March 2021

Invasive Species Toolkit

A Guide to Management on Maryland's Lower Eastern Shore

Chesapeake Bay Trust

Lower Shore Land Trust

Wicomico County Maryland 1867

Table of Contents

Key

Red Text = State Listed Noxious Weed

★ = LES-PRISM Top Species of Concern

I. Herbaceous Plants

Table of Contents (continued)

Cover photo: Native uninvaded tidal marsh

Introduction

The information contained in this toolkit is intended for land managers, farmers, landowners, and the general public on Maryland's Lower Eastern Shore, the Eastern Shore of Virginia, and southern Delaware. Its main purpose is to be used as a resource for the identification and management of invasive species. We hope that the fact sheets contained herein will provide the basic information necessary to identify the locations of the most problematic species in the region and give helpful information about the most effective methods to control and, potentially, eradicate those infestations. To that end, this guide includes fact sheets covering the most common and problematic species that may be encountered on the southern Delmarva Peninsula, a glossary of terms, and diagrams meant to aid in identification.

Defining Invasive Species

Many of the terms associated with invasive species management are considered loaded or have been used interchangeably in the past which has caused some confusion. For the purposes of this guide and to help move to a more consistent and cohesive effort, we are using the terms as defined by the Maryland Department of Natural Resources. A full list of those terms can be found on page 12 and includes the terms in **bold** in this paragraph. In short, an **invasive species** is defined as a species that is **non-native** to a given ecosystem and can cause ecologic and/or economic harm. It is not just the mere presence of a **non-native** species but the rapid spread and destructive quality of it that makes it **invasive**. Thus, **invasive** refers to a *quality* or *characteristic* of a species that would not normally be found in a given environment or location. **Native**, **non-native**, **introduced**, and **exotic** are all terms that are used to describe the *origin* of a species and not a particular quality or characteristic of it. Though **native** species can exhibit aggressive characteristics, they cannot, by these definitions, be **invasive** because they are normal and expected members of the region and natural environment. First succession species of tree such as red maple, black locust, or sweet gum are quite aggressive in colonizing open areas, but that is their natural place in the ecosystem, so they are not considered **invasive species** in this guide. **Noxious weeds** are a special, legally designated subset of species identified due to their overwhelmingly destructive qualities and are regulated by each state under authority of the federal Pant Protection Act.

Invasive Non-Plant Species

This guide is primarily focused on invasive plant species as they tend to be the most noticeable and destructive invasive species in the region, but we have included some common invasive animals and insects as well. Non-native insects and diseases such as gypsy moth, chestnut blight, and Dutch elm disease have caused some of the greatest ecological interruptions in American history including the functional extirpation of the American Chestnut tree, a species that once dominated eastern hardwood forests and much of the American timber industry until the introduction of the blight in the early 20th century. Currently, two of our most destructive invasive species are the emerald ash borer, which has decimated ash

species, and the spotted lantern fly, which was found in Pennsylvania in 2014 and has been spreading rapidly since.

A Regional Approach

Invasive species management in the mid-Atlantic region has been inconsistent, but the spread of existing invasive species and the introduction of new invasive species has maintained a consistent pace over time. As economic and ecologic impacts continue to mount, new interest in better and more integrated approaches to management has arisen driven largely by farmers, foresters, land managers, and ecologists. This heightened awareness of the issue led directly to the formation of the Lower Eastern Shore Partnership for Regional Invasive Species Management (LESPRISM) and was a motivation for this guide. Our hope is that this region can join in a wider collaborative approach to invasive species management that is more cohesive and based on early detection and rapid response instead of the piecemeal, reactionary approach that is more common at this time.

Toolkit Updates

We have found that invasive species information and management practices are changing at such a rapid pace that it is useful to have a guide that is easily updated. To that end, we have made this guide available electronically online at www.lowershorelandtrust.org/resources where we will post updates, new fact sheets, and other resources that we believe will be helpful. Updates will be made annually to the entire toolkit on an as-needed basis. Training modules will also be available to review in that location as well.

We recommend that uses of this resource print the entire guide and store it in a 3-ring binder or similar folder to make it easier to add new and replace old pages as new information becomes available or new threats are detected.

The Lower Eastern Shore Partnership for Regional Invasive Species Management (LES-PRISM)

The LES-PRISM is a cooperative of State, County, Federal and NGO partners and stakeholders dedicated to reducing the negative impact of nonnative invasive species on the natural and agricultural environment in Dorchester, Somerset, Wicomico, and Worcester Counties on Maryland's Eastern Shore. The LES-PRISM connects partners throughout the region to share information, procure funding, and create a network for the identification, mapping, and management of invasive species.

LES-PRISM Services:

- Provide seasonal workshops, outreach, and educational materials on the topics of invasive species identification and regional treatment protocols;
- Coordinate with state and local governments, service providers ,and NGOs to share resources, manpower, and leverage funding for treatment efforts;
- Implement eradication and restoration projects with County and State partners;
- Provide referrals to landowners about upcoming grant and funding opportunities for invasive species treatment;
- Recruit and train citizen volunteers to map invasive species on public lands;

Why report invasive species?

It is widely understood and researched that invasive species threaten natural habitat, forest and agricultural economies, cultural resources, and water quality. Invasive species management can improve water quality by preventing species such as Japanese wisteria (pictured right at Pemberton Historical Park restoration site in Wicomico County, MD) from girdling and pulling down trees and choking out native vegetation. The resulting loss of tree canopy and forest integrity leads to increased stormwater flows and reduced nutrient retention.

Infestation of species like Japanese knotweed (pictured bottom left at Leonard's Mill Park restoration site in Wicomico County, MD) along waterways eliminates native species and their stabilizing root systems, making banks more susceptible to erosion and increasing the amount of sediment in waterways.

Currently, the Lower Eastern Shore does not participate in any cooperative weed management programs, unlike most other Maryland Counties on the eastern and western shores. There has been little coordinated effort to identify the scope of the problem and the economic impacts of invasive species to our resource-based industries and natural resources here on the Lower Shore.

With your assistance, we will collect information to establish a baseline of the extent of the problem and the impacts invasive species have on our area as well as identify the most effective management tools and priorities for addressing the issues created by invasive species on public and private lands.

To report invasive species, visit www.EDDmapS.org and create an account to report sightings. To track reports stemmed from LES-PRISM outreach and training efforts, please enter "LES-PRISM" as your organization. For convenience in the field we recommend downloading the EDDMapS Pro app in the app store. This platform collects data from every day users at which point it is reviewed and vetted by local administrators and published online.

Quick Notes

Using this Toolkit

Species in this toolkit are grouped by type (herbaceous plants, trees and shrubs, vines, aquatic species, and non-plant species) and organized alphabetically by common name. Each species factsheet provides pictorial keys based on simple characteristics such as leaf type and arrangement, a short description including habitat, look-a-likes, why it is a threat, and possible management options.

Reporting Invasive Species

Users of this toolkit are encouraged to survey their surroundings for invasive species and document their observations by identifying species, taking photos, and recording locations to be uploaded to www.EDDMapS.org. For convenience in the field we recommend downloading the EDDMapS Pro app in the app store. When creating your login, please enter "LES-PRISM" as your organization to track data stemmed from the LES-PRISM outreach and training efforts. Data is used to inform land managers of new species entering our region and educate elected officials on the importance of a regional invasive species management approach. If species are found on private property, disclosing exact location is optional.

Disclaimer

The Lower Eastern Shore PRISM and the contents of this toolkit do not provide recommendations for specific herbicides or guides on treatment techniques. If you are a licensed applicator, please rely on training materials provided by the Maryland Department of Agriculture. If you are a homeowner and purchase herbicides at a retail outlet, remember that **the label is the law**.

Additional Resources

For detailed management strategies and treatment technique guides developed by our partners at the MD Forest Service, www.dnr.maryland.gov/forests.

Herbicide Basics

DISCLAIMER: THE LOWER EASTERN SHORE PRISM AND THE CONTENTS OF THIS TOOLKIT DO NOT PROVIDE RECOMMENDATIONS FOR SPECIFIC HERBICIDES OR GUIDES TO TREATMENT TECHNIQUES.

What are Pesticides?

Pesticides are compounds used to kill unwanted insects, fungi, rodents, and plants around our homes, gardens, agricultural operations, and forests. An *insecticide* is a pesticide that kills insects. A *fungicide* kills molds, mildews, and other fungi. A *rodenticide* kills mice and rats, and an *herbicide* kills plants. Pesticides are designed to work by altering the biochemistry of the organisms they are meant to control.

If used and handled correctly, modern-day herbicides are unlikely to have a long-term impact on people, animals, and insects, because they alter biochemical processes found only in plants. When it comes to controlling invasive plants, herbicides are usually necessary when the threat from their uncontrolled growth far outweighs any environmental risk, such as harming beneficial native vegetation from herbicide application.

For the Homeowner —THE LABEL IS THE LAW

The "General Use" class of herbicides may be purchased at retail outlets and used by the general public. In this scenario, the label is a legally binding agreement between the EPA, the manufacturer, and the user. The label contains the product's name, chemical name, common name, and provides directions for proper use, safety precautions, and disposal instructions. It may also indicate if the product can cause environmental damage, and instructions to follow to prevent damage (right). Avoid misuse by reading the *entire* label before each use and consult with your local Ag Extension officer if unsure.

ENVIRONMENTAL HAZARDS
This product is extremely toxic to aquatic and estuarine invertebrates.
Do not contaminate water by cleaning equipment or disposal of wastes.

BEE CAUTION: MAY KILL HONEYBEES IN SUBSTANTIAL NUMBERS.
This product is highly toxic to bees exposed to direct treatment or residues on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds if bees are visiting the treatment area.

<u>Understanding the Type of Herbicide & Application Timing</u>

When selecting an herbicide it is important to note the surrounding vegetation.

- Broad-spectrum herbicide– targets any type of plant that have broad, flat leaves. Accidental application to non-target plants will result in killing native vegetation.
- Selective herbicide- targets very specific kinds of plants. You might choose a "selective" herbicide that is grass-specific to kill Japanese stiltgrass in a forest for instance, because it will not harm the native vegetation, even if you spray them directly.

Some invasive species will benefit from a pre-emergent and/or post-emergent herbicide application.

- Pre-emergent herbicide– applied before the weeds begin to germinate
- Post-emergent herbicide– applied directly to the foliage after plant has germinated

Maryland's Pesticide Applicator Law

The Maryland Pesticide Applicator's Law dictates how pesticides are sold, handled, stored, applied, and disposed. The Maryland Department of Agriculture (MDA) Pesticide Regulation Section administers and enforces this law. Any person or business that applies pesticides commercially – that is, anyone who gets paid to handle pesticides – must be trained, certified, and registered with MDA to help ensure that only knowledgeable, competent individuals handle and apply pesticides.

Licensing, Permitting & Certification

Generally, businesses are "licensed," public agencies are "permitted", and individuals are "certified." However, before a pesticide business can be licensed or a public agency can be permitted, they must have at least one certified applicator on staff.

Find a professional

MDA has three online, searchable databases to help consumers ensure they do business with appropriately registered professionals. The databases can be accessed for free at:

http://mda.maryland.gov/plants-pests/Pages/pesticide_db.aspx

Additional Resources for Herbicide & Treatment

In 2021, Maryland Forest Service developed "Good Green: Land Manager's Guide to Managing Invasive Plants", a partner document to "Good Green: Invasive Plant Management on Private Land" for homeowners. These comprehensive guides provide treatment technique guides, herbicide recommendations, and detailed instructions on how to develop a long term invasive species management plan based on your specific objectives and goals. These guides can be found online at: www.dnr.maryland.gov/forests

Glossary

Abscise: to separate (something, such as a flower from a stem) by abscission

Achene: a small, dry one-seeded fruit that does not open to release the seed.

Axil (leaf): a place on a plant where the shoot grows out of the main stem. The leaf axil is the point on the main stem where the buds or shoots develop.

Basal Bark Treatment: an invasive plant control method that involves spraying herbicide onto the bottom-most portion of the bark of target plants.

Biocontrol: the use of living organisms, such as insects or pathogens, to control invasive species infestations. It is used by reintroducing some of the specialist natural enemies that help control the invasive species it in its native range.

Bract: a modified leaf or scale, typically small, with a flower or flower cluster in its axil. Bracts are sometimes larger and more brightly colored than the true flower, as in poinsettia.

Catkins: long slim clusters of tiny flowers, with small petals or none at all

Culm: the hollow stem of a grass or cereal plant, especially that bearing the flower.

Cut Stump Method: a way to control woody invasive plants in which an herbicide solution is applied directly to the stump top immediately after cutting down the plant. The herbicide kills the stump and prevents new growth that would normally occur after cutting alone.

Exotic Species: Also referred to as: introduced, alien, non-native, non-indigenous. An organism that developed over evolutionary time somewhere other than in a given region. If your given region is Maryland, an exotic species would be one that originated outside Maryland. This term most often refers to species from completely different countries or areas of the world. An exotic species is not necessarily an invasive species. For example, many of our favorite food crops are exotic. But they are not invasive – they could not exist and spread outside agriculture without the support of humans or affect ecosystem function or biodiversity. (MD DNR)

Frill Cuts: cuts made with a hatchet or ax in the lower trunk area of the tree. Cut should chop through the bark, into the sap wood at a slightly downward angle so the frill cut will hold applied herbicide.

Foliar Spray: a method of herbicide application that involves applying the chemicals directly to a plant's leaves.

Girdle: the complete removal of the bark from around the entire circumference of either a branch or trunk of a woody plant. Girdling results in the death of the area above the girdle over time.

Hack and Squirt: a herbicide application method that introduces the herbicide into the stem using spaced cuts made at a convenient height, below the last live branch, around the trunk.

Introduced Species: A species brought accidentally or on purpose by people to a new location, across a natural geographic boundary, like an ocean or mountain chain that the species would not usually cross naturally. (MD DNR)

Invasive Species: The federal definition states that an "invasive species" is defined as a species that is non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health. In practice, an invasive species is an introduced species that has a negative impact on biological diversity or ecosystem function. (MD DNR)

Lenticels: one of many raised pores in the stem of a woody plant that allows gas exchange between the atmosphere and the internal tissues.

Glossary continued…

Midrib: The central, thick, linear structure that runs along the midline of a leaf.

Native Species: An organism that developed over evolutionary time in a specific region of interest. The "region" is most often defined as a geopolitical area such as a county, state, group of states, such as the Mid-Atlantic, or country. These political boundaries are used largely because regulatory action is taken within political jurisdictions. "Region" can also be defined as an ecosystem or natural boundary, for example, the Chesapeake Bay watershed. Generally, a species is considered native if it existed in the US before the year 1500. (MD DNR)

Nodes: the points on a stem where the buds, leaves, and branching twigs originate.

Non-native Species: an organism that developed over evolutionary time in a region other than the one in which it is found. See native species. (MD DNR)

Noxious weed: Defined in the federal Plant Protection Act, and regulated by the USDA's Animal and Plant Health Inspection Service (APHIS) a noxious weed is: "any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment." (Plant Protection Act). These species are regulated by the Maryland Department of Agriculture. See the list and the law on MDA's website: https://mda.maryland.gov/plants-pests/Pages/noxious_weeds_in_md.aspx (MD DNR)

Ocreae: a dry sheath around a stem formed by the cohesion of two or more stipules, characteristic of the dock family.

Ovate: having an oval outline or ovoid shape, like an egg.

Petioles: the stalk that joins a leaf to a stem; leafstalk.

Phenology: the study of cyclic and seasonal natural phenomena, especially in relation to climate and plant and animal life.

Racemes: a flower cluster with the separate flowers attached by short equal stalks at equal distances along a central stem.

Rhizomes: a continuously growing horizontal underground stem which puts out lateral shoots and adventitious roots at intervals.

Samara: is a type of dry fruit where one seed is surrounded by papery tissue that helps carry the seed away from the tree as the wind blows.

Seed persistence: the ability of seeds to persist in a viable state post-dispersal. Seed persistence is relevant to current research in plant community dynamics and conservation.

Senescence: the age-dependent programmed degradation and degeneration process of cells, organs, or the entire organism, leading to death. To senesce is to grow older.

Siliques: the long, narrow seedpods of many plants of the cabbage family, splitting open when mature.

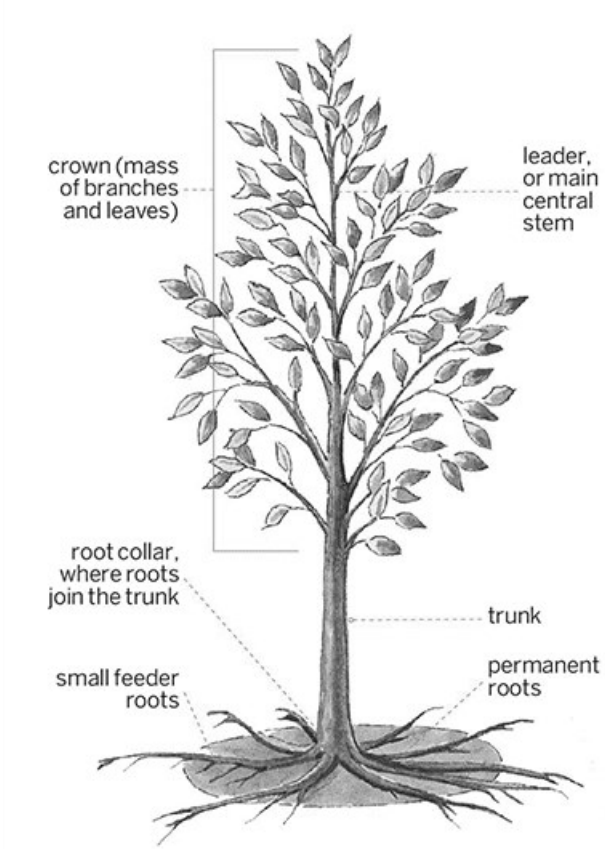
Stipules: a small leaflike appendage to a leaf, typically borne in pairs at the base of the leaf stalk.

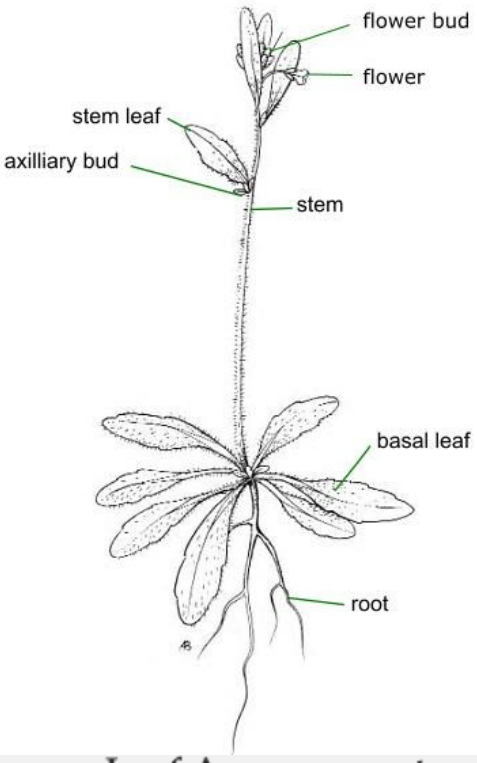
Surfactant: a substance which tends to reduce the surface tension of a liquid in which it is dissolved. They allow herbicide chemicals to better adhere to waxy plant surfaces.

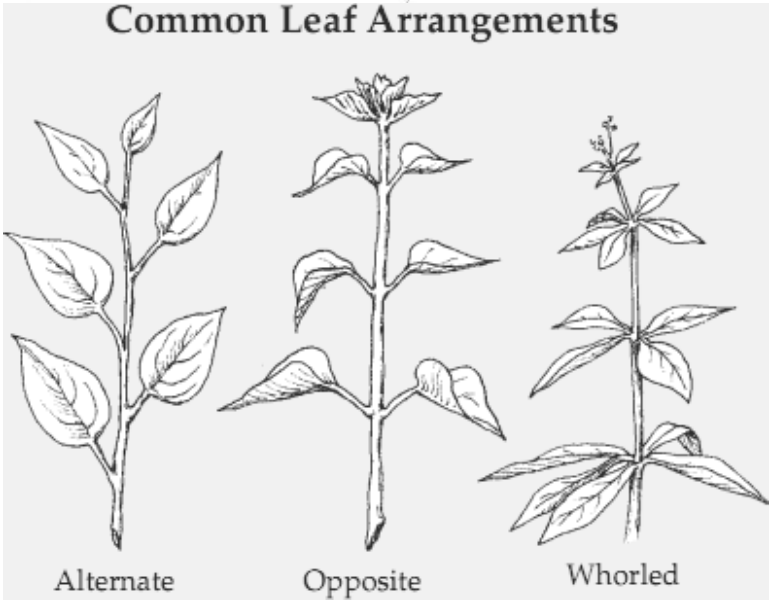
Systemic Herbicide: combinations of chemicals that are applied to the vegetative parts of a weed absorbed by foliage or roots and translocated to other parts of the plant.

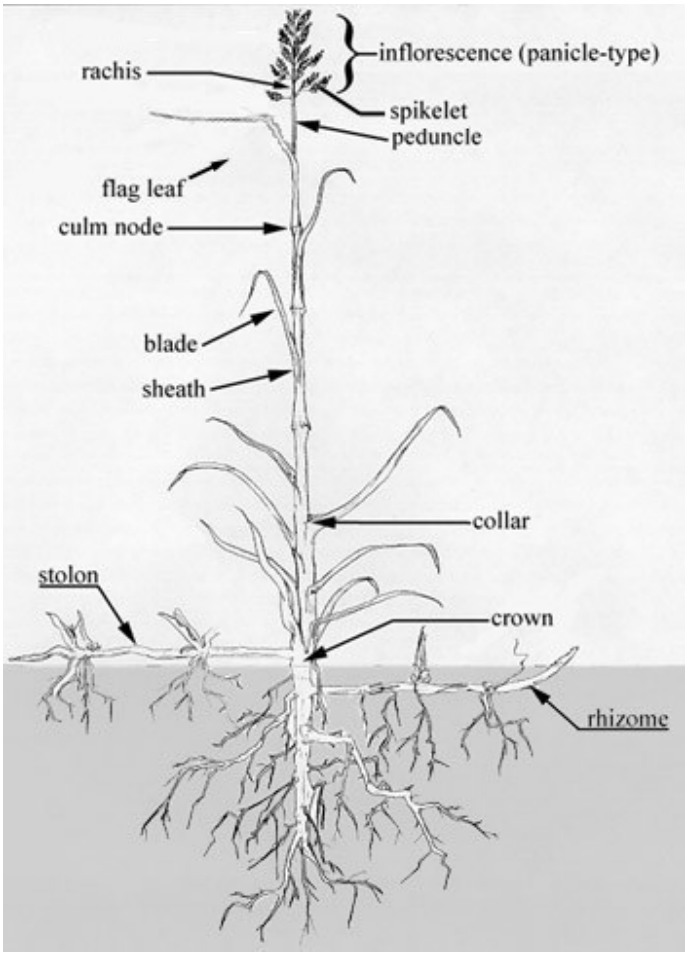
Weed Wrench: a manually operated, all-steel tool designed to remove woody plants by uprooting. It's a lever like tool that allows you to pull out a plant that would otherwise take two or three people to remove.

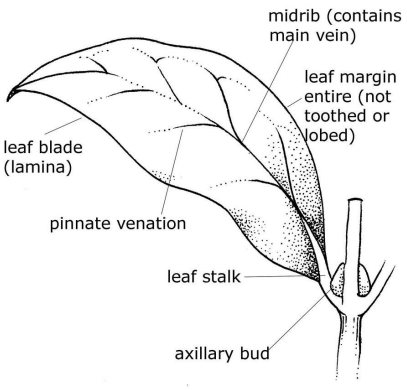
Diagrams


crown (mass of branches and leaves)
leader, or main central stem
root collar, where roots join the trunk
trunk
small feeder roots
permanent roots


flower bud
flower
stem leaf
axilliary bud
stem
basal leaf
root


Common Leaf Arrangements
Alternate
Opposite
Whorled


rachis
inflorescence (panicle-type)
spikelet
peduncle
flag leaf
culm node
blade
sheath
collar
stolon
crown
rhizome


midrib (contains main vein)
leaf margin entire (not toothed or lobed)
leaf blade (lamina)
pinnate venation
leaf stalk
axillary bud

I. Herbaceous Plants

Common Waterhemp

Amaranthus tuberculatus

Maryland State-listed Noxious Weed

Origin: North America

Introduction: Native

Propagation: Seed

Seed Dispersal: Wind

Seed Persistence: 80% of seeds lose viability within the first 12 months

Life Cycle: Annual

Description: Common waterhemp plants stand from 2-8 feet tall; Stems are hairless, and green or pinkish in color; Alternate leaves grow up to 6 inches long and 1.5 inches wide, they are smooth and have a somewhat shiny surface; Long petioles; Flowers are arranged in spikes which develop from the upper branches; Distinguished by its overall hairlessness.

Phenology: Plants emerge in spring; Blooming period occurs from late summer to early fall and lasts for 1-2 months.

Habitat: Common waterhemp prefers full or partial sun with moist conditions in loam or clay loam soils. It will tolerate drier soils in smaller sizes. It is most commonly found in disturbed areas such as cultivated fields.

Look-alikes: Palmer amaranth (*Amaranthus palmeri*—noxious)

ECOLOGICAL IMPACTS

Common waterhemp has a prolific seed count, producing hundreds of thousands of seeds per female plant. It has also been documented as herbicide resistant. Its greatest impact is when plants emerge during crop's early growth stages as it interferes and competes with water, light, and nutrient sources. It likely has a high economic impact when considering costs associated with treatment and yield losses.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Plants can be **hand-pulled** at early stages of growth and prior to seed production. Because waterhemp is commonly found in cultivated fields, some preventative management steps to combat the species include crop row spacing, tilling, and planting cover crops.

Chemical: Waterhemp has shown herbicide resistance, but **preemergent herbicides** have shown some promise in controlling it. Using herbicides effectively would require a soil-applied herbicide followed by a **post emergent herbicide**. For serious waterhemp infestations, a diverse weed management practice can deplete the seed stock over a period of 3 to 4 years. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
	Hand pull seedlings Apply preemergent herbicide
SUMMER	**FALL**
Plant cover crops	Apply post emergent herbicide

Garlic Mustard

Alliaria petiolata

Origin: Europe

Introduction: 1868, Long Island, NY

Propagation: Seed

Seed Dispersal: Water, wind, wildlife, human activity

Seed Persistence: Viable in soil for up to 10 years

Life Cycle: Biennial

Description: Alternate leaves are triangular or heart shaped and coarsely toothed that give off a garlic odor when crushed; Rosettes remain green through winter season; Second year plants produce small white flowers; Seeds are produced in silique fruit pods. Plants can reach 1-4 feet tall.

Phenology: Plants emerge in spring into early summer. Flowering occurs in the second year in spring to early summer. Fruit pods develop within a month in early summer. Plants then die but will continue to drop seeds into the fall season.

Habitat: Frequently occurs in moist, shaded soils of river floodplains, forests, roadsides, edges of woods, trails, and forest openings. Disturbed areas are susceptible to invasion.

Look-alikes: Saxifrage (*Saxifraga virginiensis*—native), sweet cicely (*Osmorhiza claytonia*—native), toothworts (*Dentaria*—native),

ECOLOGICAL IMPACTS

Once garlic mustard is established, it emerges earlier in spring than native plants allowing it's dense stands to suppress the growth of many native plants and wildflowers. Garlic mustard roots also releases chemicals that alter the important underground fungi network that helps connect nutrients between native plants.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Hand removal of plants is possible for smaller infestations found near native species. When removing the plant one must take care to remove the entire root system as new plants will sprout from root fragments. Pulling plants should occur when the soil is moist and should be removed from the site, especially if the plants are in bloom. When hand pulling is not feasible, plants can be cut at ground level to prevent seed production.

Chemical: For heavy infestations and where the risk to native desirable plants is minimal, application of **systemic herbicides is** also effective. As long as temperatures are above 50 degreed F, herbicide can be applied year round. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Apply herbicide	Hand pull plants Apply herbicide
SUMMER	**FALL**
Hand pull plants Apply herbicide	Hand pull plants Apply herbicide

Giant Hogweed

Heracleum mantegazzianum

Origin: Southwest Asia, Caucasus mountains

Introduction: Early 1900s

Propagation: Seed

Seed Dispersal: Water, human activity, wind, wildlife

Seed Persistence: Viable in soil for 3-7 years

Life Cycle: Perennial

DO NOT TOUCH—SAP CAUSES SERIOUS BURNS

Description: Giant hogweed stands tall topped with numerous large, umbrella-shaped white flower clusters; Stems are hollow and ridged, 2-4 inches in diameter with dark reddish purple blotches; Plants can reach up to 8-15 feet in height when in bloom; Large compound leaves are typically 3-5 feet wide and deeply incised with hairs on the underside; Seeds are 3/8 inch, elliptic dry fruits with wings and swollen brown resin canals

Phenology: Plants emerge in spring and grow very quickly into early summer. Flowering occurs in June and July, while fruits emerge and ripen by late August. Plants senesce in early fall months.

Habitat: Prefers rich, damp soils in varied life conditions. It quickly invades rivers, wetlands, and stream banks and is most commonly found in urban settings along roadsides, ditches, and unmanaged yards.

Look-alikes: Poison hemlock (*Conium maculatum*—native), Queen Anne's lace (*Daucus carota*—non-native)

ECOLOGICAL IMPACTS

Giant hogweed crowds out desirable native and crop plants with its aggressive growth. It serves no useful purpose for wildlife and can increase erosion by replacing soil-protecting wood plants. It is a public health hazard as sap can cause blistering of the skin and permanent scarring when exposed to light.

INTEGRATED MANAGEMENT OPTIONS

Wear proper clothing, shoes, and eye protection when attempting any control measures. Always avoid skin contact. Clear, watery sap in leaves and stems can cause burns, blisters and scarring.

Mechanical: Mature plants can be manually removed by **digging up** the first 4-6 inches of central root. Seedlings tend to be more resilient and can break off when being pulled from soil. When **hand-pulling**, be sure to bag flowers and seedheads and properly dispose. **Mowing** can be effective and needs to be repeated every 2 weeks. This will eventually deplete the roots, though it could take years.

Chemical: Post-emergent herbicides can be effective but care needs to be taken to avoid killing desirable native species adjacent to infestations. If applying herbicide, do not cut plants as this can stop the plant from absorbing the chemical. Herbicides are effective when applied in spring and followed up with an application in the summer. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Dig/cut plants Mow	Apply herbicide Dig/cut plants Mow
SUMMER	**FALL**
Apply herbicide Dig/cut plants Mow	Dig/cut plants Mow

Golden Bamboo

Phyllostachys aurea

Origin: Asia

Introduction: 1882

Propagation: Rhizome system

Dispersal: Seed production is inconsistent, primarily spread by water and improper rhizome disposal

Seed Persistence: Unknown

Life Cycle: Perennial

Description: Golden bamboo is a is a woody, rhizomatous perennial grass; culm is made up of jointed segments; stems and branches are green when plants are young but turn golden yellow with age and can grow over 30 feet tall emerging thicker each year; branches occur in uneven pairs.

Phenology: New culms emerge in the spring and reach their mature height in a few weeks; leaves change each year in late-spring; old leaves fall off and are gradually replaced with new leaves

Habitat: Infestations occur in undisturbed habitats including streamside and riparian corridors; it is tolerant of cold temperatures; it thrives in full sun but also tolerates shade causing it to spread into forests.

Look-alikes: Giant cane (*Arundinaria gigantean*—native)

ECOLOGICAL IMPACTS

Golden bamboo forms dense monospecific stands that displace and suffocate native species, altering the entire ecosystem. They may also damage property and could have a negative impact on property values. Rapid spread has been seen as far as 9.3 miles in all directions from the plant's emerging site.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Cutting and **mowing** have been used on small infestations or in sensitive areas where herbicides cannot be used. Plants should be cut as close to the ground as possible. As plants resprout, mowing should continue until rhizomes are exhausted.

Chemical: Foliar spray application can be used for large areas of bamboo when temperatures are above 65°F. The cut-stem control method can also be used to treat individual plants or where native plants risk exposure to foliar spray. Cut-stem can be used as long as the ground is not frozen. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Cut/mow plants	Cut/mow plants Cut-stem method Foliar spray application
SUMMER	**FALL**
Cut/mow plants Cut-stem method Foliar spray application	Cut/mow plants Cut-stem method Foliar spray application

Japanese Stiltgrass

Microstegium vimineum

★ **LES-PRISM Top Species of Concern**

Origin: Asia and the Caucasus Mountains

Introduction: 1919

Propagation: Seed

Seed Dispersal: Wind, water, animals, and human activity

Seed Persistence: Viable in soil for up to 5 years

Life Cycle: Annual

Description: Japanese stiltgrass is a branching, sprawling, rapidly spreading grass; leaves are alternate and are 2-4 inches long and roughly 1/2 inch wide with silvery midrib, smooth edges, and are pointed at both ends; there are often multiple smooth, thin stems branching off near the base that may vary in color; flowers emerge on delicate stalks often in groups of 2 or 3 spikes; roots are shallow and come up easily when pulled.

Phenology: Seedlings germinate in late spring or after disturbance; flowers late summer through early fall; seeds mature in fall months when the plant turns a purple-brown color

Habitat: Forest, forest edges, stream banks, road and trail edges, areas prone to flooding such as ditches, lawns, and damp fields.

Look-alikes: Whitegrass (*Leersia virginica*—native) and Nimbleweed (*Muhlenbergia schreberi*—native)

ECOLOGICAL IMPACTS

Japanese stiltgrass is a rapid spreading, aggressive invader of forested lands. Infestations eliminate native plant species and degrade wildlife habitat disrupting important ecosystem functions. Stiltgrass grows well in many light conditions allowing it to spread from deeply shaded forests to sunny open fields.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Plants can be **hand pulled** or a **weed wrench** can be used to manage small infestations or young plants when soil is moist. Hand pull, or if area is too large, cut it back with a **mower** -do this in late summer before it goes to seed in the fall.

Chemical: Systemic herbicides can be used to control infestations. Grass-specific herbicides have often been chosen over broad-spectrum herbicides to prevent killing non-target species. These should be applied as a **foliar spray. Pre-emergent** and **post-emergent** herbicides are also effective used in combinations with each other while continually monitoring for seed germination. Review the Herbicide Basic factsheet before proceeding.

Biological: Grazing sheep have been useful in managing Japanese stiltgrass populations. In a New Jersey study, stiltgrass never reached more than three inches in height and did not reproduce.

WINTER	SPRING
Apply pre-emergent herbicide	Apply pre-emergent herbicide Hand pull or mow Graze
SUMMER	**FALL**
Apply post-emergent herbicide Hand pull or mow Graze	

Johnsongrass

Sorghum halepense

Maryland State-listed Noxious Weed

★ **LES-PRISM Top Species of Concern**

Origin: Mediterranean Region

Introduction: Early 1800s

Propagation: Seed and rhizomes

Seed Dispersal: Water and wind.

Seed Persistence: Viable in soil for up to 2.5 years

Life Cycle: Perennial

Description: Johnsongrass is a warm-season grass that grows 3-10 feet tall; leaves are broad-bladed and are one -half to one inch wide with a distinct light green midrib; stems are similar to the size of a pencil; seed heads are at the tip of the stem and become reddish with maturity.

Phenology: Johnsongrass flowers from May to July, usually 6-9 weeks after emergence in early to mid-spring. Growth ceases when soil temperatures return to 60 F. Seed heads resemble a Christmas tree.

Habitat: Johnsongrass is most common in riparian, wetland, subtropical, and tropical habitats. Other than riparian and wetland habitats, it is commonly found in silty loams of agricultural fields, disturbed areas, and streambanks.

Look-alikes: Switch grass (*Panicum virgatum*—native) and eastern gamagrass (*Tripsacum dactyloides*—native)

ECOLOGICAL IMPACTS

Johnsongrass in agricultural fields can reduce corn and soybean yield over 30% and 40% respectively. Johnsongrass forms dense spreading patches, and a single patch can produce up to 300 feet of rhizomes and over 28,000 seeds. It also serves as an alternate host for several insect, nematode, and disease pests of desirable crops.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Fall **plowing** to a depth below the rhizomes, roughly 3-5 inches, can be effective when rhizomes are exposed to killing temperatures. No mechanical controls for Johnsongrass are currently in widespread use.

Chemical: Foliar application of a **post-emergent herbicide** application will yield the best results. Used alone, herbicides are rarely a complete or long-term solution but have been effective in combination with plowing. Review the Herbicide Basic factsheet before proceeding.

Biological: Aside from livestock **grazing**, no widespread use of biological controls is utilized in the United States. Heavy grazing over 2 or more years reduces Johnsongrass by depleting rhizome reserves. Several biological agents are being tested for possible use though much is still unknown.

WINTER	SPRING
Graze livestock	Graze livestock
SUMMER	**FALL**
Graze livestock Apply herbicide	Graze livestock Apply herbicide Plow fields

Wavyleaf Basketgrass

Oplismenus hirtellus

Origin: Southern Europe and southeast Asia

Introduction: 1996; Baltimore County, MD

Propagation: Seeds

Seed Dispersal: Wildlife and human activity

Seed Persistence: Unknown

Life Cycle: Perennial

Description: Leaves are dark green with distinct ripples across the width of the blade which has a long tapering tip; Leaves grow up to 4 inches long; Hairy stem branches from base and is long and trailing; Feathery white flowers emerge from the end of branches; Seeds occur in pairs of spikelets, each with a bristle that becomes sticky in fall.

Phenology: Bloom period begins in mid-July and fruiting continues into November.

Habitat: Wavyleaf Basketgrass is highly shade tolerant and is found both in the margins and interior of full canopy forested areas. It is most commonly found in coastal plain habitat in Maryland and some parts of Virginia.

Look-alikes: Deer-tongue grass (*Dichanthelium clandestinum*—native), bottlebrush grass (Elymus hystrix–native)

ECOLOGICAL IMPACTS

Wavyleaf basketgrass spreads rapidly and has devastating impacts on deciduous forests. It crowds out native herbaceous plants with its dense stands and prevents regeneration of native tree species therefore decreasing biodiversity. It also provides very little value to local wildlife. Sticky bristles allow the seeds to adhere to passing animals, people, and vehicles.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Because of its weak root system, **hand-pulling** infestations is very effective. Removing from high trafficked areas should take priority to avoid spread by human activities on trails and roadsides. Be careful to pull the entire plant, bagging and disposing of the remains properly.

Chemical: Post-emergent herbicides are effective in controlling wavyleaf basketgrass but should be combined with hand-pulling to achieve the best results. Applying as a **foliar spray** later in the year, or a grass specific herbicide in the spring has shown effectiveness. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Hand-pull	Hand-pull Apply herbicide
SUMMER	**FALL**
Hand-pull	Hand-pull Apply herbicide

Japanese Knotweed

Fallopia japonica

★ **LES-PRISM Top Species of Concern**

Origin: Eastern Asia

Introduction: Late 1800s

Propagation: Stem fragments, rhizomes, and seed

Seed Dispersal: Wind, animals, water, and human activity

Seed Persistence: Remain viable in soil for 4-6 years

Life Cycle: Perennial

Description: Japanese knotweed has spreading rhizomes and reddish freely branched, upright stems; it can reach 4 to 8 feet in height; flowers are white and green and grow in drooping clusters from leaf axils; leaves are ovate, alternate, and have a truncated base and pointed tip.

Phenology: Plants break dormancy in early spring; flowers bloom from June through August; fruit begins to form in late August, matures in September and remains on the plant through winter; leaves senesce at first autumn frost

Habitat: Often found in gardens, roadsides, streams, wetlands, and riverbanks; prefers moist, well-drained soils

Look-alikes: Pokeweed (*Phytolacca Americana*—native)

ECOLOGICAL IMPACTS

Japanese knotweed has a vigorous root system which can spread nearly 30 feet from the parent stem and grow through concrete and asphalt. Infestations create dense thickets that degrade wildlife habitats and compete with native vegetation thereby reducing plant biodiversity. Large thickets can cause increased erosion and flooding.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Control typically takes several years with close monitoring of regrowth sites. **Hand-pulling** small plants is time consuming but could aid in preventing the spread. Manual control requires careful consideration not to leave fragments behind. The entire root system must be removed to prevent re-sprouting and all plant material should be properly disposed of. Frequent **cutting** or **mowing** for many years can eventually kill the plant.

Chemical: Systemic herbicide is an effective management option for Japanese knotweed. **Foliar spray** should be used on leaves and stems, or applied to **cut-stems.** Plants should be cut in the summer and herbicide should be applied in the fall to ensure herbicide reaches rhizomes. Review the Herbicide Basic factsheet before proceeding.

Biological: Grazing may provide some reduction in plants but additional control methods are typically needed.

WINTER	SPRING
	Graze Hand pull plants
SUMMER	**FALL**
Mow, cut, or graze Hand pull plants	Hand pull plants Apply herbicide as a foliar spray, cut stem , or inject stems

Lesser Celandine

Ficaria verna

Origin: Europe, Asia, North Africa

Introduction: 1867, Pennsylvania

Propagation: Vegetatively by tubers

Dispersal: Fragments

Seed Persistence: Unknown

Life Cycle: Perennial

Description: Low-growing and mat-forming, lesser celandine has long stalked leaves arranged in a basal rosette; Mature plans can reach up to 30 cm in diameter and 30 cm tall; Leaves are kidney shaped and 4-9 cm wide with smooth, wavy edges; Petioles are deeply grooved; Flowers are yellow and have long stems; Roots are tuberous.

Phenology: Emergence is triggered by increased light availability. Shoots emerge from late-March to mid-May. Seed production occurs in late spring and by summer the above ground vegetation dies back and the plant becomes dormant. Seeds require an after-ripening period to fully mature.

Habitat: Lesser celandine prefers moist, sandy, soils and thrives along stream banks, river banks, in open forested flood plains, and in other wetland sites. It tolerates drier areas and is often found in urban and semi-urban areas.

Look-alikes: Marsh marigold (*Caltha palustris*—native)

ECOLOGICAL IMPACTS

Lesser celandine divides and spreads forming thick mats. Its aggressive and early growth outcompetes native plants creating a monoculture. It has no, or very few, natural enemies in America to keep population growth in check. Displacement of native plants leads to little food options for native wildlife, decreasing biodiversity in the area. The mature foliage, roots, and tubers are quite toxic and can cause blistering if consumed.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Individual plants can be easily **hand dug**, being careful to remove all tubers. Hand-digging is difficult in larger infestations due to the high degree of soil disturbance and the abundance of small tubers. The site will need to be monitored for the next few years for regrowth.

Chemical: Herbicide treatments can be effective but need to be carried out in early spring when lesser celandine has emerged, prior to the emergence of other native plants. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Hand-dig	Apply herbicides early spring Hand-dig
SUMMER	**FALL**
Hand-dig	Hand-dig

Mugwort

Artemisia vulgaris

Origin: Europe and Eastern Asia

Introduction: 1600s

Propagation: Rhizome system and seeds

Seed Dispersal: Wind

Seed Persistence: Unknown; seed production not a major factor in spread

Life Cycle: Perennial

Description: This perennial herb can grow between 2-5 feet tall; Alternate leaves are dark green with a smooth upper surface with wooly hairs on the underside; Stems are angular with long ridges and range in color from green to purple; Each plant has numerous, small yellow flowers that grow in racemes and clusters at the end of stems and branches.

Phenology: Shoots emerge during the spring while flowering occurs in late summer to early fall

Habitat: It is most commonly found is disturbed sites such as pastures, ditches, restoration areas, roadsides, steep slopes, and forest edges. It prefers areas of full sun with moist soil conditions.

Look-alikes: chrysanthemum species (*Chrysanthemum spp.*—non-native), tansy (*Tanacetum vulgare*—non-native), dogfennel (*Eupatorium capillifolium*—native)

ECOLOGICAL IMPACTS

Mugwort has a shallow, yet extensive, rhizome system. Through the dispersal of root fragments, mugwort spreads largely through vegetative expansion. Plants can regenerate from rhizome fragments as small as 2 cm making it very problematic in nurseries. Stands of mugwort displace native vegetation. Mugwort pollen is also a common cause of hay fever.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Manual and mechanical removal is difficult due to mugwort's substantial root system. Pulling the plant may promote growth by leaving root fragments in the soil. Mugwort tolerates mowing. Even long term mowing will not fully eradicate mugwort stands. The most effective way to control mugwort is to **cover** patches with biotech fabric or other tarp like fabric for a few years to weaken the plant and then use manual methods to careful remove it.

Chemical: Herbicide options for mugwort are limited. Some **broadleaf herbicides** can help with control, though unlikely to be highly effective. Small infestations can be treated with multiple spot-treatments. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Cover/keep covered Apply herbicide to small infestations	Cover/keep covered Apply herbicide to small infestations
SUMMER	**FALL**
Cover/keep covered Apply herbicide to small infestations	Cover/keep covered Apply herbicide to small infestations

Palmer Amaranth

Amaranthus palmeri

Maryland State-listed Noxious Weed

★ **LES-PRISM Top Species of Concern**

Origin: U.S.A. and Mexico

Introduction: Native to the southwestern United States

Propagation: Seed

Seed Dispersal: Water, wildlife, and practices such as plowing, harvesting, and spreading manure

Seed Persistence: Limited depending on depth, likely at least 3 years

Life Cycle: Annual

Description: Palmer amaranth commonly reaches 6-8 feet in height; green leaves are smooth, ovate, and alternate with a small spike at tip; some variations have a white v-shaped mark on the leaves; stems are hairless, unlike some of the plant look-a-likes; flowers are thick with long terminal branches; female plant flowers have large green bracts up to 1/4 inch in length

Phenology: Seedlings emerge in late spring/early summer; flowers begin to bloom in late July/early August; seeds disperse in fall and as harvesting season continues

Habitat: Annual row crop fields and disturbed, sunny areas

Look-alikes: Tall waterhemp (*Amaranthus tuberculatus*– native), redroot (*Amaranthus retroflexus*– native), smooth pigweeds (*Amaranthus hybridus*– native)

ECOLOGICAL IMPACTS

Palmer amaranth has spread out of native areas and now aggressively competes with crops. It has a prolonged emergence period, rapid growth rate, prolific seed production, and quickly evolves to herbicide resistance making it a serious threat to crop yield. Individual plants have been found to have more than 250,000 seeds.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Plant can be **hand pulled** when less than 6" in height and disposed of prior to seed production. **Mowing** in conjunction with herbicide application has shown some effect. After mowing, herbicide must be applied immediately to prevent regrowth from stalks and seed close to the ground. **Prescribed fire** and **propane weed torching** have also been used in conjunction with herbicide application.

Chemical: Palmer Amaranth is difficult to control as it can be resistant to different classes of **herbicide.** Resistance has been documented for the follow classes: Dinitroanilines, triazines, ALS (acetolactate synthase) inhibitors, glyphosate, and HPPD (4-hydroxyphenylpyruvate dioxygenase) inhibitor herbicide. **Pre-emergent herbicides** have shown success in combination with **post-emergent herbicides** which should be applied later in the season. Using and rotating different herbicide programs repeatedly will be the most effective in combating resistance. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
	Hand pull seedlings Mow or cut Apply pre-emergent herbicide
SUMMER	**FALL**
Hand pull seedlings Mow or cut Apply pre-emergent herbicide	Apply post-emergent herbicide

Phragmites/ Common Reed

Phragmites australis

★ **LES-PRISM Top Species of Concern**

Origin: Europe

Introduction: 1700s

Propagation: Rhizomes, stem fragments, and seeds

Seed Dispersal: Wind, water, human activity, and birds

Seed Persistence: Very short lived, but can vary year to year

Life Cycle: Perennial

Description: Stems are hollow and usually green reaching over 15 feet in height. Nodes are more commonly yellow; leaves are green, sometimes greenish-blue and up to 20 inches long and 1-1.5 inches wide; leaves grow along one side of stem. Blooms in purple to gold panicles of flowers with gray seeds that appear fluffy in texture.

Phenology: Shoots emerge in March and April. Phragmite blooms in late July and into August. Seeds mature in late summer and disperse November through January.

Habitat: Most commonly found in roadside ditches, wetlands, freshwater and brackish marshes, river, lake, and pond edges, and disturbed areas. Prefers full sun.

Look-alikes: The much less common Native Phragmites species.

ECOLOGICAL IMPACTS

Infestations negatively affect the biodiversity and ecological functions of invaded habitats by robbing the native ecosystem of nutrients and space, blocking access to the water for swimming, fishing, and other recreation endeavors, spoiling shoreline views, and posing a fire hazard. It is easily able to adjust its growing based on environmental conditions and can survive in oxygen poor or salty conditions.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Repeated **mowing** may be a solution in high water years. Mowing has shown short term results due to repeated stem breakage. Hand pulling is not effective for Phragmites due to its extensive root and rhizome system. Any manual efforts to remove roots are likely to be ineffective as portions of rhizomes will be left in the soil and will create new plants.

Chemical: Post-emergent herbicides have been effective in Phragmites control. Treatment on newer colonies with less developed root and rhizome systems will be easier to control with herbicide. Herbicides are most affective when applied after the plant has flowers in late summer or fall but before seed formation. Multiple years of treatment, monitoring, and follow up will be necessary to eliminate any surviving rhizomes. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Mow	
SUMMER	**FALL**
Mow Apply herbicide	Apply herbicide

Purple Loose-strife

Lythrum salicaria

Origin: Europe, Asia, & Northern Africa

Introduction: 1830s

Propagation: Seed and rootstock

Seed Dispersal: Wind, water, and human activity

Seed Persistence: Viable for at least 3 years

Life Cycle: Perennial

Description: Leaves are opposite, lance-shaped, and 5-14 cm long. Stems are hairy and angular, reaching up to 4 meters in height. Mature plants can appear bush-like. Purple flowers have 5-7 petals and grow in clusters on spikes. Seeds are less than 1mm in length.

Phenology: Shoots emerge and seeds germinate as early as late April with flowering beginning by mid-June. Seeds begin to develop by late July and continue into fall. Plants senesce with the first frost though dead stems persist throughout the winter.

Habitat: Prefers wet, open soil in relatively warm temperatures (greater than 68 F).

Look-alike: Blue vervain (*Verbena hastata*– native)

ECOLOGICAL IMPACTS

A single plant is known to produce over two million seeds making this species extremely difficult to manage. It is competitive and can rapidly displace native species once established. Its dense canopy suppresses growth and regeneration of native plant communities and some aquatic wildlife species.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Hand-pulling small infestation has been effective but only when special care is taken to completely remove the root system. Exhausting the seed bank will take multiple years of monitoring and follow up.

Chemical: Herbicides can be used on smaller infestations but are generally unsuitable for large infestations. Exhausting the seed bank with take multiple years of monitoring and follow up. Review the Herbicide Basic factsheet before proceeding.

Biological: There are 2 leaf beetles (*Galerucella calmariensis* and *G. pusilla*) and 2 weevils (*Nanophyes marmoratus* and *Hylobius transversovittatus*) that have been released in the US as **insect biocontrol** agents for purple loosestrife. They have shown some success in controlling purple loosestrife populations by attacking buds and feeding on seeds, flowers, roots, and foliage.

WINTER	SPRING
	Hand pull small infestations
SUMMER	**FALL**
Hand pull small infestations Apply herbicide	Hand pull small infestations Apply herbicide

Shattercane

Sorghum bicolor

Maryland State-listed Noxious Weed

Origin: Northeastern Africa

Introduction: Early 1800s

Propagation: Seed

Seed Dispersal: Wind, wildlife, human activity

Seed Persistence: Viable in soil for 2-3 years

Life Cycle: Annual

Description: Stems are robust and range from 4-8 feet in height; Leaves and long and flat, roughly 1-2 feet long and 1-2 inches wide, rolled at the shoot; Flower seed heads are compact and spikelets occur in pairs; Seeds are black to reddish, shiny, and oval to round in appearance.

Phenology: Shattercane flowers July-October, 55-70 days after seeds germination. After pollination, seeds mature in about 30 days.

Habitat: Shattercane is found in fields, vegetable crops, disturbed sites, and along roadsides. It grows best in warm temperatures on well-drained, but moist, fertile soils, but it can also tolerate hot, dry conditions.

Look-alikes: Johnsongrass (*Sorghum halepense*—non-native)

ECOLOGICAL IMPACTS

Shattercane can form dense stands that displace native vegetation, restrict seedling establishment, and compete with food crops. It's primary a problem in agricultural fields, but it can crowd out native vegetation in natural ecosystems as well.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Hand-pulling, hoeing, cultivating, and **mowing** are all control methods for shattercane. Hand-pulling and hoeing are useful on small infestation but much too time-consuming for a large scale infestation. Mowing prevents seed production in small grains, pastures, and non-agricultural areas but is not suitable in corn or soybean fields. Cultivating/disking can control shattercane between crop rows but will not kill it near crop plants.

Chemical: Post-emergent herbicides can be used in combination with mechanical and preventative methods as a spot treatment on isolated patches. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Hand-pull/how small infestations	Hand-pull/how small infestations Apply herbicide
SUMMER	**FALL**
Hand-pull/how small infestations Apply herbicide	Hand-pull/how small infestations

Bull Thistle

Cirsium vulgare

Maryland State-listed Noxious Weed

Origin: Europe, Western Asia, Northern Africa

Introduction: 1800s

Propagation: Seed

Seed Dispersal: Wind and human activity

Seed Persistence: Short lived on soil surface but can persist for many years when buried

Life Cycle: Biennial

Description: Bull thistle stands upright and up to 3-6 feet tall; Stems are erect, branched, and hairy in appearance; Alternate leaves are green on the upper side with wooly hairs on the underside and long pointed, spines; Flowers are large, disk-shaped, compact, and purple/pink located at the tip of the stem; Each flower head produces up to 250 light straw-colored seeds.

Phenology: Bull thistle flowers and seeds in its second year. Germination occurs in the fall and spring, while basal rosettes form and continue to grow until winter. Flowering usually starts mid-June and continues into early fall.

Habitat: Prefers sunny open habitat, can tolerate both moist and dry soils, and is typically found in disturbed areas such as roadsides, logged areas, cultivated land, and pastures.

Look-alikes: Canada thistle (*Cirsium arvense*—noxious weed), Musk thistle (*Carduus nutans*—noxious weed)

ECOLOGICAL IMPACTS

Dense stands of bull thistle are common in overgrazed pastures, which can dramatically reduce productivity and exclude livestock from infested areas. In forest clear cuts and some natural areas, bull thistle outcompetes native plants and tree seedlings for space, water, and nutrients. Mature plants can produce 4,000-10,000 seeds per plant.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Bull thistle can be **dug up** with a shovel, or similar tool. Removing the top a few inches from the root is usually enough for sufficient removal. If removed during flowering, flowering stems should be carefully collected and destroyed to prevent further spread. Contaminated hay is a primary means of spread of this species so be careful to purchase weed free hay or watch closely for new plants in the areas hay is kept or spread.

Chemical: Several herbicides can be effective on bull thistle. In grassy or pasture areas, a selective **broadleaf herbicide** works best to keep grasses intact. If being applied to a grazing site, be careful to read grazing restrictions on instructions. Review the Herbicide Basic factsheet before proceeding.

Biological: Goats and sheep have been used for **grazing** management of bull thistle. There is also a bull thistle seed gall fly (*Urophora stylata*) that lays eggs on closed flower buds in the summer. The larvae burrow into the seed-producing tissues forming galls and reducing seed production. This insect can be an effective way to reducing seed production, however, it will not eradicate bull thistle.

WINTER	SPRING
Dig/cut plants Apply herbicide	Dig/cut plants Apply herbicide
SUMMER	**FALL**
	Dig/cut plants Apply herbicide

Canada Thistle

Cirsium arvense

Maryland State-listed Noxious Weed

Origin: Europe

Introduction: 1600s

Propagation: Rhizomes and seeds

Seed Dispersal: Wind, water, and wildlife

Seed Persistence: vVable in soil for 10-20 years

Life Cycle: Perennial

Description: Canada thistle forms in clumps and grows approximately 2-5 feet tall; leaves are long and narrow, alternate, with spiny margins and a spineless stem. Female flowers are flask-shaped, 1-1.5 cm in diameter, and 1-2 cm tall; flowers range from purple to pink or white; roots are fleshy, creeping, and extensive; seeds are smooth, brown, pointed, and approximately 1/8 inch long.

Phenology: Seedlings emerge in spring, usually April or May; plants flower from June to August producing mature fruit from July to September. Plants senesce in November and December.

Habitat: It is commonly found in agricultural and disturbed sites or sites that are undergoing restoration. Because of it's intolerance to shade, it is found primarily in full sun. It can be found in dry and sandy areas but is most commonly found along edges of stream banks, lakeshores, and wetlands.

Look-alikes: Bull thistle (*Cirsium vulgare*—noxious weed), Musk thistle (*Carduus nutans*—noxious weed)

ECOLOGICAL IMPACTS

Canada thistle invades habitat, displacing native vegetation and decreasing biodiversity. As it is commonly found in agricultural sites, it presents an economic threat to farmers because it competes with crops and could reduce crop yield. High seed count and viability requires continuous annual monitoring for many years.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: New infestations can be managed by **hand pulling** and **digging** out the roots but care must be taken to dispose of all root fragments. Care must also be taken to dispose of any plants that have bloomed as flowers can continue developing and produce seeds. **Mowing** during the growing season will deplete the food reserve stored in the roots and essentially "starve" the plant but may take several years to succeed.

Chemical: Canada thistle's deep root systems make it resilient to most control methods including herbicides. **Herbicides** can be effective when targeted both for seed production and the root system. Herbicide effect is enhanced when roots are weakened during the growing season by herbicide treatment, crop competition, or frequent mowing, and new shoots are stimulated to grow. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
	Hand pull or dig seedlings Mow Apply herbicide
SUMMER	**FALL**
Mow Apply herbicide	Apply herbicide

Musk Thistle

Carduus nutans

Maryland State-listed Noxious Weed

Origin: Eurasia

Introduction: 1952

Propagation: Seed

Seed Dispersal: Primarily wind, some through machinery, livestock, human activity, and water

Seed Persistence: Viable in soil for at least 10 years

Life Cycle: Biennial

Description: Musk thistle can reach up to 6 feet in height; Leaves and multi branching stems are dark green and very spiny; Leaves are coarsely lobed and have a smooth waxy surface; Flowers are red to purple, disk-shaped, and solitary; Flowers grow 1-3 inches in length and often droop once mature; Each plant produces up to 120,000 straw-colored seeds

Phenology: Seedlings emerge in mid to late July and develop into a basal rosette; In the second year flowers bloom from June to September

Habitat: Musk thistle will usually invade disturbed areas. It is common in pasture and meadows. It does not grow well in excessively wet, dry, or shady conditions.

Look-alikes: Native species of thistle (*Cirsium sp.)*

ECOLOGICAL IMPACTS

Musk thistle crowds out desirable species in pastures reducing forage yield and availability to livestock. As a prolific seed producer, it spreads seeds for an extended period of time, dispersing them close to the plant creating dense stands. A single plant can produce close to 11,000 seeds. Animals do not feed on musk thistle.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Hand-pulling, cutting, and repeated **mowing** is used to stop the spread of musk thistle. Mowing or hand-cutting before seed set will prevent seed development and dispersal. Musk thistle can be hand pulled but care should be take to completely remove the crown so the plant does not re-bolt and produce seeds. Hand pulling is most effective with small populations and should be completed before flowering, though it can be done year round.

Chemical: Musk thistle is commonly controlled with a **systemic herbicide.** It is best treated at the rosette stage, and effectiveness decreases as the plant matures. Herbicide can be applied to rosettes in the fall as well, especially when other plants are dormant having less of an impact on adjacent species. Treatment will work best prior to flowering. Review the Herbicide Basic factsheet before proceeding.

Biological: Biological control agents are not recommended at this time, though some have been released. The most common is the **weevil** (*Rhinocyllus conicus)*. Egg are deposited and larvae bore into the flowerhead reducing the ability of the plant to produce viable seed. While the weevil has reduced musk thistle populations, it will also attack native thistles.

WINTER	SPRING
Hand-pull Mow/cut	Apply herbicide Hand-pull Mow/cut
SUMMER	**FALL**
Hand-pull Mow/cut	Apply herbicide Hand-pull Mow/cut

Plumeless Thistle

Carduus acanthoides

Maryland State-listed Noxious Weed

Origin: Europe and Asia

Introduction: 1988

Propagation: Seed

Seed Dispersal: Wind

Seed Persistence: Viable in soil for at least 10 years

Life Cycle: Biennial

Description: Plumeless thistle is an upright, spiny, biennial that grows up to 8 feet tall; Flowers are solitary or in clusters of 2-3 and reddish-purple in color; Leaves are dark green and deeply lobed with hair on the underside and spines along leaf margins; Stems are tough with spiny wings; Seeds are smooth and hairless

Phenology: Seeds germinate spring through late summer. In the second year, the plant bolts and forms branched stems with alternate leaves. The plant blooms in mid to late summer.

Habitat: Grows in pastures, stream valleys, fields, and roadsides. It is most common is disturbed areas. It can aggressively invade natural areas and land restoration sites. Prefers dry, well-drained soils.

Look-alikes: Canada thistle (*Cirsium arvense*—noxious), bull thistle (*Cirsium vulgare*—noxious), musk thistle (*Carduus nutans*—noxious)

ECOLOGICAL IMPACTS

Plumeless thistle invades pastures, meadows, and fields crowding out other desirable and native forage plant species. Livestock tend to avoid grazing in areas heavily infested with plumeless thistle. Infestations may reduce productivity of pastures. Plumeless thistle reduces native plant biodiversity.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Hand-pulling small infestations can be an effective control method and is best done at the seedling and rosette growth stages. Hand-pulling plants should be done before the reproductive stage to prevent seed production. **Mowing** can also be an effective control methods if done prior to seed dispersal and if repeated several times over the growing season.

Chemical: Post-emergent herbicides are effective for plumeless thistle control and should be applied in late fall or early spring when thistles are in seedling or rosette growth stages. Herbicides applied prior to flowering will eventually eradicate plumeless thistle infestations. Review the Herbicide Basic factsheet before proceeding.

Biological: Biological control agents are not recommended at this time, though some have been released. The most common is the **weevil** (Rhinocyllus conicus). Egg deposits and larvae bore into the flowerhead reducing the ability of the plant to produce viable seed. While the weevil has reduced musk thistle populations, it will also attack native thistles.

WINTER	SPRING
Hand-pull young plants Mow	Hand-pull young plants Mow Apply herbicide
SUMMER	**FALL**
Hand-pull young plants Mow	Hand-pull young plants Apply herbicide

II. Trees & Shrubs

Autumn Olive

Elaeagnus umbellata

Origin: Asia

Introduction: 1830

Propagation: Primarily through seed, sometimes through rootstock

Seed Dispersal: Wildlife

Seed Persistence: Unknown

Life Cycle: Perennial

Description: Autumn olive can be either a multi-stemmed shrub or single trunked tree and can grow more than 20 feet high. Alternating leaves are ovate with smooth margins and silver scales. The underside of the leaves have a silvery sheen; flowers are small, whiteish-yellow, and aromatic while fruit are small, round, and red in color, dotted with scales.

Phenology: Autumn olive breaks dormancy in the early spring and flowers quickly thereafter around May-June. Fruits develop July-August and ripen in early fall. After several frosts, plants senesce.

Habitat: Adapts to both sun and partial shade but prefers well drained soils. It tolerates many different soil types including salt and low soil pH. It is most often found in fields, open forest, along streams, and in disturbed areas.

Look-alike: American silverberry (*Elaeagnus commutata* – native)

ECOLOGICAL IMPACTS

This fast growing tree displaces native plants under its dense shade and can alter soil chemistry thereby interfering with natural plant succession. Because it thrives in many different soil types, it can easily invade grasslands, fields, open woodlands, and disturbed areas.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Young plants can be **hand pulled**, ensuring that roots are completely removed. Larger shrubs should be removed using a **weed wrench** or dug out. The best time to remove shrubs is when the soil is moist. Mowing and cutting in combination with herbicide treatment is also effective. Cutting can be done by a brush mower, chain saw, or similar tool.

Chemical: After stumps are cut, they should be treated with a systemic herbicide using the **cut-stem** or **basal bark method**. Herbicides can also be used as a foliar spray which has been effective but will likely impact native or non-target species. Foliar spray should only occur when fruits are not present to lessen the potential poisoning of birds and other wildlife that feed on them. Review the Herbicide Basic fact-sheet before proceeding.

WINTER	SPRING
	Mow, cut, or girdle Hand pull or dig small shrubs and seedlings Apply foliar spray
SUMMER	**FALL**
Mow, cut, or girdle Hand pull or dig small shrubs and seedlings Apply herbicide to cut stems or basal bark	Apply herbicide to cut stems or basal bark

Bush Honeysuckle

Lonicera spp.

Origin: Asia, Europe

Introduction: Late 1800s

Propagation: Seed and root

Seed Dispersal: Wildlife

Seed Persistence: Viable in soil for 2 or more years

Life Cycle: Perennial

Description: Bush honeysuckle grows 6-15 feet tall and 6-12 feet wide; Leaves are opposite, oval to oblong and roughly 1-2.5 inches long and 1-1.5 inches wide; Leaves are dark green and somewhat glossy in appearance; Stems are hollow with light, grayish-brown shaggy bark in long strips; White flowers bloom in pairs at the nodes along the stem and are generally less than 1 inch long; Red fruits are about 1/2 inch wide and contain many seeds

Phenology: Bush honeysuckle flowers from May-June. Fruits ripen in mid-summer. Seeds require a cold, moist period to break dormancy which occurs in the soil during winter.

Habitat: Bush honeysuckle commonly invades woodlands, especially those that are disturbed. It can also be found along lakeshores, forest edges, abandoned fields, pastures, and roadsides. They can grow under a broad range of light and moisture conditions.

Look-alikes: Native bush honeysuckles (*Diervilla Lonicera, Lonicera canadensis*)

ECOLOGICAL IMPACTS

Bush honeysuckle is commonly found in dense thickets that outcompete native plants for soil moisture, light, and nutrients. Wildlife eats the berries and deposit the seeds elsewhere, contributing to the spread of this species. Because it tolerates many habitats, it can become established anywhere that birds can go, often forming an impenetrable understory layer.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Seedlings and smaller plants can be **hand-pulled**. For larger infestations or shrubs, a tool like a **weed wrench** or shovel should be used when soil is moist. Plants should be dug up or pulled prior to fruiting. Care should be taken to remove the entire root system. **Mowing, cutting, girdling,** and **burning** are also effective against bush honeysuckle. These strategies would need to be repeated for several years to effectively kill the root systems.

Chemical: A systemic herbicide should be used in late summer or fall using the **cut-stem** or **basal bark** method. Herbicides can also be used as a **foliar spray** when fruits are present in the spring. Treatments will need to be repeated annually until the plants are eradicated. Review the Herbicide Basic factsheet before proceeding.

Biological: Goat have been used to **graze** honeysuckle. Goats can be used in combination with other control methods to help eradicate the infestation.

WINTER	SPRING
	Graze Mow/Cut/Hand-pull Apply herbicide—foliar
SUMMER	**FALL**
Graze Mow/Cut/Hand-pull Apply herbicide—cut stems or basal bark	Apply herbicide—cut stems or basal bark

Callery Pear

Pyrus calleryana

★ **LES-PRISM Top Species of Concern**

Origin: East Asia

Introduction: Early 1900s

Propagation: Seed, cuttings, and rootstock grafting

Seed Dispersal: Wildlife

Seed Persistence: Unknown

Life Cycle: Perennial

Description: A small deciduous tree; alternate, ovate, **leaves** are dark green, glossy, with waved edges that turn red, purple, and orange in the fall; twigs sprout large, hairy terminal **buds**; white clustered **flowers** have 5 petals; olive-brown and tan **fruits** with reddish specks. Bradford pear is one of many cultivated varieties (cultivars) of callery pear and a popular landscaping tree in the US. As with most cultivars of the callery pear, Bradford pears are unable to self-pollinate or cross-pollinate with other Bradford pear trees. However, they will produce viable seeds by crossing with other pear varieties or other non-Bradford pear cultivars of callery pear. Callery pear and all of its cultivars are prolific fruit producers, and the fruit is eaten by many species of birds. Where cross-pollination has created viable seeds, birds will eat and distribute them across the landscape producing trees that yield viable seeds and lead to aggressive infestations.

Phenology: Trees break dormancy in early spring, leafing out shortly after flowering begins. Small fruits ripen in September/ October and persist throughout winter months. In the summer, the foliage is dark green while in fall the leaves gain vibrant colors such red, pink, purple, and orange.

Habitat: Roadside, forest edge, garden, and meadow. They prefer full sun but are also found in partial shade and do well on a wide range of soil types and moisture ranges.

Look-alikes: Cultivated apple (*Malus spp.* - non-native) and pear (*Pyrus spp.* - non-native)

ECOLOGICAL IMPACTS

The Callery pear spreads aggressively by seed and vegetative means. Dense thickets are often formed, thereby displacing native trees and plants. Their fast growth rate prevents light from reaching understory species such as wildflowers and other species favored by pollinators. In addition, the brittleness of the wood make it prone to splitting.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Seedlings can be **hand-pulled** or dug up using a weed wrench when the soil is moist making sure to remove the entire root. Saplings and large trees should be **felled** and stumps chemically treated immediately after to prevent re-sprouting. If cutting down the tree is not possible, saplings and large trees can be **girdled** by cutting through the bark around the trunk, six inches above the ground. Subsequent treatments will be required for several years to limit the potential for re-sprouting and to exhaust the persistent seed bank.

Chemical: After felling saplings and large trees, stumps should be treated immediately with **herbicide** to prevent re-sprouting. Dense thickets should be treated with a foliar spray of a systemic herbicide solution. Take caution with broad-spectrum herbicides as they could kill desirable, native plant species as well. **Basal bark** methods can be used for trees up to 6 inches in diameter. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Fell or girdle trees	Pull seedlings Fell or girdle trees
SUMMER	**FALL**
Pull seedlings Fell or girdle trees Apply herbicide to stumps or basal bark	Pull seedlings Fell or girdle trees Apply herbicide to stumps or basal bark

Japanese Barberry

Berberis thunbergii

Origin: Japan

Introduction: 1875

Propagation: Seed, roots

Seed Dispersal: Wildlife, mostly birds

Seed Persistence: Viable in soil up to 2 years

Life Cycle: Perennial

Description: Japanese barberry is typically 3-6 feet tall; Branches are deeply grooved, brown, and have sharp spines; Green to blueish-green leaves are .5-1.5 inches long and shaped like narrow ovals; Flowers are pale yellow and occur the entire length of the stem; Fruits are bright red berries

Phenology: Plants break dormancy in early spring. Flowering occurs in spring and fruit matures from July-October and persist throughout winter. Plants senesce after several frosts.

Habitat: Japanese barberry grows well in both full sun and deep shade. Dense stands are commonly found in closed canopy forests, open woodlands, wetlands, and fields.

Look-alikes: American barberry (*Berberis Canadensis*—native)

ECOLOGICAL IMPACTS

Japanese barberry forms dense stands that compete with native trees and other desirable herbaceous plants. In very large infestations, its leaf litter can change the soil chemistry, making it more basic. Infestation have been found to harbor high mice and tick populations under its thick canopies.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Being mindful of the thorns, some Japanese barberry plants can be easily **pulled**. In addition to hand-pulling, larger plants can be **dug** with a shovel or **Weed Wrench** or cut. Cutting in the spring or summer will slow the growth of plants and could prevent flowering, fruit, and seed production. These strategies can be done at any time during the year; however, the best times are the months before or during flowering. **Burning** targeted plants with propane torches, once in early spring with a follow-up burn in summer has been effective at controlling the growth and spread of infestations.

Chemical: Herbicides have been effective at controlling Japanese barberry in summer and early fall with a **foliar** spray or **cut stump** method. A cut stump method would work best if the cut was done in spring to early summer, and the herbicide then applied to the sprouted plant in summer to early fall. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Pull/Dig/Cut	Burn Pull/Dig/Cut
SUMMER	**FALL**
Burn Pull/Dig/Cut Apply herbicide	Pull/Dig/Cut Apply herbicide

Multiflora Rose

Rosa multiflora

★ **LES-PRISM Top Species of Concern**

Origin: China, Japan, Korea

Introduction: 1860s

Propagation: Seed

Seed Dispersal: Wildlife

Seed Persistence: Viable in the soil bank for 10-20 years depending upon soil conditions

Life Cycle: Perennial

Description: Multiflora rose is a single or multi-stem climbing shrub that can grow 10-15 feet or more. Branchlets have paired, short, curved thorns. Leaves are alternate and are composed of 5-11 leaflets. Leaflets are approximately 1/2 inch to 2 inches long and are ovate with a pointed tip. White flowers are clustered; Round, red berries are clustered and approximately 1/4 inch wide.

Phenology: Plants break dormancy in early spring months; Flowers bloom from May-June; berries appear in August and persist into the winter, shrubs senesce around October.

Habitat: Most commonly found in abandoned fields, grasslands, roadsides, forest edges, wetlands, stream banks, and other riparian areas.

Look-alikes: Native roses

ECOLOGICAL IMPACTS

Because of its prolific seed count, Multiflora rose forms dense stands that suffocate native species thereby reducing the biodiversity of native ecosystems. The loss of native species diminishes the amount of food and habitat for wildlife. Sprawling growth also allows easy access to nesting birds by ground predators.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Hand pulling, digging, mowing, and **cutting** are all effective options for management. Being careful of the thorns, small plants can be pulled. Otherwise, digging with a **Weed wrench**, mowing, or cutting will work. Repeated cutting or mowing on a monthly cycle will be more effective at stunting the plant and inhibiting fruit and seed production. Mowing allows increased sunlight on the seeds, which encourages germination. Controlling Multiflora rose will take time, monitoring, and follow-up. These controls can be done at any time during the year; however, the best times are in the late-winter or early spring or during flowering.

Chemical: Foliar spray and **cut-stump method** application of herbicides are effective for Multiflora rose. The best time for any control option is just before a plant flowers. Chemical control should be applied in coordination with cuttings. Cutting the shrubs down to 1 inch above the ground and immediately applying herbicide has been very effective. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Hand pull, cut, dig, or mow	Hand pull, cut, dig, or mow Apply foliar spray or cut-stump method herbicides
SUMMER	**FALL**
Hand pull, cut, dig, or mow Apply foliar spray or cut-stump method herbicides	Hand pull, cut, dig, or mow Apply foliar spray or cut-stump method herbicides

Norway Maple

Acer platanoides

Origin: Europe and Eastern Asia

Introduction: 1756

Propagation: Seed

Seed Dispersal: Wind and water

Seed Persistence: Unknown

Life Cycle: Perennial

Description: Norway Maples grow 40-60 feet in height but can reach heights of 100 feet; Leaves are opposite, 5 -lobed with pointed tips; Leaves are green and usually a yellow orange in fall; Norway Maple is distinguished from other native maples by white sap that oozes from broken petioles; Winter buds are reddish green and rounded; Flowers are yellow-green, high in the canopy; Fruit looks like a typical maple samara but has a very wide angle; Bark is dark grey and furrowed but not shaggy like native maples.

Phenology: Buds emerge in winter; Flowers emerge and bloom in spring; Fruits mature in late summer.

Habitat: Commonly found in forests, along forest edges, and open areas. Norway maple is extremely shade tolerant and easily germinates under a closed canopy.

Look-alikes: Sugar Maple (*Acer saccharum*—native), Red Maple (*Acer rubrum*—native, invasive), Amur Maple (*Acer ginnala*—non-native)

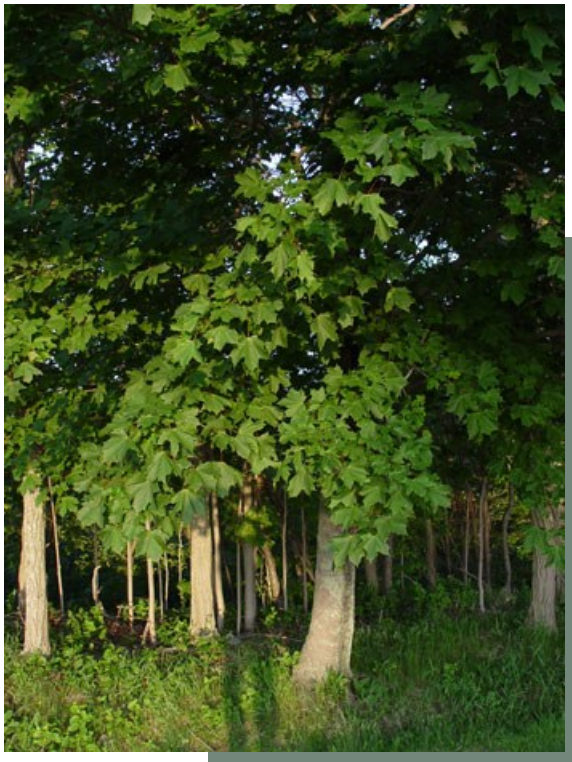
ECOLOGICAL IMPACTS

Norway maple's monotypic populations displace desirable native vegetation in forests. Once an infestation is established, it creates a dense canopy that shades out native seedling in the understory. There is some research attempting to confirm Norway maple releases toxins that inhibit the growth of other plants.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Seedling can be hand pulled or dug up if necessary. Larger trees can be cut but will need to be treated with a herbicide to prevent resprouting. Cutting trees is not effective in early spring due to sap rising. Girdling can be effective if done in the spring.

Chemical: A **cut-stump** method of herbicide application should be used for trees previously cut. A **foliar spray** can be effective on seedling and short saplings as long as you can reach the top of the plant. **Basal bark** and **hack and squirt treatments** are also effective on Norway maples and can be applied year round. Review the Herbicide Basic factsheet before proceeding.



WINTER	SPRING
Cut-stump Hand-pull-Dig Basal bark method	Hand-pull/Dig Basal bark method Girdle
SUMMER	**FALL**
Cut-stump Hand-pull/Dig Basal bark method	Cut-stump Hand-pull/Dig Basal bark method

Russian Olive

Elaeagnus angustifolia

Origin: Eurasia

Introduction: Early 1900s

Propagation: Seed

Seed Dispersal: Wildlife and water

Seed Persistence: Viable in soil for up to 3 years

Life Cycle: Perennial

Description: Russian olive is a large, thorny, shrub or small tree that grows 10-25 feet tall; Alternate greenish-gray leaves are 1-4 inches long and 0.5-1.5 inches wide with smooth edges; Mature trunk bark is brown-gray and ridged while mature stems are smooth and brown; New stems are covered in hair with a gray-silver appearance; Thorns are 1-2 inches long and alternately arranged on stems; Flowers are yellow and arranged in clusters; Olive shaped fruit ripen to a red/brown.

Phenology: Flowers appear in May/June. Fruits ripen August-October. Trees produced seed after 3-5 years. Seeds remain on trees throughout the winter or until consumed by animals. Seed dispersal occurs throughout fall and winter.

Habitat: Russian olive is found primarily on coasts, riparian areas, and in other relatively moist habitats. It can thrive under a wide range moisture and soil conditions including sandy, loamy, and silty soil with moderate soluble salt concentrations.

Look-alikes: Silverberry (*Elaegnus commutata*—native)

ECOLOGICAL IMPACTS

Russian olive is gaining invasive status in many states. It has been documented as out-competing and crowding out many native species. Russian olive grows quickly and its dense stands can form a continuous, closed canopy, while the lower vegetation is often made up of a tangle of dense branches. Growth on streambanks can also alter natural flooding regimes.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Some mechanical control options for Russian Olive include **hand-pulling, mowing, cutting**, and **girdling**. Seedlings can be hand-pulled or continually mowed until stems grow larger than 1 inch in diameter. Russian olive can be cut, aiming to cut as close to the ground as possible to eliminate top growth. Girdling is also an effective option to starve the plant.

Chemical: Herbicides have been effective as **foliar sprays** and **basal bark** applications. Foliar applications are best conducted in late fall to reduce the impact to desirable vegetation and are effective on large or dense infestations. Basal bark application can be done at any time of the year as long as temperatures are above freezing. These methods work best when combined with mechanical strategies. Review the Herbicide Basic factsheet before proceeding.

Biological: Trained goats will **graze** on Russian olive seedlings and younger trees, however, other control methods should be used in combination.

WINTER	SPRING
Apply herbicide—basal bark application Pull/Mow/Cut/Girdle Graze	Apply herbicide—basal bark application Pull/Mow/Cut/Girdle Graze
SUMMER	**FALL**
Apply herbicide—basal bark application Pull/Mow/Cut/Girdle Graze	Apply herbicide –foliar spray or basal bark application Pull/Mow/Cut/Girdle Graze

Tree-of-Heaven

Ailanthus altissima

★ **LES-PRISM Top Species of Concern**

Origin: China and Taiwan

Introduction: 1748 (Pennsylvania)

Propagation: Seeds and root sprouts

Seed Dispersal: Wind, water, and human activity

Seed Persistence: Less than a year

Life Cycle: Perennial

Description: Tree-of-Heaven grows rapidly and can reach heights of 80-100 feet; bark is smooth and green eventually turning light brown to gray and resembles the skin of a cantaloupe; leaves grow on a central stem ranging from 1-4 feet with anywhere from 10-40 smooth, lance-shaped leaflets; seeds are 1-2 inch long samara which are found in clusters and stay on the tree into the winter.

Phenology: Plants break dormancy in the spring and bloom in early summer. Fruits mature late summer into early fall, August-October. Some seeds stay on through winter, most disperse in October and November.

Habitat: They can grow almost anywhere. Besides urban areas, tree-of-heaven is found growing along woodland edges, roadsides, railways, fencerows, and forest openings. It is intolerant of shade.

Look-alikes: Staghorn sumac (*Rhus typhina*– native), black walnut (*Juglans nigra*– native), and hickory trees (*Carya spp*.– native).

ECOLOGICAL IMPACTS

Tree-of-Heaven is common in urban areas and causes damages to sewers and structures. It poses a great threat to agricultural and natural ecosystems due to its vigorous growth and prolific seed production. It establishes dense stands that push out native species and affects biodiversity. It is the preferred tree of spotted lanternfly, an invasive insect that causes impacts on vineyards, orchards, and other hardwood trees.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Seedlings can be **hand-pulled** when soil is moist but pay close attention to removing the entire root system. Cutting and mowing are ineffective as the tree responds by producing large numbers of stump sprouts and root suckers. When cutting is necessary, treat with an herbicide first, allowing 30 days for it to take effect and then cut.

Chemical: Roots can be treated with systemic **herbicides** in the summer. Application at any other time will injure only above ground growth. To control growth, herbicides can be applied to foliage, bark, or **frill cuts** on the stem. For extensive infestations **foliar application** should be used first to eliminate small, low growth. Bark or frill application can then be used on the remaining larger stems. **Basal bark** applications provide a target-specific method for treating tree-of-heaven that, in general, is less than 6 inches in diameter. Continuous monitoring for signs of regrowth is critical to prevent reinfestation. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Fell treated trees if needed	Pull seedlings
SUMMER	**FALL**
Apply herbicide to roots, foliage, bark, or frill cuts	Apply herbicide to roots, foliage, bark, or frill cuts

White Mulberry

Morus alba

Origin: China

Introduction: 1600s

Propagation: Seed

Seed Dispersal: Wildlife and roots

Seed Persistence: Viable in soil for up to 2 years

Life Cycle: Perennial

Description: Alternate leaves are variably shaped, 2-8 inches long, and shiny with blunt teeth and heart shaped bases; Mature bark is gray with irregular fissures; Flowers are small, green, and occur in long catkins; Fruits are multiple seeded berries and can range in color from black to pink to white.

Phenology: White mulberry generally flowers in May. Fruits begin forming in May and may continue to develop into late summer.

Habitat: White mulberry is most commonly found in old fields, urban lots, forest edges, and other disturbed areas.

Look-alikes: Red Mulberry (*Morus rubra*– native), hackberry (*Celtis occidentalis*—native), black gum (*Nyssa sylvatica*—native) and sassafras (*Sassafras albidum*-native)

ECOLOGICAL IMPACTS

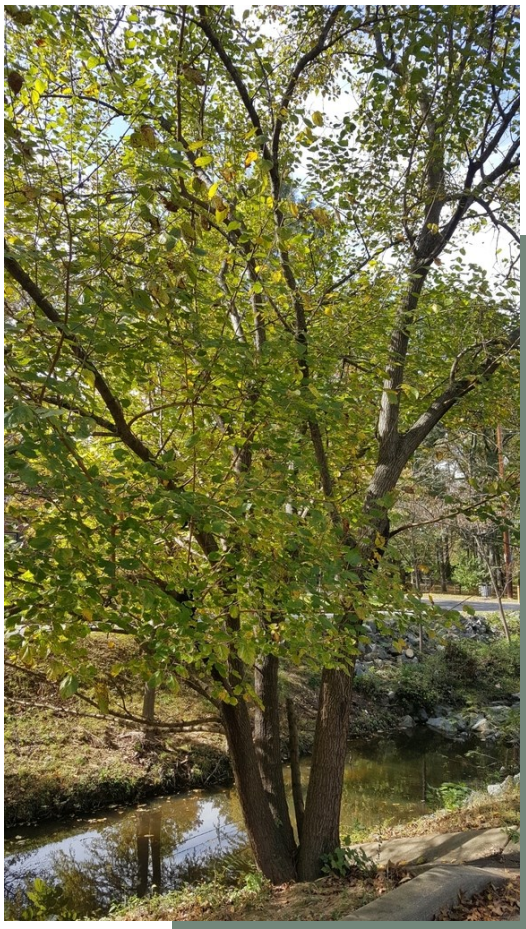
White mulberry invades forest edges, disturbed areas, and open areas, displacing native species. It outcompetes native species but especially native red mulberry through hybridization. It is also possible that white mulberry transmits a root disease to the native red mulberry.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Seedlings can be **hand-pulled.** Otherwise, **cutting** or **girdling** are effective options when combined with chemical control methods. These methods may be limited by the potential of white mulberry to sprout from the stump, roots, or cut stems that get buried under the soil.

Chemical: Systemic herbicides have been shown to be one of the most effective management options for white mulberry. Herbicides can be applied as a **foliar spray, basal bark, cut stump,** or **hack-and-squirt** treatment method. Care should be taken to avoid impacting surrounding desirable vegetation. Herbicides are best used to gain initial control of new or severe infestations but may not be a complete solution. Review the Herbicide Basic factsheet before proceeding.

Biological: Some use of **grazing** goats has been used to suppress white mulberry in prairie settings in the Midwest.



WINTER	SPRING
Pull/Cut/Girdle	Pull/Cut/Girdle Apply herbicide
SUMMER	**FALL**
Pull/Cut/Girdle Apply herbicide	Pull/Cut/Girdle Apply herbicide

III. Vines

English Ivy

Hedera helix

★ **LES-PRISM Top Species of Concern**

Origin: Europe, Western Asia, and Northern Africa

Introduction: 1727

Propagation: Seeds and vegetative runners

Seed Dispersal: Wildlife

Seed Persistence: Unknown

Life Cycle: Perennial

Description: Evergreen leaves are dark green, waxy, and alternate along the stem. Usually leaves are three-lobed with a heart-shaped base. Mature leaves can be un-lobed and spade-shaped. Flowers are small, greenish-yellow and occur in globular starburst type cluster at tips of flowering stems; fruits are black with a fleshy outer layer and stone-like seeds.

Phenology: Leaf initiation occurs primarily from April to May; Flowering occurs in late summer and early fall; fruiting occurs fall-winter.

Habitat: Prefers semi-shade to full sun, and moist soil but grows in many environments such as woodlands, fields, forest edges, roadsides, and coastal areas. It also grows on and damages building façades.

Look-alikes: Boston ivy (*Parthenocissus japonicus*—non-native); Virginia creeper (*Parthenocissus quinquefolia*—native)

ECOLOGICAL IMPACTS

English ivy is an aggressive invader that threatens vegetation of forested and open areas. Vines climbing up tree trunks spread out and envelop branches and twigs blocking sunlight from reaching the host tree's foliage. Heavy vines can take trees down in wind, snow, and icy conditions. English ivy also serves as reservoir for bacterial leaf scorch, a disease in maples, oaks, and elms.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Vines can be **cut** and **pulled** down from trees and pulled up from its roots. Pulling ivy from the roots may disturb soil and promote erosion or compaction of the soil or facilitate reinvasion of English ivy or other invasive plants. If hand removal is used, following-up with other types of treatments may improve control. Sprouts from the stumps of cut vines may be treated with herbicide or cut repeatedly until sprouting stops.

Chemical: Information pertaining to the chemical control of English ivy is inconsistent and offers only incomplete control. English ivy may be tolerant of pre-emergent herbicides and its waxy leaves make effective application of post emergent herbicide difficult even when a surfactant is added. Herbicides may provide safe and effective control of English ivy, even during the winter. Herbicide is most effective when used as a part of an integrated management plan. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Cut and pull vines Apply herbicide	Cut and pull vines Apply herbicide
SUMMER	**FALL**
Cut and pull vines Apply herbicide	Cut and pull vines Apply herbicide

Japanese Honeysuckle

Lonicera japonica

Origin: Eastern Asia

Introduction: 1806, Long Island, NY

Propagation: Seed

Seed Dispersal: Birds

Seed Persistence: Unknown, likely > 2 years

Life Cycle: Perennial

Description: Japanese honeysuckle is deciduous twining vine with reddish brown to light brown stems; Opposite leaves are ovate and about 1-3 inches long and 0.5-1.5 inches wide; Flowers are bi-lobed, white turning yellow, and highly fragrant; Fruits are black when mature, paired, and produced in the fall.

Phenology: Plants break dormancy in early spring. Flowers bloom in early summer; Fruits emerge and ripen in fall

Habitat: Japanese honeysuckle has adapted over the years to a wide variety of habitats from full sun to heavy shade. The vine is commonly found along field edges, under dense canopies, and in high canopies.

Look-alikes: Coral honeysuckle (*Lonicera sempervirens*—native), hairy honeysuckle (*Lonicera hirsute*—native), crossvine (*Bignonia capreolata*—native) and trumpet creeper (*Campsis radicans*—native)

ECOLOGICAL IMPACTS

Japanese honeysuckle is a fast growing woody vine that twists around stems of desirable native shrubs and herbaceous plants. It can kill shrubs and saplings by girdling and forms its largest tangles in full sun. Its dense stands smother and kill native vegetation. This species poses serious threats to forested and riparian areas.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Small infestations can be **hand pulled. Mowing** is best used for larger infestations and will need to be done at least twice per year in combination with a post-emergent herbicide. Large infestations can also be reduced with **fire** but will grow back after several years so fire should be combined with chemical control as well.

Chemical: Previously mowed vines can be treated with a **post emergent herbicide** for effective control. Entire stands can also be treated with a **foliar spray** in late summer. Herbicide treatment should be avoided in spring to avoid harm to non-targeted plants. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Apply herbicides Mow	Hand-pull Mow
SUMMER	**FALL**
Mow/Cut Apply herbicides Mow	Apply herbicides Mow

Japanese Hops

Humulus japonicus

Origin: Asia

Introduction: Late 1800s

Propagation: Seed

Seed Dispersal: Wildlife, human activity, and floodwaters

Seed Persistence: Unknown, likely at least 3 years

Life Cycle: Annual

Description: Japanese hops is a twining shallow-rooted vine that climbs with the help of rough texture stems covered with short, sharp, prickles; Leaves are rough textured, paired, simple with 5-7 lobes with toothed leaf margins; Flowers are pale green, drooping, cone-like structures with overlapping scales that become hops; Seeds are round with a blunt tip and light brown with darker specks

Phenology: Seeds germinate in early spring but new plants can continue to emerge with adequate sunlight and soil moisture. Flowering occurs in mid to late summer months. Seeds mature through September.

Habitat: Japanese hops prefers high sun and rich, moist, exposed soil. It is most commonly found along streambanks and floodplains. It is tolerable of shade and drier soils but growth is less vigorous. In mild climates, it can survive winter temperatures.

Look-alikes: Native grapes (*Vitis*—native), Virginia creeper (*Parthenocissus quinquefolia*—native)

ECOLOGICAL IMPACTS

Japanese hops spreads to cover large areas of open land, blanketing understories, and can spread to cover large trees and shrubs. The vines grow rapidly in the summer and twine around shrubs and trees causing them to break or fall. It displaces native vegetation, prevents the emergence of new plants, and kills newly planted trees, preventing restoration.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Vines can be hand-pulled wearing protective clothing and gloves to avoid injury from the prickly hooked hairs. Hand pulling will need to be repeated and is best done early in the season before the root system becomes intensive. Take care to prevent seed from moving on clothing, vehicles, or equipment. Hand pulling works best with routine follow up and spot treatments. Cutting is also an option, however, the vines re-grow quickly from cut stem so frequent cutting is necessary.

Chemical: Systemic herbicides work best for Japanese hops. Foliar applications are effective in the early summer to prevent seed production. In some cases, foliar applications have been combined with a preemergent herbicide for more effective control. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Cut	Hand pull Cut Preemergent herbicide
SUMMER	**FALL**
Foliar herbicide application Cut	Cut

Kudzu

Pueraria montana

★ **LES-PRISM Top Species of Concern**

Origin: China, Japan, India

Introduction: 1876, Philadelphia, PA

Propagation: Root and seed

Seed Dispersal: Wind, wildlife, human activity, and water

Seed Persistence: Unknown, likely several years

Life Cycle: Perennial

Description: Kudzu produces long, hairy vines from a central root crown; Compound leaves are dark green, hairy, alternate, and roughly 2-8 inches long with three oval to heart shaped leaflets; Flowers grow on 4-8 inch racemes and are typically red, purple, or magenta with a strong aroma; Seed pods are produced in clusters of 20-30 and are brown and hairy.

Phenology: Flowers typically bloom in late-summer on vertical vines but not until its third year. Some infestations can survive over winter, though trailing stems in open areas tend to die back in winter.

Habitat: Warmth and humidity are important factors that help determine how great the infestation will become. Warmer average annual temperatures and high average humidity has shown greater colonization. Typical kudzu habitats are usually open, disturbed areas such as roadside ditches, rights-of-way, and abandoned fields.

Look-alikes: Thick tangles of various vines including grape, porcelainberry, and bittersweet.

ECOLOGICAL IMPACTS

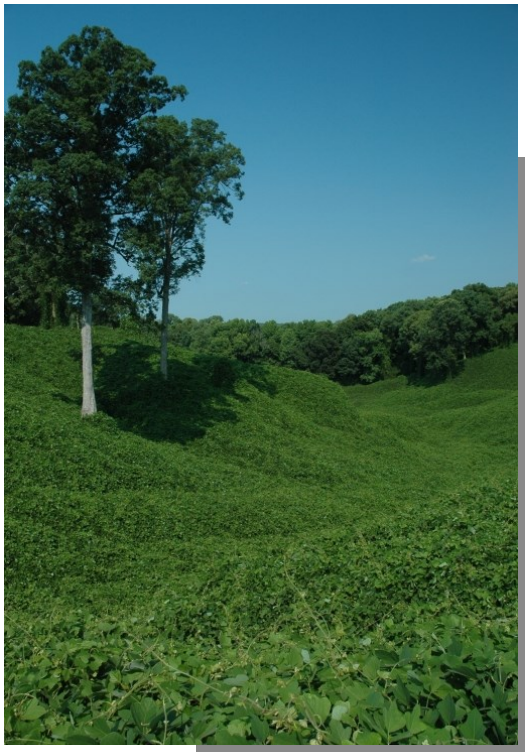
Kudzu is a semi-woody vine that climbs into forest canopies to get access to light. Kudzu vines can grow up to 30-100 feet per year. Their growth and climbing can cause weakened trees to fall from the weight of the overgrowth. This species usually physically crushes, crowds out, and outcompetes native plant communities.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Mowing can help on immature matches of kudzu assuming that all root heads are mowed. To be effective, mowing needs to be repeated every two week and could take many years to fully eradicate the infestation. Mowing should be used in combination with a chemical control to effectively eradicate the infestation. All cut plant material should be destroyed by burning or bagging and landfilling. To prevent reinvasion, complete eradication is required, making sure every root crown on a site is killed.

Chemical: Many herbicides will kill back the stems and leaves of kudzu; however, most will not provide eradication by killing of the root systems. A **systemic herbicide** as a **foliar application** has shown effectiveness in controlling kudzu infestations in combination with mowing. Early fall application of herbicides has been shown to help diminish reserves of starch. Review the Herbicide Basic factsheet before proceeding.

Biological: Sheep and goat **grazing** can be used to help control young kudzu growth and help to make chemical controlling options more effective over short periods of time by helping to reduce energy reserves.



WINTER	SPRING
Graze Mow	Graze Mow
SUMMER	**FALL**
Graze Mow	Graze Mow Apply herbicide

Mile-a-minute

Persicaria perfoliata

Origin: India and Eastern Asia

Introduction: 1930 (Pennsylvania)

Propagation: Seed

Seed Dispersal: Wildlife and water

Seed Persistence: Viable in soil for 6 years

Life Cycle: Annual

Description: A barbed vine with alternating light green leaves shaped like an equilateral triangles; green vines are narrow and fragile but become woody and red with time; ocreae surround the stems at nodes; Flower buds and fruit grow from ocreae; flowers are small and white forming spikes of blue and purple berry-like fruits containing one glossy seed.

Phenology: Seedlings emerge in spring. Flowering begins in early summer. Fruits being to develop in mid-summer and ripen in the early fall months of September and October.

Habitat: Usually found in disturbed open areas. Also common along forest edges, streams, wetlands, and roads. Plant prefers high moisture soil and full sun though it will tolerate shade and drier soils.

Look-alikes: Halbard-leaved tearthumb (*Polygonum arifolium*—native), climbing false buckwheat (*Polygonum scandens*—native), and hedge bindweed (*Calystegia sepium*—native)

ECOLOGICAL IMPACTS

A barbed vine, mile-a-minute can grow up to 6 inches per day. It forms dense mats that smother and physically damage herbaceous plants, shrubs, and trees. It blocks sunlight, decreasing the ability of the understory to photosynthesize. The weight and pressure of the dense mats can also hinder growth of branches and foliage.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Small populations of mile-a-minute can be **mowed** or **cut** repeatedly to reduce flower and fruit production. **Hand-pulling** vines is an effective management strategy early in the season before barbs harden and fruit emerges. Take caution with plants that have fruit as they could be knocked off and encourage further spread. All plant material should be burned or bagged and taken to a landfill.

Chemical: A **broad spectrum herbicide** can be applied as a **foliar spray** in early spring when native plants are dormant. For larger, long-term infestations, a **pre-emergent herbicide** can help prevent seeds from germinating. Treatments will likely need to be repeated annually and work best in combination with mechanical or manual treatments. Review the Herbicide Basic factsheet before proceeding.

Biological: Goats and **sheep** in **managed grazing** systems have shown a similar effect to mowing. The Asiatic stem-boring weevil (*Rhinocomimus latipes*) has also been used as an **insect biocontrol** as it feeds exclusively on the mile-a-minute plant.

WINTER	SPRING
Apply pre-emergent herbicide	Mow, cut, or graze Pull small plants Introduce weevils Apply foliar spray
SUMMER	**FALL**
Mow, cut, or graze Pull small plants Introduce weevils	Pull small plants (take care with fruit)

Oriental Bittersweet

Celastrus orbiculatus

★ **LES-PRISM Top Species of Concern**

Origin: Eastern Asia, Korea, China, and Japan

Introduction: 1860s

Propagation: Seed and rhizomes

Seed Dispersal: Birds, wildlife, water, and human use of berries and vines

Seed Persistence: Limited, likely 1-2 years

Life Cycle: Perennial

Description: A deciduous, woody vine, Oriental bittersweet climbs and grows up to 60 feet in length; vines can grow up to 4 inches in diameter; finely toothed light green leaves alternate and are 2 to 5 inches in length; round fruits are yellow until they split in the fall and winter months to reveal bright red berries.

Phenology: Seedlings emerge in early spring, usually April. Flowering begins in May through June. Fruits develop and ripen mid-summer into early fall. Leaves abscise in late fall, seeds remain on plant through winter.

Habitat: Abandoned fields and home sites; forest edges, roadsides, saltmarsh edges, and riparian areas. It prefers full sun in open sites but tolerates some shading.

Look-alikes: American bittersweet (*Celastrus scandens*—native)

ECOLOGICAL IMPACTS

The weight of this vine is able to kill trees and break branches when it grows into the canopy. It decreases sunlight to native vegetation in the understory. The rapid spread of oriental bittersweet makes it easy to take over many acres of forest. In some places, such as New England, oriental bittersweet seems to be displacing native bittersweet through competition and hybridization.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Efforts to control oriental bittersweet will require multiple years of consistency due to the numerous seeds and their viability. **Hand-pulling** small populations that have not yet climbed into the tree canopy has seen success prior to fruiting. All plant material, especially fruits, should be bagged and properly disposed. In larger infestations, vines can be **cut** close to the ground though they will resprout unless an herbicide is applied immediately. **Mowing** can prevent the plant from fruiting, though mowing less than once a week may promote root sprouts and further spread.

Chemical: Once vines are cut or mowed, **systemic herbicides** can successfully manage the spread of bittersweet if applied immediately in a **cut-stem** method. **Foliar** application has also seen success in managing bittersweet in the early spring months when native plants are dormant. Review the Herbicide Basic factsheet before proceeding.

Biological: Goats are fond of oriental bittersweet and managed **grazing** could help with control in some cases. Manual pulling will still likely be needed based on how high the vines have climbed.

WINTER	SPRING
Remove plants from native trees	Hand pull small plants Apply herbicide—foliar application or cut-stem Mow, cut, or graze
SUMMER	**FALL**
Remove plants from native trees Apply herbicide—cut stem Mow, cut, or graze	Hand pull small plants Apply herbicide—cut stem

Porcelain Berry

Ampelopsis brevipedunculata

★ **LES-PRISM Top Species of Concern**

Origin: Northeast Asia—China, Korea, Japan, and far east Russia

Introduction: 1870s

Propagation: Seed, root suckering, and rootstock

Seed Dispersal: Birds, wildlife, and water

Seed Persistence: Unknown

Life Cycle: Perennial

Description: A deciduous, woody vine, porcelain berry can climb more than 20 feet high; the **vine** twines with non-adhesive tendrils occurring opposite of leaves; the **bark** has lenticels and does not peel; ovate **leaves** are roughly 5 inches with a heart-shaped base; **flowers** are greenish-white; **fruits** change from pale purple to green and bright blue

Phenology: Seedlings emerge in the spring; flowers bloom from June through August; fruits appear and ripen in late summer and into the fall.

Habitat: Grows best in most soils including forest edges, pond margins, stream banks, and thickets. Prefers full sun though some shade is tolerated. Less tolerant of heavily shaded areas such as mature forests.

Look-alikes: grape (*Vitis*– native) and peppervine species (*Ampelopsis*– native).

ECOLOGICAL IMPACTS

Porcelain berry invades both open and wooded habitats with ample sun. Infestations form dense mats which shade out native herbaceous plants, shrubs, and small trees. Fast growth and spread rates in areas of moderate or full sunlight lead to vines growing up to 15 feet in one growing season.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Small plants can be pulled when soil is moist. If possible, remove plants to the ground before seeds are formed and dispersed, this may take several seasons of manual removal to get under control. To prevent flower buds from forming, **hand-pull** vines in the fall or spring. Hand-pulling should take place before fruits emerge to prevent seed dispersal. Fruits need to be carefully collected and disposed of in a landfill if vines are pulled during fruiting. Larger vines can be cut close to the ground and treated with systemic herbicide. Vines may need to be cut again as needed if regrowth is apparent.

Chemical: Systemic herbicides have been used successfully in combination with manual methods on large infestations. **Cut-stem** or **basal bark** methods have both been used. To protect dormant native plants, **foliar** herbicide should be used in early spring. Review the Herbicide Basic factsheet before proceeding.

Biological: Goats are fond of porcelain berry and managed **grazing** could help with control in some cases. Manual pulling will still likely be needed based on how high the vines have climbed.

WINTER	SPRING
Remove plants from native trees	Hand-pull vines Apply herbicide as a foliar spray Mow, cut, or graze
SUMMER	**FALL**
Remove plants from native trees Apply herbicide Mow, cut, or graze	Hand-pull vines Apply herbicide using basal bark or cut-stem method

Wisteria

Wisteria sinensis & Wisteria floribunda

★ **LES-PRISM Top Species of Concern**

Origin: China and Japan

Introduction: 1816 & 1830 (respectively)

Propagation: Seed and rootstock

Seed Dispersal: Water and improper root removal

Seed Persistence: Unknown

Life Cycle: Perennial

Description: Chinese wisteria stems twine in a counter-clockwise direction; Japanese wisteria stems twine in a clockwise direction. Chinese wisteria produces fragrant, lavender blue-violet or white colored flowers while Japanese wisteria can produce white and pink-lavender colored flowers. Deep green leaflets are roughly 1 foot long and alternate. Chinese wisteria has 7-13 leaflets while Japanese wisteria has 13-19 leaflets.

Phenology: Wisterias are slow to mature and may not begin flowering until three to five years after emergence. Chinese and Japanese wisteria flower in the spring and produce a velvety seed pod.

Habitat: Infestations are often found along forest edges, roadsides, and ditches. Ideal habitat is full sun but vines continue to grow in shade. Wisteria tolerates a variety of soil and moisture types but prefers loamy, deep, well-drained soil.

Look-alikes: American wisteria (*Wisteria frutescens*—native)

ECOLOGICAL IMPACTS

Wisteria's growth is rampant and it is resilient in different conditions. It climbs tall into the tree canopies where it shades out smaller trees and plants below. Even large trees are killed by infestations, and the loss of canopy cover can increase sunlight, which further encourages wisteria's aggressive growth. Wisteria's longevity increases its ability to invade forested areas and suffocate native plants.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Manually removing the entire plant from the roots is appropriate for small populations or sensitive areas where herbicides shouldn't be used. Using a **weed wrench**, remove the entire plant including the roots. Seedlings can be **hand pulled** when soil is moist paying special attention to removing all roots. Any part of the root system that is left behind could resprout. All parts of the plant should be bagged carefully and disposed of in a dumpster or landfill.

Chemical: Systemic herbicide can be used with a **cut stump** treatment where vines are established around native plants or in tree canopies. Subsequent treatments of **foliar application** may be necessary for resprouting. Foliar application may also be used to control large infestations. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Remove plants from native trees	Hand pull appropriate plants Apply systemic herbicide Apply foliar treatment
SUMMER	**FALL**
Remove plants from native trees Apply systemic herbicide	Hand pull appropriate plants Apply systemic herbicide Apply foliar treatment

IV. Aquatic Species

Eurasian Milfoil

Myriophyllum spicatum

Origin: Europe, Asia, North Africa

Introduction: Unknown; between 1880s-1940s

Propagation: Root fragmentation

Dispersal: Wind, waves, and human activity

Persistence: Unknown

Life Cycle: Perennial

Description: Eurasian milfoil has long stems and 12 to 21 leaflet pairs which are limp when out of water; Flowers are arranged on spikes which bear whorls of female flowers basally and whorls of male flowers apically; Flowers are small and yellow, rising 5-10 cm above the surface; Stems are 1-3 meters in length and are thin and can appear green, brown, or pinkish white; Stem thickness below the inflorescence is almost double that of the lower stem; There are typically four feather-like, deeply-dissected leaves whorled around the stems with 14 or more uniform (in diameter) leaflets on each leaf.

Phenology: Plants begin to photosynthesize and grow earlier in the spring than natives. Flowering typically takes place in early summer and can continue for several months.

Habitat: Inhabits ponds and lakes with varying depths. Waters may be stagnant, slow-moving fresh, or slightly brackish

Look-alikes: Native milfoil (*Myriophyllym sibiricum*) Native M. sibiricum has 5 to 10 leaflet pairs which remain rigid when out of the water.

ECOLOGICAL IMPACTS

This species is a submerged aquatic plant rooted at the lake bottom. It grows rapidly in depths of 3-13 feet but has been found in water up to 33 feet deep. It forms dense beds and canopies in relatively shallow waters shading out native species and reducing their growth. *M. spicatum* has been found to hybridize with native *M. sibiricum* with an intermediate number of leaf segments. The hybrid plant tends to be more aggressive than the invasive parent species.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Mechanical harvesting efforts have been relatively unsuccessful in providing more than short-term relief. Small populations in areas that are easily accessible can be **hand-pulled**, but care should be taken to prevent breaking off fragments that can start new populations. On managed water-bodies, drawing down water levels to expose standing infestations and root crown for several weeks can **dehydrate** and eradicate the plant.

Chemical: Herbicides have been found to suppress growth but considerable negative effects on non-targeted organisms have been seen. Herbicide treatments are most effective in still water in the spring while the plant is still growing.

Biological: The grass carp (*Ctenopharyngodon idella*) has been used to reduce Eurasian milfoil in North America. Unfortunately in most cases grass carp only eats Eurasian milfoil after native plants have been consumed.

WINTER	SPRING
Hand-pull	Treat with herbicides Hand-pull
SUMMER	**FALL**
Hand-pull	Hand-pull

Hydrilla

Hydrilla verticillata

Origin: Eastern Hemisphere, possibly Asia

Introduction: 1950s

Propagation: Primarily tubers, also stem fragments

Dispersal: Human activity and waves

Persistence: Tubers remain viable out of water for several days and in undisturbed sediment for over 4 years

Life Cycle: Perennial

Description: Rooted in the waterbed, with long stems (up to 25 feet) that branch at the surface where growth becomes horizontal and dense mats form. Small, pointed, bright-green, leaves are arranged in whorls of 4 to 8. Leaves have serrated margins and may have one or more sharp teeth under the midrib. Thin stalks from the stem end in a single, small, floating white flower at the water's surface. A key identifying feature is the presence of small (up to half inch long), dull-white to yellowish, potato-like tubers which grow 2 to 12 inches below the surface of the sediment at the ends of underground stems.

Phenology: Hydrilla depends on tubers for overwintering.

Habitat: Found in freshwater lakes, ponds, rivers, impoundments, and canals. It has a low salinity tolerance.

Look-alikes: Canadian waterweed (*Elodea canadensis*—native) 3 smooth-edged leaves as opposed to whorls of 4 to 10 serrated and spined leaves.

ECOLOGICAL IMPACTS

Hydrilla grows aggressively and competitively, forming thick mats in shallow waters that block sunlight to the native plants below. In some areas, it has displaced native vegetation altogether. It has been shown to alter physical and chemical characteristics of lakes such as reduced weight and size of sportfish, decreased oxygen levels, and disruption in water flow.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: While the best way to combat hydrilla is prevention by cleaning boats, **mechanical harvesting** is a common control method. Mechanical harvesting techniques include the used of power weed cutters with suction harvesting vacuum hoses, though it is very costly as it needs to be repeated several times during the growing season. Water drawdowns will **dehydrate** and eradicate the plant but would need to be done for a long period and regrowth could still appear from buried tubers.

Chemical: Herbicides are used as a common control method for hydrilla. Herbicide spraying works best on small, enclosed bodies of water. It will not be effect in large bodies of water or in moving water such as streams and rivers. Herbicides may have a negative effect on non-targeted species.

Biological: Leaf-mining flies from Australia and India have been attempted in Florida with mixed results. The insects are not native to MD, therefore there is a risk to use a non-native species to attempt to control another non-native species. Some use of grass carp has been used on small bodies of water.

WINTER	SPRING
	Mechanical harvesting Treat with herbicides
SUMMER	**FALL**
Mechanical harvesting	Mechanical harvesting

Water Chestnut

Trapa natans

Origin: Western Europe, Africa, Asia

Introduction: 1859

Propagation: Seed

Seed Dispersal: Current and waterfowl

Seed Persistence: Seeds remain viable in sediment for up to 12 years

Life Cycle: Annual

Description: Each seed produces 10 to 15 stems with submerged and floating leaves, terminating in floating rosettes. Feathery, submerged leaves grow up to six inches long and alternate on the stem. Floating leaves have prominent veins and short stiff hairs underneath; Petioles contain buoyant bladders that allow the leaves to float on the surface; Stems reach up to 16 feet in length and are anchored to the bed of the waterbody by numerous roots. One single, small, white flower sprouts from the center of the rosette. Each rosette can produce up to 20 hard nut-like fruits which have 4 very sharp spines.

Phenology: Seeds germinate in the spring; Fruits in mid-summer and ripens about 1 month later; Seeds generally fall directly beneath their parent plant.

Habitat: Freshwater lakes, ponds, and slow-moving streams and rivers

Look-alikes: Water chestnut is not easily confused with other aquatic plants.

ECOLOGICAL IMPACTS

Water chestnut forms dense stands of floating vegetation which negatively impacts ecosystem functions. The density of the mats can limit light penetration, reducing the growth of native aquatic plants beneath the canopy. Reduced biodiversity in combination with the decomposition of the water chestnut plants results in reduced levels of dissolved oxygen in the water, impacting other organisms. It serves little nutritional or habitat value.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Hand-pulling is effective from canoes and kayaks. Because it is any annual plant, effective control can be achieved if seed formation is prevented. Large infestations usually require **mechanical harvesting** techniques in combination with the application of herbicides. Because seeds are viable in sediment for up to 12 years, mechanical harvesting procedures will need to be repeated to ensure control.

Chemical: Treatment of **herbicides** has shown effectiveness before fruit has ripened and dropped. Herbicides can have negative impacts on non-target species

Biological: A number of potential biological control agents show promising news, though additional studies on hosts are on-going.

WINTER	SPRING
Hand-pull Mechanical harvesting	Hand-pull Mechanical harvesting Herbicide treatment
SUMMER	**FALL**
Hand-pull Mechanical harvesting	Hand-pull Mechanical harvesting

Water Hyacinth

Eichhornia crassipes

Origin: South America

Introduction: 1884

Propagation: Root fragments and seed

Dispersal: Wind and human activity

Seed Persistence: Seeds remain dormant in sediment until exposed to a drying event, likely 15-20 years

Life Cycle: Perennial

Description: An erect floating aquatic plant; Leaves are ovate, thick and glossy, roughly 12-15 cm wide; Petioles are bulbous, spongy, and inflated which hold leaves above the water; Generally there are 6-8 leaves per plant with a rosette arrangement from a central growing point; Roots are feathery and dark in color; Showy flower spikes are lavender; Flowers are 4-6 cm wide and have 6 lobes; Pollinated flowers produce capsules containing many seeds.

Phenology: Water hyacinth germinates in spring and flowers bloom summer to early fall. Plants will cease growth or die depending on winter climate. When climate starts to warm again, plants rebound and continue growing to spring in which germination process begins again.

Habitat: All types of freshwater habitats but prefers slow-flowing water and relatively open conditions. This species does not tolerate brackish waters.

Look-alikes: Pickerel weed (*Pontederia cordata*—native)

ECOLOGICAL IMPACTS

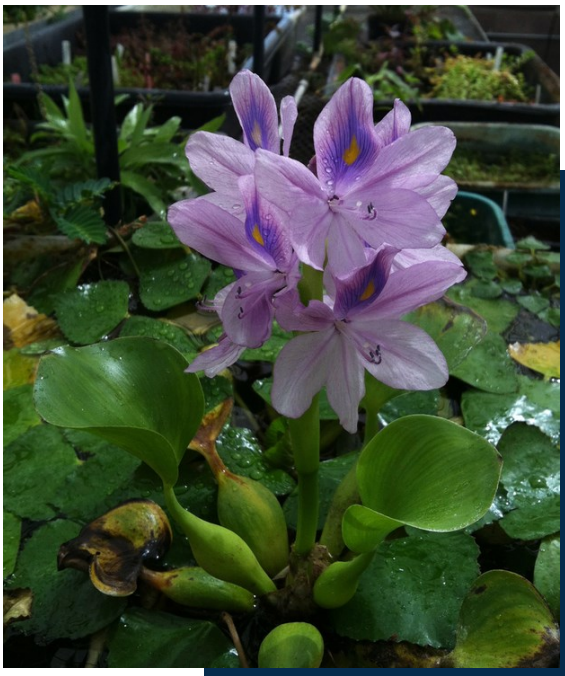
Once established, infestations of water hyacinth quickly spread. Without a sustained freeze, the plant grows as a perennial. Water hyacinth forms dense floating mats that can clog waterways preventing travel or blocking irrigation canals. As mats decay, there is a sharp increase in nutrient levels in the water, which spark algae growth that further reduces oxygen levels. In southern ranges, it doubles its size in two weeks.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Small infestations can bee controlled by **hand pulling**. It thrives best in nutrient-rich waters, so reducing nutrient concentrations in impacted waters may decrease growth. **Mechanical harvesting** such as chopping machines, raking, and seining can be used to remove water hyacinth and transport it to disposal on shore.

Chemical: Aquatic **herbicides** can provide temporary control but may have negative effects on non-targeted species.

Biological: Water hyacinth is the main food source for the Neochetina beetle. They are commonly used as a biological management method for water hyacinth.



WINTER	SPRING
Hand-pull	Hand-pull Mechanical harvesting Herbicide treatment
SUMMER	**FALL**
Hand-pull Mechanical harvesting	Hand-pull Mechanical harvesting

V. Non-Plant Species

Emerald Ash Borer

Agrilus planipennis

Origin: Eastern Russia, China, Japan, and Korea

Introduction: 2002 (Michigan)

Size: Approximately 1/2 inch long

Range: Alabama, Arkansas, Colorado, Connecticut, **Delaware**, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, **Maryland**, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Texas, **Virginia**, West Virginia, and Wisconsin.

Description: Adults are typically ½ inch long and ⅛ inch wide. Eggs are extremely small and are reddish-brown in color. Larvae are white, flat-headed borers with distinct segmentation.

Phenology: Adults emerge in late spring or early summer from infestations to the trees during the previous year. Females lay their eggs shortly after and continue into August. The larvae bore into the ash tree and feed under the bark, leaving tracks visible underneath. This leads to bark splitting and dieback. Telltale sign of emerald ash borer presence is D-shaped exit holes.

Habitat: Ash trees primarily in the Midwest and Eastern United States

Look-alikes: Six-spotted Green Tiger Beetle (*Cicindela sexguttata*—native)

ECOLOGICAL IMPACTS

The Emerald Ash Borer is responsible for the destruction of tens of millions of ash trees in 30 states. Ash trees lose most of their canopy within 2 years of infestation and die within 3-4 years. All 16 species of ash trees and White Fringetree (*Chionanthus virginicus*) have been impacted. The larval stage feeds beneath the bark and disrupts water and nutrient flow within the tree, leading to its death.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: It's important not to move firewood from your property or across state lines. Firewood should be kiln-dried and bought from local sources to prevent the spread of emerald ash borer. It's recommended to burn any remaining firewood before spring to eliminate any chance of emerald ash borer spreading to live trees.

Chemical: The most common treatment is systemic **insecticide** applied via **soil drenches** or **trunk injections**. Both deliver the insecticide to the tree's tissue which assures it is evenly dispersed throughout the canopy. Injections will target the larvae tunneling under the bark which is the most destructive phase of the emerald ash borer. These methods are most effective when applied in the spring, but can also be applied in the fall.

WINTER	SPRING
Burn any remaining firewood	Apply insecticide via soil drench or tree injection Buy local firewood
SUMMER	**FALL**
Buy local firewood	Apply insecticide via soil drench or tree injection Buy local firewood

Gypsy Moth

Lymantria dispar dispar

Origin: France

Introduction: 1869

Size: The caterpillars grow to about 2.2 inches in length;

Range: Northeastern U.S. west to Minnesota

Life Span: Caterpillar stage lasts approximately 7 weeks; adults live 2 weeks

Description: The caterpillars grow to about 2.2 inches in length. They have five pairs of raised blue spots followed by six pairs of raised red spots along its back. Female moths are white with brown markings. Males are brownish. Females do not fly. Egg masses are light brown in color and appear as fuzzy patches on tree trunks, branches, firewood, or in a sheltered spot, even on lawn furniture. Each egg mass contains 600-700 eggs.

Phenology: Gypsy moth caterpillars emerge from tan, fuzzy egg masses in April and feed on leaves through late June.

Habitat: Typically its habitat is in forests or wooded areas.

Look-alikes: Eastern tent caterpillar (*Malacosoma americanum*—native)

ECOLOGICAL IMPACTS

Gypsy moth populations rise and fall in cycles and vary over the years. During a heavy infestation, caterpillars may devour much, if not all, foliage from trees. This defoliation is an additional stress that can affect tree physiology and may ultimately result in death. Gypsy moth outbreaks often extend for hundreds of square miles and the defoliated areas may be extensive.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Egg masses can be destroyed by **scraping** them off trees or other structures and dropping them in a container of detergent. During outbreaks, manual removal may not be practical.

Chemical: Insecticides can have an impact on a variety of beneficial, native insects (such as bees), so they should be used wisely. Spraying is not effective against pupae or egg masses, and it is less effective once caterpillars reach 1 inch long. Keep in mind that nesting birds, beneficial insects, and other animals could be endangered by use of chemical insecticides.

WINTER	SPRING
Scrape egg masses	Scrape egg masses Apply insecticide
SUMMER	**FALL**
Apply insecticide	Scrape egg masses

Northern Snakehead

Channa argus

Origin: China

Introduction: 1997

Size: Up to 4 feet long

Life Span: Roughly 8 years

Range: Considered established in **Virginia**, **Maryland**, Pennsylvania, New York and Arkansas. Found in the Potomac River and several of its tributaries in Maryland and Virginia

Description: Northern snakeheads have long, narrow bodies with long dorsal and anal fins. Their large mouth is highlighted by a protruding jaw and canine-like teeth. They have enlarged scales and irregular, blotchy coloration giving them a snake-like appearance. They can grow up to 4 feet in length depending on location and age.

Phenology: Female snakeheads reach sexual maturity at two years old. They lay as many as 15,000 eggs 1-5 times a year which hatch in 1-2 days. Spawning begins in April, peaks in June, and lasts into August.

Habitat: Freshwater streams, rivers, wetlands, or ponds. They prefer slow moving to stagnant waters and shallow waters during spawning season.

Look-alikes: Burbot (*Lota lota*—native) and Bowfin (*Amia calva*—native)

ECOLOGICAL IMPACTS

Northern snakehead fish are predators. Native species are often outcompeted for resources. Adults deplete populations of fish, crustaceans, small amphibians, reptiles, and some birds and mammals. Northern snakehead are very territorial and aggressive during and after spawning season. Due to their ability to breathe out of the water, snakeheads are capable of traveling over small pieces of land and into new bodies of water.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Control methods vary with each infestation site. Physical removal using nets, traps, angling, or electrofishing have been used but are not likely to be successful on large infestations. Water drawdown has been used in areas with water level control capacity, however, this method is harmful to many other desirable plant and fish species.

Chemical: Using a **broad spectrum piscicide**, such as rotenone, can be used to eradicate the species from lakes and ponds. However, this puts other species at risk. The major issue of treating with rotenone is losing other native fish species. However, native fish species may be impacted by the introduction of northern snakeheads. In many cases, rotenone may be the only option to eradicate the population and ensure these fish do not spread to other waterbodies.

WINTER	SPRING
Physical removal	Physical removal Piscicide application
SUMMER	**FALL**
Physical removal Piscicide application	Physical removal

Spotted Lanternfly

Lycorma delicatula

Origin: China, India, and Vietnam

Introduction: 2012

Size: 1-inch long

Life Cycle: One generation per year

Life Span: 6 months

Range: The spotted lanternfly has been seen in parts of Pennsylvania, **Delaware**, **Maryland**, New York, and **Virginia**.

Description: Adults are very colorful when their interior hind wings are displayed which are red with black dots. Their head is black and they have a yellow body with black bands. Their forewings are gray with black dots and a brick pattern on the tips. Egg masses usually contain 30-50 eggs covered in a wax-like substance. Adult males are slightly small than adult females.

Phenology: Adults develop in the summer. They lay eggs in late summer and into fall. The eggs overwinter, hatching the first nymphs in the spring.

Habitat: Spotted lanternfly feeds on a wide range of fruit, ornamental, and woody trees, with tree-of-heaven being one of the preferred hosts. They are usually seen at dusk in large numbers. They are considered poor fliers but are very good at hitching rides on vehicles and will hide in firewood and other solid items.

Look-alikes: Tiger moth (*Arctia caja—native*) and Giant Leopard moth (*Hypercompe scribonia—native*)

ECOLOGICAL IMPACTS

Spotted lanternflies have great impacts on vineyards, orchards, and hardwood trees leading to an increase in management costs and crop loss. Eggs are laid on any hard surfaces, making it easy to unknowingly transport egg masses. They pierce the plant's tissues and feed on the sap which weakens the plant. The honeydew left behind by the infestations also promotes the growth of sooty mold.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Check for egg masses from September through May. During the summer, check for nymphs and adults. If egg masses are found, **scrape** them off into a bag filled with rubbing alcohol or hand sanitizer and keep them in this solution permanently. In the summer, wrap tree trunks in **tree traps** to catch the nymphs. Invasive species such as tree of heaven and oriental bittersweet are often host to spotted lanternfly. In these cases, follow **removal procedures for host** plants paying careful attention not to spread any eggs masses.

Chemical: Systemic **insecticides** work well as either **bark sprays, soil drenches,** or **direct contact sprays**. Ideally, soil drenches work best when applied in the early summer to trees that had high spotted lanternfly populations in the past and are likely to have them again. Soil drenches of systemic insecticides should be applied after a tree's flowers have faded to protect pollinators. These methods may take several days or weeks to move within the entire tree so, unlike contact sprays, you should not expect immediate results.

WINTER	SPRING
Check for egg masses	Check for egg masses
SUMMER	**FALL**
Apply insecticide via soil drench, bark spray, or direct contact spray	Check for egg masses Apply insecticide via direct contact spray.

VI. Aggressive Natives

Dogfennel

Eupatorium capillifolium

Origin: Eastern Canada & U.S.A.

Introduction: Native

Propagation: Seed and rootstock

Seed Dispersal: Wind

Seed Persistence: Unknown

Life Cycle: Perennial

Description: Woody-cased brown or copper stems reach up to 6 feet in height; leaves are crowded, finely-dissected, and divided into linear segments; flowers are small, greenish-white and develop into large flower heads at the top of stems; the 3-5 flowered heads are arranged in pyramid-shaped clusters; achene up to 1.5 mm long

Phenology: Seedlings emerge in spring; blooms from September through November; achenes ripen early to mid-November and disperse late-November to early-December

Habitat: Dogfennel prefers moist, well-drained soils in full sun or partial shade. It does best in hot summer climates with afternoon shade. It is tolerant of dry, sandy soils and is native to fields, clearings, woodlands, and roadsides in coastal plain regions.

Look-alikes: Horseweed (*Conyza Canadensis*—native) and mugwort (*Artemisia vulgaris*—non-native)

ECOLOGICAL IMPACTS

Dogfennel is a common issue in pastures and can spread from its root stock causing increasingly large groups that shade the desired forage and reducing yields. Due to strong winds during the winter months, and the tiny, airborne carried seed, dogfennel is aggressive and wide spreading in coastal regions from Florida to Massachusetts.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Dogfennel becomes increasingly more difficult to manage as it continues to get heavily established. **Mowing** the plants is successful when the plants are small and before seed emerge. Mowing can help to exhaust the rootstock. Dogfennel has been found to reproduce at six inches tall, so mowing close to the ground is necessary.

Chemical: Many different **systemic herbicides** have been effective in controlling dogfennel. Foliar application should occur when the plants are under 20 inches tall. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Mow	Dig or hand-pull plants Apply pre-emergent herbicide Mow
SUMMER	**FALL**
Apply foliar herbicide Mow	Dig or hand-pull plants Apply foliar herbicide Mow

Sweetgum

Liquidambar styraciflua

Origin: Native

Introduction: N/A

Propagation: Seed, Root

Seed Dispersal: Wind and wildlife

Seed Persistence: Unknown

Life Cycle: Perennial

Description: Sweetgum is a large deciduous tree that can grow 100 feet tall and 3-5 feet in diameter with a cone shaped crown; Alternate leaves are simple with 5-6 points resembling a star shape and are dark green in color until fall when they turn bright orange/red; Fruit hangs and is shaped like a brown, woody tipped "gum ball" with small brownish seeds.

Phenology: Trees begin to produce seed when about 20 -30 years old. Can sprout new stems long after the main trunk has been cut. Flowers appear from March to May and fruit ripens from September to November. Fruit often persists through winter.

Habitat: Sweetgum grows in areas of rich, moist soil conditions. The tree does not do well in areas with limited room for root development. It is very intolerant of shade but is tolerant to flooding. It also tolerates seaside sites in areas protected from high wind.

Look-alikes: American sycamore (*Platanus occidentalis*)

ECOLOGICAL IMPACTS

Sweetgum trees have shallow roots that can lift sidewalks and curbs. These trees can become invasive in an area as they take root easily from seed and grow quickly, often out-competing all other plants. Removal can be difficult because new growth can sprout from root fragments long after the main trunk has been cut down.

INTEGRATED MANAGEMENT OPTIONS

Mechanical: Seedlings can be **hand-pulled** when soil is moist but pay close attention to removing the entire root system. **Cutting** mature trees can be effective if in combination with chemical management options.

Chemical: A **cut stump** herbicide treatment should be used on mature sweetgum trees. After cutting with either a hand saw or chain saw, depending on the size of the tree, a herbicide should be applied to the stump. The stump should be watched carefully for new growth and herbicide should be reapplied if necessary. Review the Herbicide Basic factsheet before proceeding.

WINTER	SPRING
Cut mature trees Apply herbicide	Pull seedlings Cut mature trees Apply herbicide
SUMMER	**FALL**
Pull seedlings Cut mature trees Apply herbicide	Pull seedlings Cut mature trees Apply herbicide

Photo Credits

Herbaceous Plants

Bull Thistle (*Cirsium vulgare*)
Flower: Loke T. Kok, Virginia Polytechnic Institute and State University, Bugwood.org
Stem; Foliage: Dan Tenaglia, Missouriplants.com, Bugwood.org
Seeds: Forest and Kim Starr, Starr Environmental, Bugwood.org
Infestation: Invasive Weed Solutions UK
Main photo: Idaho Fish & Game

Canada Thistle *(Cirsium arvense)*
Infestation: Jan Samanek, Phytosanitary Administration, Bugwood.org
Flower: Steve Dewey, Utah State University, Bugwood.org
Leaves: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org
Whole Plant: Peggy Greb, USDA Agricultural Research Service, Bugwood.org
Stem: UAF Cooperative Extension , University of Alaska - Fairbanks, Bugwood.org
Seedling: Ohio State Weed Lab, The Ohio State University, Bugwood.org

Common Reed (*Phragmites australis*)
Flower cluster: David Cappaert, Bugwood.org
Stem: Rob Routledge, Sault College, Bugwood.org
Leaves: Ohio State Weed Lab , The Ohio State University, Bugwood.org
Seeds: Ken Chamberlain, The Ohio State University, Bugwood.org
Main photo; Infestation: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Common Waterhemp (*Amaranthus rudis*)
Main photo; Stem; Foliage: Illinoiswildflower.info
Seedhead: NDSU.edu
Seedling: Aaron Hager, USDA Agricultural Research Service, Bugwood.org
Infestation: Missouri Weed ID—University of Missouri

Dogfennel (*Eupatorium capillifolium*)
Stem; Flower Heads: Alexander Krings, NC State Extension
Leaves: 101 Species, wordpress.com
Infestation: University of Florida—Institute of Food and Agricultural Research
Seedling: Mature Plant: J. Neal, NC State Extension

Garlic Mustard (*Alliaria petiolata*)
Foliage; Flower; Seedpods; Main photo: Chris Evans, University of Illinois, Bugwood.org
Seedling: Tom Heutte, USDA Forest Service, Bugwood.org
Infestation: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Giant Hogweed (*Heraclum mantegazzianum*)
Fruit; Infestation: Jan Samanek, Phytosanitary Administration, Bugwood.org
Foliage: Donna R. Ellis, University of Connecticut, Bugwood.org
Stem: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org
Seeds: USDA APHIS PPQ , USDA APHIS PPQ, Bugwood.org
Main photo: Thomas B. Denholm, New Jersey Department of Agriculture, Bugwood.org

Photo Credits (continued)

Golden Bamboo (*Phyllostachys aurea*)
Shoots: Joseph LaForest, University of Georgia, Bugwood.org
Leaves: Karan A. Rawlins, University of Georgia, Bugwood.org
Seedling; Branch: James H. Miller, USDA Forest Service, Bugwood.org
Plant: James R. Allison, Georgia Department of Natural Resources, Bugwood.org
Infestation: Chuck Bargeron, University of Georgia, Bugwood.org

Japanese Knotweed (*Fallopia japonica*)
Stem; Shoot; Flowers; Leaves: Environet
Mature Plant: MN Department of Agriculture
Infestation: Mary's River Watershed Council

Japanese Stilitgrass (*Microstegium vimineum*)
Leaf: Rutgers University
Stem: Bobby Hathaway
Flower: J.C. Neal, NS State Extension
Seedling: Nomad Seed Project
Infestation: Chris Evans, University of Illinois, Bugwood.org
Mature Plant: Richard Gardner, invasive.org

Johnson Grass (*Sorghum halepense*)
Main photo: Karan A. Rawlins, University of Georgia, Bugwood.org
Infestation: Nancy Loewenstein, Auburn University, Bugwood.org
Seeds: Barry Rice, sarracenia.com, Bugwood.org
Stem: James H. Miller, USDA Forest Service, Bugwood.org
Seedling: Howard F. Schwartz, Colorado State University, Bugwood.org
Leaf: Chris Evans, University of Illinois, Bugwood.org

Lesser Celandine (*Ficaria verna*)
Main photo; Fruit; Flower; Roots: Leslie J. Mehrhoff, UConn, Bugwood.org
Leaves: Rebekah D. Wallace, University of Georgia, Bugwood.org
Infestation: Richard Gardner, Bugwood.org

Musk Thistle (*Carduus nutans*)
Main photo: University of MN—Extenstion
Infestation: Vince Belleci, Bugwood.org
Flowers: Steve Dewey, Utah State University, Bugwood.org
Stem: Dan Tenaglia, Missouriplants.com, Bugwood.org
Stem with foliage: Mary Ellen (Mel) Harte, Bugwood.org
Basal rosette: Loke T. Kok, Virginia Polytechnic Institute and State University, Bugwood.org

Mugwort (*Artemisia vulgaris*)
Main photo: Robert Vidéki, Doronicum Kft., Bugwood.org
Infestation: UCONN.edu
Foliage; Flowers; Stem: Ohio State Weed Lab , The Ohio State University, Bugwood.org

Photo Credits (continued)

Palmer Amaranth (*Amaranthus palmeri*)
Seedling: Travis Legleiter, Purdue Weed Science
Flower: Eugene Sturla, Southwest Desert Flora
Leaves: Rebecca D. Wallance, University of Georgia, Bugwood.org
Mature Plant: University od California Agriculture and Natural Resources
Infestation; Stem: University of Tennessee Institute of Agriculture
Basal Rosette: Todd Pfeiffer, Klamath County Weed Control, Bugwood.org

Plumeless Thistle (*Carduus acanthoides*)
Flowers: Gary L. Piper, Washington State University, Bugwood.org
Foliage; Spines: Steve Dewey, Utah State University, Bugwood.org
Basal Rosette: Todd Pfeiffer, Klamath County Weed Control, Bugwood.org
Main photo: Marty Hudson, Klickitat County NWCB
Infestation: Minnesota Department of Agriculture

Purple Loosestrife (*Lythrum salicaria*)
Infestation: Richard Gardner, Bugwood.org
Main Photo; Seed; Leavess: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org
Flower: Shaun Winterton, Aquarium and Pond Plants of the World, Edition 3, USDA APHIS PPQ, Bugwood.org
Cone: David Cappaert, Bugwood.org

Shattercane (*Sorghum bicolor*)
All photos: University of Missouri Division of Plant Sciences

Wavyleaf Basketgrass (*Oplismenus hirtellus*)
Seedling: EDD Maps Virginia
Infestation; Foliage; Main photo; Flowers; Spikelets: Kerrie L. Kyde, Maryland Department of Natural Resources

Trees & Shrubs

Autumn Olive (*Elaeagnus umbellate*)
Flowers; Leaves: T. Davis Sydnor, The Ohio State University, Bugwood.org
Fruit: Emma Erler, University of New Hampshire, Bugwood.org
Branch: James H. Miller, USDA Forest Service, Bugwood.org
Main; Infestation: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Bush Honeysuckle (*Lonicera spp.*)
Infestation: Chris Evans, University of Illinois, Bugwood.org
Flowers: Massachusetts Audubon
Foliage; Stem; Main photo: Minnesota Department of Agriculture
Fruit: Wayne National Forest—USDA Forest Service

Callery Pear (*Pyrus calleryana*)
Leaves: Chuck Bargeron, University of Georgia, Bugwood.org
Stem; Fruit: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org
Bloom: Dan Tenaglia, Missouriplants.com, Bugwood.org
Flowering Callery Pear: James H. Miller, USDA Forest Service, Bugwood.org
Infestation: Midwest Drone Services LLC, Indystar.com

Photo Credits (continued)

Japanese Barberry (*Berberis thunbergii*)
Foliage: James H. Miller, USDA Forest Service, Bugwood.org
Main photo; Infestation; Flowers; Stem; Fruit: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Multiflora Rose (*Rosa multiflora*)
Fruit: David Cappaert, Bugwood.org
Leaves: Richard Gardner, Bugwood.org
Flowers: Ansel Oommen, Bugwood.org
Infestation: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org
Stem: Chris Evans, University of Illinois, Bugwood.org
Main Photo: Rob Routledge, Sault College, Bugwood.org

Norway Maple (*Acer platanoides*)
Leaves; Flowers: Jan Samanek, State Phytosanitary Administration
Seeds: Paul Wray, IA State Univ.
Infestation: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org
Bark; Main photo: Maine Natural Areas Program, Maine.gov

Russian Olive (*Elaeagnus angustifolia*)
Stem; Foliage with flowers; Bark: Patrick Breen, Oregon State University, Bugwood.org
Infestation: David J. Moorhead, University of Georgia, Bugwood.org
Fruit: Barry Rice, sarracenia.com, Bugwood.org
Main photo: Robert Vidéki, Doronicum Kft., Bugwood.org

Tree-of-Heaven (*Ailanthus altissima*)
Leaves: James H. Miller, USDA Forest Service, Bugwood.com
Bark; Seeds: Dave Jackson, Penn State Extension
Flower: Jan Samanek, Phytosanitary Administration, Bugwood.org
Infestation: Washington State Noxious Weed Control Board
Large tree: University of Minnesota Extension

Sweetgum (*Liquidambar styraciflua*)
Seedling: Jeff McMillian. Provided by Almost Eden
Fruit; Main photo: NC State Extension
Infestation: Oregon State University
Foliage; Bark: J.S. Peterson. USDA NRCS National Plant Data Center (NPDC). United States, DC, Washington, USDA ARS National Arboretum.

While Mulberry (*Morus alba*)
Infestation: Gardenia.net
Main Photo: Jenny Glenn, iNaturalist
Fruit; Stem; Flowers; Foliage: NC State Extension

Vines

English Ivy (*Hedera helix*)
Fruits; Flowers: Forest and Kim Starr, Starr Environmental, Bugwood.org
Stem; Leaves: James H. Miller, USDA Forest Service, Bugwood.org
Infestation: Chris Evans, University of Illinois, Bugwood.org
Main Photo: Chuck Bargeron, University of Georgia, Bugwood.org

Photo Credits (continued)

Japanese Honeysuckle (*Lonicera japonica*)
Vine: James H. Miller, USDA Forest Service, Bugwood.org
Main photo: Chris Evans, University of Illinois, Bugwood.org
Infestation; Fruit; Flowers; Foliage: Chuck Bargeron, University of Georgia, Bugwood.org

Japanese Hops (*Humulus japonicus*)
Seeds: Carole Ritchie, USDA NRCS PLANTS Database, Bugwood.org
Infestation; Flower: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org
Main photo; Vine; Foliage: Chris Evans, University of Illinois, Bugwood.org

Kudzu (*Pueraria montana*)
Vine; Foliage; Fruit/Seeds: James H. Miller, USDA Forest Service, Bugwood.org
Infestation: Robert L. Anderson, USDA Forest Service, Bugwood.org
Flower: NC State Extension
Main Photo: David J. Moorhead, University of Georgia, Bugwood.org

Mile-a-minute (*Persicaria perfoliata)*
Fruit: Kate St. John, birdoutsidemywindow.org
Vine: Westport News, Connecticut
Leaves: Elizabeth J. Czarapata, Wisconsin Department of Natural Resources
Thorns: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org
Infestation: Alyssa Coleman, Lower Hudson PRISM
Plant: Robert Hartzler, Iowa State Univeristy Extension

Oriental Bittersweet (*Celastrus orbiculatus*)
Leaves: James H. Miller, USDA Forest Service, Bugwood.org
Fruit: Ansel Oommen, Bugwood.org
Vine; Plant: Richard Gardner, Bugwood.org
Flower: University of Minnesota Extension
Infestation: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Porcelain Berry (*Ampelopsis brevipedunculata*)
Seedling; Infestation; Bark: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org
Fruit; Leaves: James H. Miller, USDA Forest Service, Bugwood.org
Plant: Massachusetts Audubon

Wisteria (*Wisteria sinensis; Wisteria floribunda*)
Infestation: James R. Allison, Georgia Department of Natural Resources
Leaves: Kerrie Kyde, MD DNR
Flowers: Ecosystem Gardening
Plant; Chinese Vine: Chris Evans, University of Illinois, Bugwood.org
Japanese Vine: Michael Ellis, M-NCPPC

Non-Plant Species

Emerald Ash Boerer (*Agrilus planipennis*)
Damage: Elizabeth McCarty, University of Georgia, Bugwood.org
Eggs, Main photo: David Cappaert, Bugwood.org
Adult: Brian Sullivan, USDA APHIS PPQ, Bugwood.org
Infestation: LaCrosse Tribune

Photo Credits (continued)

Gypsy Moth (*Lymantria dispar dispar*)
Main photo; Pupae; Adults: USDA APHIS PPQ , USDA APHIS PPQ, Bugwood.org
Larvae: Jon Yuschock, Bugwood.org
Eggs: Karla Salp, Washington State Department of Agriculture, Bugwood.org
Infestation: University of Kentucky Entomology

Snakehead (*Channa argus*)
Full body: Cornell Cooperative Extension
Head/Teeth: Bay Weekly
Teeth profile: Chesapeake Bay Program
Adult: Arkansas Game and Fish Commission , Bugwood.org
Immature: USGS , US Geological Survey, Bugwood.org
Infestation: iNaturalist CC-BY-NC

Spotted Lanternfly (*Lycorma delicatula*)
Identification: Pennsylvania Department of Agriculture
Infestation; Egg mass; Early nymph; Late nymph, Adult: Penn State Extension

Aquatic Species

Eurasian Milfoil (*Myriophyllum spicatum*)
Infestation: Leslie J. Mehrhoff, UConn, Bugwood.org
Main: Alison Fox, University of Florida, Bugwood.org
Leaves: Graves Lovell, Alabama Department of Conservation and Natural Resources, Bugwood.org
Sample: Bruce Ackley, The Ohio State University, Bugwood.org
Flower: Shaun Winterton, Aquarium and Pond Plants of the World, Edition 3, USDA APHIS PPQ, Bugwood.org

Hydrilla (*Hydrilla verticillata*)
Main photo; Infestation; UConn, Bugwood.org
Flower; Leaves; Rhizomes: Shaun Winterton, Aquarium and Pond Plants of the World, Edition 3, USDA APHIS PPQ, Bug wood.org
Plant head: Tim Krynak, Cleveland Metroparks, Bugwood.org

Water Chestnut (*Eleocharis dulcis*)
Infestation; Fruit; Flower: Leslie J. Mehrhoff, UConn, Bugwood.org
Leaves: Mike Naylor, MD DNR
Petioles; Main photo: oars3rivers.org

Water Hyacinth (*Eichhornia crassipes*)
Main photo: Shaun Winterton, Aquarium and Pond Plants of the World, Edition 3, USDA APHIS PPQ, Bugwood.org
Leaves: Flower; Petiole; Seedling: Leslie J. Mehrhoff, UConn, Bugwood.org
Infestation: James R. Holland, Bugwood.org

References

Arbor Day Foundation. Emerald Ash Borer. Available: https://www.arborday.org/trees/health/pests/emerald-ash-borer.cfm

Bargeron, CT. Golden Bamboo. Golden Bamboo - Southeast Exotic Pest Plant Council Invasive Plant Manual. Available: https://www.se-eppc.org/manual/PHAU1.html

BioAdvanced. Controlling Emerald Ash Borers to Protect Ash Trees. Availabile: https://www.bioadvanced.com/articles/controlling-emerald-ash-borers-protect-ash-trees

Blue Ride Partnership for Regional Invasive Species Management. Herbicide Basics. 2018. Available: https://blueridgeprism.org/wp-content/uploads/2018/04/Herbicide-Basics-Factsheet-4-25-18-FINAL.pdf

Byrd, J. & Maddox, V. (2019) Callery Pear. Mississippi State University Extension. Available: http://extension.msstate.edu/sites/default/files/publications/publications/P3316_web.pdf

Carignan, C. 2018. Bradford Pear. University of Maryland Extension. Available: https://extension.umd.edu/hgic/topics/bradford-pear

Carignan C. (2018) Chinese and Japanese Wisteria. University of Maryland Extension. Available: https://extension.umd.edu/hgic/topics/chinese-and-japanese-wisteria

Carignan C. & Ricigliano D. 2018. Autumn Olive. University of Maryland Extension. Available: https://extension.umd.edu/hgic/topics/autumn-olive

Carignan C. & Ricigliano D. (2018). English Ivy. University of Maryland Extension. Available: https://extension.umd.edu/hgic/topics/english-ivy

Carroll, J., Mattoon, N., & Eshenaur, B. Invasive Species & Exotic Pests: Spotted Lanternfly. New York State Integrated Pest Management Program, Cornell University. Available: https://ecommons.cornell.edu/bitstream/handle/1813/60603.2/spotted-lanternfly-NYSIPM.pdf?sequence=6&isAllowed=y

Center for Invasive Species and Ecosystem Health. 2010. Japanese Barberry. Available: https://www.invasive.org/alien/pubs/midatlantic/beth.htm

Center for Invasive Species and Ecosystem Health. 2010. Japanese Honeysuckle. Available: https://www.invasive.org/alien/pubs/midatlantic/loja.htm

Center for Invasive Species and Ecosystem Health. 2010. Japanese Hops. Available: https://www.invasive.org/alien/pubs/midatlantic/huja.htm

Center for Invasive Species and Ecosystem Health. 2010. Wavyleaf Basketgrass. Available: https://www.invasive.org/alien/pubs/midatlantic/ophiu.htm

Chesapeake Bay Programs. Northern Snakehead. Available: https://www.chesapeakebay.net/S=0/fieldguide/critter/northern_snakehead

Chesapeake Bay Program. Spotted Lanternfly. Available: https://www.chesapeakebay.net/discover/field-guide/entry/spotted_lanternfly

Coladonato, M. 1992. Liquidambar styraciflua. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available: https://www.fs.fed.us/database/feis/plants/tree/liqsty/all.html

Colorado State Parks. 2005. Weed Profile: Musk Thistle. Available: https://cpw.state.co.us/Documents/ResourceStewardship/MuskThistle.pdf

Cully, T. & Hardiman, N. 2007. The Beginning of a New Invasive Plant: A History of the Ornamental Callery Pear in the United States, *BioScience*, Volume 57, Issue 11, December 2007, Pages 956–964, https://doi.org/10.1641/B571108

Davey Tree Service. 2016. Does Emerald Ash Borer Treatment Work? Tree Care Tips, News and Checklists. Available: https://blog.davey.com/2016/03/does-emerald-ash-borer-treatment-work/

Ecological Landscape Alliance. 2012. Japanese Barberry: An Exotic Invasive Plant Fact Sheet. Available: https://www.ecolandscaping.org/11/landscape-challenges/invasive-plants/japanese-barberry-exotic-invasive-plant-fact-sheet/

Enloe, SF., Manning, ST., & Miller, JH. (2010) A Management Guide for Invasive Plants in Southern Forests. Southern Research Station, Insect, Disease, and Invasive Plants Research Work Unit, and Forest Health Protection. Available: https://www.forestpests.org/pdf/A%20Management%20Guide%20for%20Invasive%20Plants%20in%20Southern%20Forests.pdf

References (continued)

Fryer, J. (2011) Celastrus orbiculatus. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available: https://www.fs.fed.us /database/feis/plants/vine/celorb/all.html

Gassmann, A. & Kok, L.T. 2018. University of Georgia—Center for Invasive Species and Ecosystem Health. Bull Thistle (Spear Thistle). Available: https://www.invasive.org/biocontrol/19BullThistle.cfm

Gover, A., & Jackson, D. 2018. PennState Extension. Tree-of-heaven (Ailanthus altissima). Available: https://extension.psu.edu/tree-of-heaven

Gucker, CL. 2009. Phyllostachys aurea. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory.

Hartzler B. Palmer amaranth: ID, biology and management. Palmer amaranth: ID, biology and management | Integrated Crop Management. Available: https://crops.extension.iastate.edu/encyclopedia/palmer-amaranth-id-biology-and-management

Howard, J. 2004. Sorghum halepense. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available: https://www.fs.fed.us /database/feis/plants/graminoid/sorhal/all.html.

Illinois Wildflowers. Water Hemp. Available: https://www.illinoiswildflowers.info/weeds/plants/water_hemp.htm

iNaturalist. White Mulberry. Available: https://www.inaturalist.org/guide_taxa/354710

Invasive Plant Atlas of the United States. 2018. White Mulberry. Available: https://www.invasiveplantatlas.org/subject.html?sub=6050

Jacono, C.C., M.M. Richerson, V. Howard, E. Baker, C. Stottlemyer, J. Li, P. Alsip, and E. Lower. 2021. Eichhornia crassipes (Mart.) Solms: U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, FL, and NOAA Great Lakes Aquatic Nonindigenous Species Information System, Ann Arbor, MI, https://nas.er.usgs.gov/queries/greatlakes/FactSheet.aspx?SpeciesID=11&Potential=Y&Type=2&HUCNumber,

Jacono, C.C., Richerson, M.M., Howard Morgan, V., and Pfingsten, I.A. 2021. Hydrilla verticillata (L.f.) Royle: U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, FL, https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=6

Jefferson County Noxious Weed Control Board. Canada Thistle Fact Sheet. Available: https://www.nwcb.wa.gov/images/weeds/CanadaThistle_Jefferson.pdf

King County. 2021. Bull Thistle identification and control. Available: https://www.kingcounty.gov/services/environment/animals-and-plants/noxious-weeds/weed-identification/bull-thistle.aspx#:~:text=Bull%20thistle%20is%20a%20widespread,now%20introduced%20throughout%20North%20America.&text=Bull%20thistle%20is%20also%20commonly,trails%2C%20roads%20and%20vacant%20fields.

Korres, NE. & Norsworthy, JK. (2017) Palmer Amaranth (Amaranthus palmeri) Demographic and Biological Characteristics in Wide-Row Soybean, Weed Science, 65(4), 491-503
Leach, H., Korman, A., Biddinger, D., & Krawczyk, G. (2020) Spotted Lanternfly Management for Homeowners. Penn State Extension. Available: https://www.citationmachine.net/bibliographies/b5cb5f49-75be-49ce-beb9-ccda840763a8

Maine Department of Agriculture, Conservation and Forestry. 2019. Norway Maple. Available: https://www.maine.gov/dacf/mnap/features/invasive_plants/acerplat.htm

Manuchehri, M. & Rocateli, A. 2017. Oklahoma State University Extension. Johnsongrass in Pastures: Weed or Forage? Available: https://extension.okstate.edu/fact-sheets/johnsongrass-in-pastures-weed-or-forage.html

Maryland Department of Agriculture. Pesticide Information Sheet. Available: https://mda.maryland.gov/plants-pests/Documents/bmp.pdf

Maryland Department of Agriculture Ag Brief Pesticide Regulation. 2013. Available: https://mda.maryland.gov/Documents/ag_brief/AgBrief_PesticideReg.pdf

Maryland Department of Natural Resources. Aquatic Invasive Species: Water Chestnut. Available: https://dnr.maryland.gov/waters/bay/Pages/Water-Chestnut.aspx

Mason County Noxious Weed Control Board Weed Alert. 2007. Giant Hogweed. Available: https://www.nwcb.wa.gov/images/weeds/Giant-Hogweed_Mason.pdf

References (continued)

Minnestoa Department of Agriculture. 2021. Japanese Hops. Available: https://www.mda.state.mn.us/plants/pestmanagement/weedcontrol/noxiouslist/japanesehops

Minnesota Department of Agriculture. 2021. Palmer Amaranth. Available: https://www.mda.state.mn.us/plants/pestmanagement/weedcontrol/noxiouslist/palmeramaranth

Missouri Department of Conservation. Bush Honeysuckles. Available: https://nature.mdc.mo.gov/discover-nature/field-guide/bush-honeysuckles

Missouri Department of Conservation Invasive Species Coordinator. (2018) Callery Pear. Missouri Department of Conservation. Available: https://mdc.mo.gov/sites/default/files/downloads/callerypearinvasive.pdf#:~:text='%20Native%20to%20China%2C%20it%20was,many%20other%20cultivars%20were%20developed.

National Park Service (2018) Invasive Species Factsheet: Wavyleaf basketgrass. Available: https://www.nps.gov/orgs/1103/upload/FactSheet_WavyLeafBasketgrass.pdf

NC State Extension. Eupatorium capillifolium (Dogfennel, Dog Fennel) | North Carolina Extension Gardener Plant Toolbox. Available: https://plants.ces.ncsu.edu/plants/eupatorium-capillifolium/

New Hampshire Department of Agriculture. Japanese Knotweed Fact Sheet. Available: https://www.agriculture.nh.gov/publications-forms/documents/japanese-knotweed.pdf

New York Invasive Species (IS) Information. 2019. Common Reed. Available: http://nyis.info/invasive_species/common-reed/

New York Invasive Species (IS) Information. 2019. Eurasian Watermilfoil. Available: http://nyis.info/invasive_species/eurasian-watermilfoil/

New York Invasive Species (IS) Information. 2019. Hydrilla. Available: http://nyis.info/invasive_species/hydrilla/

New York Invasive Species (IS) Information. Japanese Stiltgrass. Available: http://nyis.info/invasive_species/japanese-stiltgrass/

New York Invasive Species (IS) Information. Kudzu. Available: http://nyis.info/invasive_species/kudzu/#:~:text=Kudzu%20(Pueraria%20montana)%20is%20a,member%20of%20the%20bean%20family.

New York Invasive Species (IS) Information. 2019. Lesser Celandine. Available: http://nyis.info/invasive_species/lesser-celandine/

New York Invasive Species (IS) Information. Mile-a-minute. 2019 Jul. Available: . http://nyis.info/invasive_species/mile-a-minute/

New York Invasive Species (IS) Information. 2019. Mugwort. Available: http://nyis.info/invasive_species/mugwort-draft/

New York Invasive Species (IS) Information. 2019. Norway Maple. Available: http://nyis.info/invasive_species/norway-maple/

New York Invasive Species (IS) Information. 2019. Purple Loosestrife. Available: http://nyis.info/invasive_species/purple-loosestrife/

New York Invasive Species (IS) Information. 2019. Water Chestnut. Available: http://nyis.info/invasive_species/water-chestnut/

New York State Department of Environmental Conservation. (2020). Gypsy Moth. Available: https://www.dec.ny.gov/animals/83118.html

Nuzzo, V. (2013) Cirsium arvense. Global Invasive Species Team, The Nature Conservancy . Available: https://wiki.bugwood.org/Cirsium_arvense#Management_Programs

OFAH/OMNRF Invading Species Awareness Program. (2012). Japanese Knotweed. Available: http://www.invadingspecies.com/japanese-knotweed/

Rickel C. Phyllostachys aurea (golden bamboo). CABI: Invasive Species Compendium. Available: https://www.cabi.org/isc/datasheet/42072

Ohio State University. OARDC Ohio Perennial and Biennial Weed Guide: Johnsongrass (Sorghum halepense). Available: https://www.oardc.ohio-state.edu/weedguide/single_weed.php?id=62

Ontario Ministry of Agriculture, Food, and Rural Affairs. 2016. Waterhemp, Common. Available: http://www.omafra.gov.on.ca/english/crops/field/weeds/common_waterhemp.htm#life

PennLive. 2019. Pennsylvania's official noxious weed: Giant Hogweed to waterhemp. Available: https://www.pennlive.com/wildaboutpa/2018/07/pennsylvanias_official_noxious.html

References (continued)

Pennsylvania Department of Conservation and Natural Resources. Musk thistle. Available: http://elibrary.dcnr.pa.gov/GetDocument?docId=1738704&DocName=musk%20thistle.pdf

Pennsylvania Department of Conservation and Natural Resources. Oriental Bittersweet. Available: http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_010240.pdf

Petrovic, K. 2020. Growing Produce. Field Scouting Guide: Waterhemp. Available: https://www.growingproduce.com/vegetables/field-scouting-guide-waterhemp/#:~:text=The%20greatest%20impact%20from%20waterhemp,yield%20and%20quality%20at%20harvest

Pfingsten, I.A., L. Berent, C.C. Jacono, and M.M. Richerson. 2021. Myriophyllum spicatum L.: U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, FL. https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=237

Plant Conservation Alliance. 2005. Fact Sheet: Garlic Mustard. Available: https://www.invasive.org/weedcd/pdfs/wgw/garlicmustard.pdf

Remaley, T. (2005). Exotic Wisterias. Plant Conservation Alliance's Alien Plant Working Group . Available: https://www.invasive.org/weedcd/pdfs/wgw/exoticwisterias.pdf

Stone, KR. 2009. Morus alba. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available: https://www.fs.fed.us/database/feis/plants/tree/moralb/all.htm

Stone, KR. 2010. Polygonum sachalinense, P. cuspidatum, P. × bohemicum. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available: https://www.fs.fed.us/database/feis/plants/forb/polspp/all.html

Swearingen, J., K. Reshetiloff, B. Slattery, and S. Zwicker. 2002. Plant Invaders of Mid-Atlantic Natural Areas. National Park Service and U.S. Fish & Wildlife Service, 82 pp.

The Allegheny Front. 2014. Goats Eat Up the Invasives. Goats Eat Up the Invasives. Available: http://archive.alleghenyfront.org/story/goats-eat-invasives.html

United States Federal Aquatic Nuisance Species Task Force. (2011) Northern Snakehead. https://www.anstaskforce.gov/spoc/snakehead.php

University of Maryland Extension Home and Garden Information Center. Japanese Stiltgrass. Available: https://extension.umd.edu/hgic/topics/japanese-stiltgrass

University of Maryland Extension Home and Garden Information Center. Lawn Herbicide Terms. Available: https://extension.umd.edu/hgic/topics/lawn-herbicide-terms

University of Minnesota. 2020. Non-Native Phragmites management recommendations. Available: https://www.maisrc.umn.edu/phrag-management

University of Missouri—Division of Plant Sciences. 2020. Shattercane. Available: https://weedid.missouri.edu/weedinfo.cfm?weed_id=315

USDA APHIS. Emerald Ash Borer. 2020. Available: https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/emerald-ash-borer

USDA Invasive Species Information Center. Northern Snakehead. Spotted Lanternfly. Available: https://www.invasivespeciesinfo.gov/profile/northern-snakehead

USDA Invasive Species Information Center. Spotted Lanternfly. Spotted Lanternfly. Available: https://www.invasivespeciesinfo.gov/profile/spotted-lanternfly

USDA Forest Service, Forest Health Staff. (2005) Callery Pear/Bradford Pear. USDA Forest Service. Available: https://www.invasive.org/weedcd/pdfs/wow/callery_pear.pdf

USDA Forest Service, Forest Health Staff. (2015) Oriental Bittwersweet. USDA Forest Service. Available: https://www.invasive.org/weedcd/pdfs/wow/oriental-bittersweet.pdf

USDA Forest Service, Forest Health Staff. (2006) Porcelain Berry. USDA Forest Service. Available: https://www.invasive.org/weedcd/pdfs/wow/porcelain-berry.pdf

USDA Forest Service, Northeastern Research Station. (2015). Gypsy Moth. Available: https://www.nrs.fs.fed.us/disturbance/invasive_species/gm/effects_impacts/

References (continued)

USDA NRCS. 2019. Russian Olive. Available: https://www.nrcs.usda.gov/wps/cmis_proxy/https/ecm.nrcs.usda.gov%3A443/fncmis/resources/WEBP/ContentStream/idd_A061986A-0000-CA12-8170-F5ABF8772E46/0/RussianOliveFactSheet.pdf

USDA NRCS National Plant Materials Center. Sweetgum. Available: https://plants.usda.gov/factsheet/pdf/fs_list2.pdf

Van Deelen, TR. 1991. Eupatorium capillifolium. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available: https://www.fs.fed.us/database/feis/plants/forb/eupcap/all.html

Virginia Native Plant Society. (2014) Wavyleaf Basketgrass: Help Stop it Now! Available: https://vnps.org/wavyleaf-basketgrass-help-stop-now/

Waggy, M 2010. Hedera helix. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available: https://www.fs.fed.us /database/feis/plants/vine/hedhel/all.html

Ward, B. Timing Critical to Controlling Thistle and Dogfennel. UGA Extension. Available: https://site.extension.uga.edu/spring-creek/files/2016/02/Thistle-and-Dogfennel-Control.pdf

Waterworth K. Managing Dogfennel Weeds: Learn About Controlling Dogfennel Plants. Gardening Know How. Available: https://www.gardeningknowhow.com/plant-problems/weeds/controlling-dogfennel-plants.htm

Washington State Noxious Weed Control. Japanese Knotweed. Available: https://www.nwcb.wa.gov/weeds/japanese-knotweed

Washington State Noxious Weed Control Board. Plumeless Thistle. Available: https://www.nwcb.wa.gov/weeds/plumeless-thistle

Wenning B. (2012) Multiflora Rosa: An Exotic Invasive Plant Fact Sheet. Ecological Landscape Alliance. Available: https://www.ecolandscaping.org/07/landscape-challenges/invasive-plants/multiflora-rose-an-exotic-invasive-plant-fact-sheet/

Western New York PRISM. Mugwort. Available: https://www.wnyprism.org/invasive_species/mugwort/

Wisconsin Department of Natural Resources. Invasives. Lesser Celandine. Available: https://dnr.wisconsin.gov/topic/Invasives/fact/LesserCelandine.html#:~:text=Leaves%20%26%20stems%3A%20Leaves%20are%20dark,arranged%20around%20a%20central%20disk.

Wisconsin Department of Natural Resources. 2009. Invasive Exotic Shrub Honeysuckles. Available: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3830307.pdf

Wisconsin Department of Natural Resources. 2019. Porcelain berry (Ampelopsis brevipedunculata). Available: https://dnr.wi.gov/topic/Invasives/fact/PorcelainBerry.html

Zouhar, K. 2005. Elaeagnus angustifolia. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available: https://www.fs.fed.us/database/feis/plants/tree/elaang/all.html

Index

Species Ordered by Common Name

Index

Species Ordered by Scientific Name