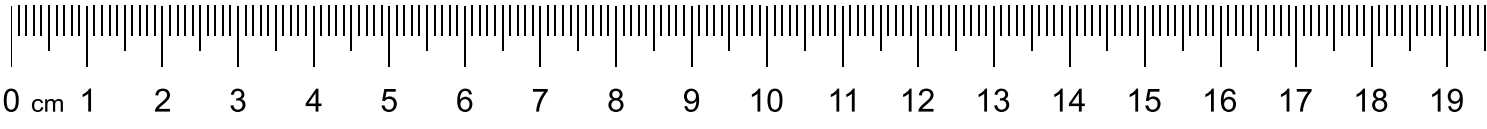

NOTES/DRAWINGS

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