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Invasive Plant Responses to Silvicultural Practices in the South

C. W. Evans, D. J. Moorhead, C. T. Bargeron and G. K. Douce

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The authors dedicate this publication to the memory of Dr. Larry Nelson (1950-2006). Larry recognized the problems posed by invasive plants in our forested, agricultural and urban landscapes and was proactive in developing research and outreach programs. Through his efforts countless professional foresters, natural resource managers, students, and the public, across the South, developed an awareness of invasive plant management. We hope this publication can serve to further his work.

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How to use this guide

This guide is intended to aid foresters and managers in the southeastern United States in developing management plans and managing forests threatened by invasive plants. This guide integrates identification of invasive plants, potential mechanisms for spread (natural seed or vegetative production, or human induced spread by cultural practices) and a suite of silvicultural management/control practices. The first section of the guide includes simple descriptions of common silvicultural practices and how they alter the habitat. General guidelines for reducing the risk and impact of invasive plants are included in a bulleted list format. Profiles for thirteen common invasive plants give detailed information on identification and ecology as well as how they are expected to respond to the habitat alterations resulting from silvicultural practices. Quick reference tables summarizing the information in this book and allow the user to quickly find information and recommendations for each of these common invasive plant species are included in the back of this publication.

Pesticide Precautionary Statement

Pesticides used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all label precautions.

Store pesticides in the original containers under lock and key—out of reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honeybees or other pollinating insects are visiting plants, or in ways that may contaminate or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dust; wear protective clothing and equipment if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed them. If a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly and in accordance with all applicable Federal, State, and local laws.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S. Environmental Protection Agency, consult your State forestry agency, county agricultural agent or State extension specialist to be sure the intended use is still registered.

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Invasive Plant Responses to Silvicultural Practices in the South

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Executive Summary

Many forest managers are unknowingly introducing and spreading invasive plants on their lands through management practices they implement. These practices, ranging from traditional silvicultural management to wildlife enhancement and land-use conversion practices, all influence invasive plant growth, reproduction, and dispersal. Recognizing and predicting the response of individual species to these practices will enable managers to take steps to prevent or reduce the impact of invasive plants on their land. Many of these species eliminate all productive uses on infested sites and are very expensive to control and/or eradicate. Knowing which invasive plants are common in your region and being able to identify them aids in quickly responding to new threats. Monitoring disturbed areas and proper sanitation of equipment helps prevent new infestations. Issues such as when and how to use prescribed fire and how different invasive plants will respond can be confusing and overwhelming. This publication integrates vegetation management guidelines and control techniques with silvicultural practices, such as prescribed fire, harvest techniques, site preparation, timber stand improvement, and wildlife plantings, in a format that will help the manager understand the relationship of management practices and invasive plants.

General Principles to Reduce the Impact of Invasive Plants

1. Learn to identify invasive plants and incorporate their management into any land-use plan.
2. Prevent introduction of invasive plants to uninfested sites: This critical component is one of the most cost-effective methods of management.
3. Contain and treat new invasive plants or those not yet well established: Controlling small infestations is more effective and economical than trying to control well-established, rapidly spreading infestations.
4. Minimize transport of invasive plants from infested to uninfested areas: Cleaning vehicles and equipment is the most effective method of prevention.
5. Minimize soil disturbance: Invasive plants often prefer disturbed ground, don't disturb soil unless it is necessary.
6. Maintain desirable species: Establishing and maintaining competitive, desirable plants along roadsides and disturbed areas prevents or slows establishment of invasive plants.

Keywords: Silviculture, invasive plants, sanitation, monitoring, herbicides, management, disturbance

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Section I: Management Practices

Harvest Activities

Harvest activities include practices in which trees are harvested, such as regeneration cuts (for example, shelterwood, seed tree, and group selection), thinning operations, or clear cuts.

Habitat Alterations:

- Soil disturbance
- Increased light to understory or forest floor
- Mechanical damage
- Use of off-site equipment

Figure 1 - Skidding can spread invasives across the harvest tract.

Prescribed Fire

Prescribed fire is the practice of using fire, intentionally set, to obtain certain management objectives. Often prescribed fire is used to inhibit establishment of undesirable species or to set back succession. The use of prescribed fire also includes creation and maintenance of fire breaks.

Habitat Alterations:

- Creation of bare soil
- Initial release of nutrients
- Kill or top kill of under and mid-story vegetation
- Increased light to understory or forest floor
- Soil disturbance (fire breaks)
- Use of off-site equipment

Figure 2 - Prescribed fire can be used to control certain invasive species and spread others.

Internal Road Construction

Roads are often built within a parcel of land to enable the owner/manager to move equipment and reach remote areas. Included within this category is the creation and maintenance of internal roads and stream crossings.

Habitat Alterations:

- Soil disturbance
- Increased light to understory or forest floor
- Open canopy
- Off-site material
- Use of off-site equipment
- Mechanical damage (Limited after initial creation)
- Potential wetland disturbance

Figure 3 - Road construction introduces off-site materials which may contain invasives.

Figure 4 - Straw mulch may harbor seeds of invasive plants

Mechanical Site Preparation

The practice of site preparation (or site prep) manipulates the ground layer to achieve a better microclimate for seedling establishment and growth. Site prep often follows a clearcut treatment and precedes planting. Common mechanical site prep treatments are: bedding, chopping, and disking.

Habitat Alterations:

- Exposes bare mineral soil
- Increased light to understory or forest floor
- Use of off-site equipment
- Removal of native vegetation
- Damage and alteration to root zone (compaction, rutting, drainage)

Figure 5 - Site preparation creates bare soil and high light environment conducive to invasive establishment and spread.

Tree Planting

Tree planting includes the practices involved in planting of seedlings. Seed bed preparation treatments, such as scalping and sub-soiling, and seedling planting are included within this category.

Habitat Alterations:

- Soil disturbance
- Mechanical damage
- Use of off-site equipment
- Off-site material

Figure 6 - Tree planting equipment may harbor invasive seeds or plant material.

Release Treatments (Intermediate Treatments)

Release treatments are used to free small trees from competition from undesirable vegetation. Treatments include herbicide, mowing, cutting, and fire.

Habitat Alterations:

- Increased light to understory or forest floor
- Midstory removal/thinning
- Understory damage/disturbance
- Soil disturbance

Figure 7 - This scalper could carry plant roots and rhizomes across sites.

Figure 8 - Release treatments create high light environments condusive to establishment of invasives.

Special Considerations

Pine Straw Production

Many pine stands are managed for pine straw production. The needles that are naturally shed from pine trees are raked, baled, and sold as pine straw mulch. Pine straw production involves managing stands for optimum straw production, removing understory vegetation with herbicide and/or fire, collecting (raking) the straw, and making bales. Often practices such as prescribed fire, mowing, and herbicide treatments are used in production areas. Stand alterations include soil disturbance, removal of understory and midstory, and increased light to the forest floor. ***Bales and equipment from infested stands can foster the widespread distribution of invasive plants.***

Figure 9 - Pine straw production

Wildlife Enhancement

Wildlife enhancement involves any practice that can improve or enhance the wildlife habitat on a land, such as food plot installation, fertilization, and selective thinning and planting. This is a varied category but can include aspects of other silvicultural practices. ***Wildlife enhancement practices are a common avenue for invasive plant introductions, either via contaminated equipment or intentional planting.*** Areas to monitor for any invasive plants are camps, food plots, and other areas used.


Figure 10 - Wildlife food plot

Streamside Management Zones (SMZ)

These areas are protected because of water quality and erosion concerns. ***They can be refuges for invasive plants which can spread into adjacent lands.*** Since SMZs are adjacent to drainages, streams, or rivers, invasive plants that favor wet areas, streamsides, or bottomlands are likely to be present.

Figure 11 - Forest stream

Land Use Conversion

This category covers practices used when converting lands previously under cultivated agriculture or pasture into trees. A different suite of invasive plants can become problems in areas undergoing land use conversion. Established invasive plant populations or viable seedbanks may exist in agricultural fields or pastures. Fencerows may serve as a harbor for these invasives. ***A plant that was a minor pest in the previous land use may not be inhibited by the current management practices and suddenly expand its population drastically.***

Figure12 - Newly planted pine stand invaded by kudzu

Section II: General Guidelines for Risk Reduction

Early Detection Through Monitoring

- Monitor disturbed habitats for newly established invasive plants.
- Sites to monitor include food plots, cut-over lands, roadsides, stream sides, recently flooded areas, storm damaged areas, internal roads and trails, firebreaks, burned areas rights-of-way, and fencerows.
- Mark known infestations on a map and flag them in field for easy re-location.
- Search the surrounding areas for any "satellite" infestations and mark them as well.

Figure13 - Harvest tract with SMZs and fencerows

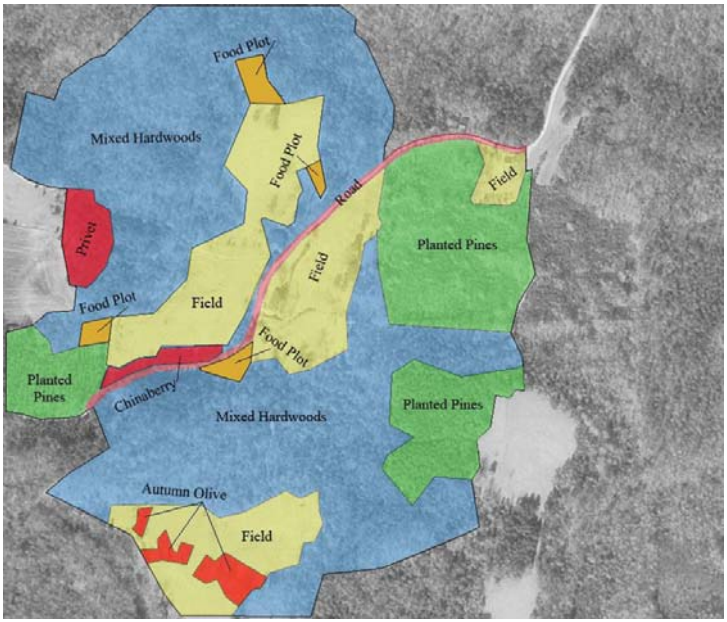


Figure14 - Resource map showing land-use and invasive plant infestations

Best Management Practices for Activities Involving Soil Disturbance

- Before starting ground-disturbing activities, inventory invasive plant infestations both on-site and in the adjacent area.
- Begin activities in uninfested areas before operating in infested areas.
- Use uninfested areas for staging, parking and cleaning equipment. Avoid or minimize all types of travel through infested areas, or restrict to those periods when spread of seed or propagules are least likely.
- When possible, to suppress growth of invasive plants and prevent their establishment, retain relatively closed canopies.
- Minimize soil disturbance and retain desirable vegetation in and around area to the maximum extent possible.
- Monitor infested areas for at least three growing seasons following completion of activities. Provide for follow-up treatments based on inspection results.
- Do not blade roads or pull ditches where new invaders are found, if possible.
- When it is necessary to conduct soil work in infested roadsides or ditches, schedule activity when seeds or propagules are least likely to be viable and to be spread.
- Quarantine soil from infested area to prevent off-site spread.

Figure 15 - Fire break


Figure 16 - Road maintainence

Best Management Practices Involving Off-site Material and Equipment

- Invasive plants can be introduced and spread by moving infested equipment, sand, gravel, borrow, fill and other off-site material.
- Determine the need and identify sites where equipment can be cleaned. Seeds and plant parts need to be collected when practical and incinerated. Remove mud, dirt, and plant parts from project equipment before moving it into a project area and clean all equipment before leaving the project site, if operating in infested areas.
- Inspect material sources at site of origin to ensure that they are free of invasive plant material before use and transport. Treat infested sources for eradication, and strip and stockpile contaminated material before any use.
- Inspect and document the area where material from treated infested sources is used annually for at least three years after project completion to ensure that any invasive plants transported to the site are promptly detected and controlled.
- Maintain stockpiled, uninfested material in a weed-free condition.
- Incorporate invasive plant prevention into road work layout, design, and decisions.
- Minimize roadside sources of seed that could be transported to other areas.
- Periodically inspect system roads and rights-of-way for invasion. Inventory and mark infestations and schedule them for treatment.
- Avoid working in infested areas if possible. Postpone work until invasive plants have been eliminated from the site.
- Perform road maintenance such as road grading, brushing, and ditch cleaning from uninfested to infested areas to help prevent moving seeds and plant material from infested areas into adjacent uninfested areas.
- Clean road graders and other equipment immediately after operating in infested areas. Clean all dirt and plant parts from the top and underside of mower decks.

Figure 17 - Food plot equipment with plant material that can be transported to other sites

Figure 18 - Cogongrass seeds on radiator screen

Best Management Practices for Re-Vegetation

- Re-vegetate all disturbed soil, except on surfaced roads, in a manner that optimizes plant establishment for that specific site, unless ongoing disturbance at the site will prevent establishment of invasive plants.
- Use local seeding guidelines and appropriate mixes, but realize that many species previously recommended for this purpose are now presenting invasive problems.. Use native material where appropriate and available. Re-vegetation may include planting, seeding, fertilization, and mulching.
- Monitor and evaluate success of re-vegetation in relation to project plan.
- When re-vegetating areas that were previously dominated by invasive plants, try to achieve at least 90% control of the invasive before attempting restoration.

Figure 19 - Applying mulch for soil stabilization

Figure 20 - Seeding

Figure 21 - Native longleaf wiregrass stand

Invasive Plants of Concern in Forested Landscapes in the South

Across the South, foresters and resource managers can encounter numerous invasive plants that can impact silvicultural practices and management goals. The following is a list of common invasive plants in the South. This publications highlights and provides information on the response of thirteen invasive plants to common silvicultural practices (highlighted in bold).

Trees

Tree of Heaven - *Ailanthus altissima*
Mimosa, Silktree - *Albizia julibrissin*
Paper mulberry - *Broussonetia papyrifera*
Russian Olive - *Elaeagnus angustifolia*
Chinaberrytree - *Melia azedarach*
Paulownia, Princesstree - *Paulownia tomentosa*
Tallow tree - *Triadica sebifera*

Shrubs

Thorny Olive - *Elaeagnus pungens*
Autumn Olive - *Elaeagnus umbellata*
Winged Burning Bush - *Euonymus alata*
Privet - *Ligustrum* spp.
Bush Honeysuckles - *Lonicera* spp.
Nandina - *Nandina domestica*
Multiflora rose - *Rosa multiflora*

Vines

Oriental Bittersweet - *Celastrus orbiculatus*
Purple crownvetch *Coronilla varia*
Climbing Yams - *Dioscorea* spp.
Winter Creeper - *Euonymus fortunei*
English Ivy - *Hedera helix*
Japanese Honeysuckle - *Lonicera japonica*
Japanese Climbing Fern - *Lygodium japonicum*
Kudzu - *Pueraria montana*
Vincas, Periwinkles - *Vinca minor/V. minor*
Nonnative Wisterias - *Wisteria sinensis/W. floribunda*

Grasses

Giant Reed - *Arundo donax*
Cogongrass - *Imperata cylindrica*
Tall Fescue - *Lolium arundinaceum*
Nepalese Browntop - *Microstegium vimineum*
Chinese Silvergrass - *Miscanthus sinensis*
Golden bamboo - *Phyllostachys aurea*
Johnsongrass - *Sorghum halepense*

Forbs

Garlic Mustard - *Alliaria petiolata*
Exotic Lespedezas - *Lespedeza bicolor/L. cuneata*
Tropical Soda Apple - *Solanum viarum*
Japanese knotweed - *Polygonum cuspidatum*

Section III: Invasive Plant Profiles
Tree of Heaven - *Ailanthus altissima*

Identification

Tree of heaven is a rapidly growing small tree but can reach up to 80 feet in height and 6 feet in diameter. It has pinnately compound leaves that are 1-4 feet in length with 10-41 leaflets (Figure 22). Tree of heaven resembles the sumacs and hickories, but is easily recognized by the glandular, notched base on each leaflet (Figure 23). The thick twigs are light brown in color with large lenticels, and have large, heart-shaped leaf scars. Young twigs emit a strong odor, somewhat like peanut butter, when broken. The small yellow flowers occur in terminal clusters on female plants (Figure 24). The winged fruit can be from yellow to brilliant orange in color, turning dry and brown when ripe (Figure 25). Thickets of tree of heaven tend to be circular in shape.

Habitat and Distribution

Tree of heaven, native to Asia, was first introduced into America in 1748 by a Pennsylvania gardener. It was widely planted in cities because of its ability to grow in adverse conditions. Quickly escaping cultivation, tree of heaven has spread throughout the eastern United States, with the exception of the coastal plain areas.

Tree of heaven is extremely tolerant of poor soil conditions and has been known to grow even in cement cracks. Acidic, compacted, or nutrient poor conditions do not inhibit colonization. It commonly invades urban areas, roadsides, rights-of-way, fencerows, forest edges, savannas, open forests, canopy gaps, and other disturbed areas (Figure 26). It is very drought and flood tolerant but cannot grow in shaded conditions. The light, winged seeds can travel distances of 300 feet or more. Most reproduction is asexual, via cloning.

Impact

The ability to reproduce both by seeds and by sprouts allows tree of heaven to spread and quickly dominate disturbed areas. Dense clonal thickets displace native species and can rapidly take over fields and meadows, restricting light to the understory. Tree of heaven has alleopathic properties which aids it in displacing other species.

Figure 22


Figure 23

Figure 24

Figure 25

Response to Disturbance
Promoted by high light environments
Promoted by soil disturbance
Re-sprouts vigorously after being cut
Establishes easily after disturbance

Reproduction
Primary means – Seed and clonal growth
Mature after 10 years from seed
Mature within two years from sprout
Abundant seed production (greater than 300,000/plant)
Insect pollinated
No significant seed banking
Dioecious - male and female flowers on separate plants

Seed Dispersal
Wind blown seeds

Growth Habits
Tree
Shade intolerant (although it can persist somewhat until disturbance)
Flood tolerant
Poor soil tolerant
Drought tolerant
Prefers disturbed areas
Cold hardy
Alleopathic

Response to Prescribed Fire
Not a control option
Not a fire hazard
Re-sprout from roots after fire

Figure 26

Control Recommendations

Large trees. Make stem injections and apply Garlon 3A, Pathfinder II, or Arsenal AC in dilutions to cut spacings specified on the herbicide label (midsummer best, late winter somewhat less effective). For felled trees, apply these herbicides to stem and stump tops immediately after cutting.

Saplings. Apply Garlon 4 as a 20-percent solution in commercially available basal oil, vegetable oil, or crop oil (2.5 quarts per 3-gallon mix) with a penetrant (check with herbicide distributor) to young bark as a basal spray.

Seedlings and saplings. Thoroughly wet all leaves with one of the following herbicides in water with a surfactant (July to October): Arsenal AC as a 1-percent solution (4 ounces per 3-gallon mix), Krenite S as a 15-percent solution (3 pints per 3-gallon mix), Garlon 4 as a 2-percent solution (8 ounces per 3-gallon mix), or Escort XP at 1 ounce per acre.
(See Herbicide Quick Reference page 40-42)

Paulownia - *Paulownia tomentosa*

Identification

Paulownia or Princesstree is a deciduous tree, growing up to 60 feet in height and 2 feet in diameter. The bark is light gray to tan, often somewhat shiny, with white lenticels, becoming rough and slightly fissured with age (Figure 27). The twigs are stout with large, circular leaf scars and chambered or hollow piths. Leaves are opposite, fuzzy, large (6 to 12 inches long), and heart-shaped (Figure 29). Flowers are showy, erect, and pale-violet in color (Figure 30). The pecan-shaped fruits occur in erect terminal clusters, leaving behind the split, thin fruit capsule well into winter (Figures 28, 29). The abundant seeds are minute and winged.

Habitat and Distribution

Paulownia is native to eastern Asia and was first introduced into America in the early 1800s for ornamental purposes and as a potential export for carving wood (Figure 31). Paulownia can invade a variety of different habitats including roadsides, cliffs, riparian areas, open woods, highway embankments, stream banks, forest edges, landslides, burned-over areas, rocky out-croppings, mine spoils, old home sites, and other disturbed sites (Figure 32). It can tolerate infertile, shallow, rocky, alkaline to acidic, or very dry soils. It can even invade nearly vertical rock walls and cracks in concrete. Paulownia readily invades after fire or other types of soil disturbance. It is found throughout the Eastern United States. In the South, it is most problematic in the mountainous regions.

Impact

The tiny, winged seeds of paulownia are easily dispersed long distances via the wind. Once, established it is difficult to remove due to its ability to resprout vigorously and the prolific seed production. Its ability to colonize rocky or infertile sites, make paulownia a threat to some rare plants that require these marginal habitats. Its ability to resprout or colonize by seed quickly after a fire creates problems when managing species such as table mountain pine that require fire for regeneration.


Figure 27


Figure 28

Figure 29

Figure 30

Response to Disturbance
Promoted by high light environments
Promoted by soil disturbance
Promoted by fire
Re-sprouts vigorously after being cut
Invades readily after disturbance
Rapid growth (roots sprouts can grow over 15 feet a year)
Invades quickly after fire or disturbance

Reproduction
Primary means – seed
Time to maturity – 8-10 years
Abundant seed production (20 million/ plant)
Insect pollinated
Clonal from root sprouts

Seed Dispersal
Wind-blown and water-dispersed seeds

Growth Habits
Tree
Not very shade tolerant
Poor-soil tolerant
Flood tolerant
Drought tolerant
Prefers highly disturbed areas

Response to Prescribed Fire
Not a control option
Not a fire hazard
Colonizes quickly after fire (particularly spring fires)

Figure 31

Figure 32

Control Recommendations

Large trees. Make stem injections using Arsenal AC or a glyphosate herbicide in dilutions and cut spacings specified on the herbicide label (anytime except March and April). For felled trees, apply these herbicides to stem and stump tops immediately after cutting.

Saplings. Apply Garlon 4 as a 20-percent solution in commercially available basal oil, vegetable oil, or crop oil (2.5 quarts per 3-gallon mix) with a penetrant (check with herbicide distributor) to young bark as a basal spray.

Resprouts and seedlings. Thoroughly wet all leaves with one of the following herbicides in water with a surfactant (July to October): Arsenal AC as a 1-percent solution (4 ounces per 3-galllon mix); a glyphosate herbicide, Garlon 3A, or Garlon 4 as a 2-percent solution (8 ounces per 3-gallon mix).

(See Herbicide Quick Reference page 40-42)

Tallow Tree - *Triadica sebifera*

Identification

Tallow tree, also called popcorn tree, is a deciduous tree reaching 60 feet in height and 3 feet in diameter. The alternate leaves, which turn yellow or red in the fall, are heart-shaped with a long pointed tip (Figure 33, 34). The bark is light gray to tan, becoming fissured with age. The sap is a milky white color. The noticeable male flowers are yellowish and occur on long, dangling spikes (Figure 35). Three-lobed fruit are found in clusters at the end of branches. The fruit turn from green to black and split to reveal three waxy popcorn-like seeds (Figure 36).

Habitat and Distribution

Tallow tree is a native of China and was first introduced into America in South Carolina during the 1700s. The USDA recommended planting this tree for seed oil from 1920 to about 1940. It is currently still being sold as an ornamental. Tallow tree invades wet areas such as stream banks, ditches, wetlands, coastal prairies, and swamps, but can also invade drier upland sites such as forests, fields, pastures, and pine plantations (Figure 37). It can tolerate salty soils, flooding, and shady environments. Tallow tree readily invades disturbed areas but does not require disturbance to invade, and can invade high-quality mature forests. It is currently found throughout the southeastern United States in the Coastal Plain and lower Piedmont regions, from Texas to North Carolina. It has also been found in California.

Impact

Tallow tree is s serious threat because of its ability to invade high quality, undisturbed forests. Seed is dispersed both by birds and by water. It can displace native vegetation by forming dense monocultural stands. Tallow tree can also alter soil conditions due to the high amount of tannins present in the leaf litter. It has alleopathic properties which help it exclude other vegetations from infested sites. Open areas, such as fields and wet meadows, are quickly dominated, altering water and light regimes. It is a major threat to coastal prairies and forests on both the Gulf and Atlantic coasts. Forest regeneration in infested areas is difficult due to the quick dispersal and rapid growth of tallow tree.

Figure 33

Figure 34

Figure 35


Figure 36

Response to Disturbance
Promoted by high light environments
Promoted by soil disturbance
Discouraged by fire
Re-sprouts vigorously after being cut
Establishes well after disturbance

Reproduction
Primary means – seed
Can mature within three years
Seed production – 100,000/plant
Moderate seed bank (some survival possible up to 7 years)
Does not self pollinate
Wind pollinated

Seed Dispersal
Bird and water dispersed seeds

Growth Habits
Tree
Shade tolerant
Full sun tolerant
Flood tolerant
Salt tolerant
Can grow in varied habitat types
Not cold hardy
Able to invade undisturbed habitats

Response to Prescribed Fire
Dormant season burning may be an effective control option
Not a fire hazard
Re-growth after fire possible


Figure 37

Control Recommendations

Large trees. Make stem injections using Arsenal AC, Garlon 3A, or Pathfinder II in dilutions and cut spacings specified on the herbicide label (anytime except March and April). For felled trees, apply herbicides to stem and stump tops immediately after cutting (at least a 10-percent solution for Garlon 3A). For treatment of extensive infestations in forest situations, apply Velpar L to the soil surface within 3 feet of the stem (one squirt of spot gun per 1-inch stem diameter) or in a grid pattern at spacings specified on the herbicide label.

Saplings. Apply Garlon 4 as a 20-percent solution in commercially available basal oil, vegetable oil, or crop oil (2.5 quarts per 3-gallon mix) with a penetrant (check with herbicide distributor) to young bark as a basal spray.

Seedlings and saplings. Thoroughly wet all leaves with one of the following herbicides in water with a surfactant (July to October): Arsenal AC as a 1-percent solution (4 ounces per 3-gallon mix), Krenite S as a 20-percent solution (2 quarts per 3-gallon mix), or Garlon 4 as a 2-percent solution (8 ounces per 3-gallon mix).

(See Herbicide Quick Reference page 40-42)

Autumn Olive - *Elaeagnus umbellata*

Identification

Autumn olive is a deciduous shrub from 3 to 20 feet in height. Bark is gray-brown and smooth with small white lenticels. Scattered thorns occur on many plants but may be absent. Leaves are alternate, elliptical and 2-3 inches in length, with silvery, dotted undersides (Figure 38). The whitish-yellow flowers occur in axillary clusters, giving way to red, juicy fruits (Figure 39, 40).

Habitat and Distribution

Autumn olive is native to China and Japan and was introduced into America in 1830. Since then it has been widely planted for wildlife habitat, mine reclamation, and shelterbelts (Figure 41). Autumn olive invades old fields, woodland edges, forest openings, pastures, road sides, rights-of-way, and other disturbed areas. It can grow in sandy, loamy, and somewhat clayey soils with slightly acidic to neutral pH, but does best on sandy, dry soils. It is drought tolerate and can thrive in very infertile and dry soil. Plants cannot tolerate wet conditions. Autumn olive is somewhat shade tolerant but cannot grow in moderate or deeply shaded environments. Because the fruits are readily eaten by birds and small mammals, this plant has the ability to spread rapidly. It is found throughout the eastern United States, from Maine to Iowa and south to Florida. In the South, it is a problematic invader in the Piedmont region and farther north usually spreading from older plantings.

Impact

Both its rapid growth and prolific fruiting allow autumn olive to disperse rapidly. It can form large dense thickets, creating a monocultural shrub layer. These thickets can displace native species, reducing biodiversity and altering successional states. Meadows and forest openings can quickly become dominated and the canopy closed, restricting light availability to the understory layer. Autumn olive is a nitrogen-fixing plant, which could potentially alter soil nitrogen availability, greatly alter ecosystems that are adapted to infertile soils. Autumn olive re-sprouts vigorously, making any control work difficult and allowing it to re-grow rapidly after disturbance.

Figure 38

Figure 39

Figure 40

Response to Disturbance
Good initial colonizer (post fire and post disturbance)
Promoted by soil disturbance
Promoted by fire
Promoted by high light environments
Sprouts vigorously after cutting

Reproduction
Primary means – seed
Matures in 3-5 years on good sites
High seed production (20,000-54,000 per year)
High rate of germination (>90% with cold stratification, ~70% with no cold stratification)
Flowers April to May
Insect pollinated

Seed Dispersal
Bird and small mammal dispersed seeds

Growth Habits
Shrub/tree
Rapid growth
Somewhat shade tolerant
Flood intolerant
Drought tolerant
Open habitats
Grows on infertile soils
Nitrogen fixer
Early spring emergence

Response to Prescribed Fire
Not a control option
Not a significant fire hazard
Sprouts quickly after fire
Colonizes quickly after fire


Figure 41

Control Recommendations

Thoroughly wet all leaves with Arsenal AC, Vanquish or Garlon 4 as a 1-percent solution in water (4 ounces per 3-gallon mix) with a surfactant (April to October).

For stems too tall for foliar sprays, apply Garlon 4 as a 20-percent solution in commercially available basal oil, vegetable oil, or crop oil (2.5 quarts per 3-gallon mix) with a penetrant (check with herbicide distributor) to young bark as a basal spray (January to February or May to October). Or, cut large stems and immediately treat the stumps with one of the following herbicides in water with a surfactant: Arsenal AC as a 10-percent solution (1 quart per 3-gallon mix) or a glyphosate herbicide as a 20-percent solution (2.5 quarts per 3-gallon mix).
(See Herbicide Quick Reference page 40-42)

Privet - *Ligustrum* spp.

Identification

Although several species of privet occur in the Southeast, they are often hard to distinguish. In general, privet is a thick, evergreen to semi-evergreen shrub up to 30 feet in height. Bark is light gray to tan in color and very smooth. Trunks usually occur as multiple stems with many long, leafy branches. The opposite leaves are thick, somewhat waxy, oval and 0.5 to 1.5 inches long. White flowers are very abundant and occur in clusters at the end of branches (Figure 42). Fruit ripen to a dark purple to black color and persist into winter (Figure 43).

Habitat and Distribution

Privet was introduced into the United States in the early 1800s. It is commonly used as an ornamental shrub and for hedgerows. Privet can invade a wide variety of habitats including floodplains, stream sides, upland and bottomland forests, old fields, road sides, rights-of-way, fencerows, windbreaks, pastures, savannas, wetlands, and most any other habitat (Figure 44). It prefers moist open lands but can be found in highly shaded or dry areas. Privet readily invades both pine and hardwood forests, where it is often found as thickets in the understory. Privet is a generalist and can invade areas with a wide variety of soil types, nutrient availability, moisture, and pH. It is widespread and common throughout the southeast and scattered elsewhere in the U.S.

Impact

Privet is one of the most widespread and problematic invasive plants in the Southeast. It reproduces both by sprouts and by seeds, which are bird and mammal dispersed. It spreads quickly and once established can form dense almost impenetrable thickets. These thickets shade and displace many native understory and shrub species. Mid-canopy trees and developing seedlings and saplings can be replaced or restricted from establishing by privet infestations. It is very difficult to remove and reinfestations are common because of the abundant seed source.

Figure 42

Figure 43

Response to Disturbance
Promoted by soil disturbance
Re-sprouts vigorously after being cut
Establishes well in disturbed areas
Can invade undisturbed forests in canopy gaps

Reproduction
Primary means – seed and asexual
Seed production – 1000s/plant
Seed bank less than one year
High seed germination rates
Asexual reproduction - suckering

Seed Dispersal
Bird and water dispersed seeds

Growth Habits
Evergreen to semi-evergreen
Shrub/small tree
Shade tolerant
Full sun tolerant
Flood tolerant
Drought intolerant
Prefers forested habitats
Cold hardy depending on species

Response to Prescribed Fire
Repeated fires can control (depending on site)
Not a fire hazard
Re-sprouts after fire
Readily establishes after fire

Figure 44

Control Recommendations

Thoroughly wet all leaves with one of the following herbicides in water with a surfactant (August to December): a glyphosate herbicide as a 3-percent solution (12 ounces per 3-gallon mix), Arsenal AC as a 1-percent solution (4 ounces per 3-gallon mix), or Escort XP at 1 ounce/per acre plus 0.25 percent non-ionic surfactant).

During the dormant season (November through February) use a 3-5% glyphosate solution with water applied as a directed spray to completely wet the foliage of the privet. Use a glyphosate product that contains 41% or more active ingredient. With no soil activity and low impact on dormant (leafless) plants, glyphosate is a good option when desirable non-target plants are growing in close proximity to privet.

For stems too tall for foliar sprays, apply Garlon 4 as a 20-percent solution in crop oil (2.5 quarts per 3-gallon mix) to young bark as a basal spray. Or, cut large stems and immediately treat the stumps with Arsenal AC or Velpar L as a 10-percent solution in water (1 quart per 3-gallon mix) with a surfactant. Or, cut large stems and immediately treat the stumps with Krenite (Mixed 50-50 with water). When safety to surrounding vegetation is desired, immediately treat stumps and cut stems with Garlon 3A or a glyphosate herbicide as a 20-percent solution in water (2.5 quarts per 3-gallon mix) with a surfactant.

(See Herbicide Quick Reference page 40-42)

Oriental bittersweet - *Celastrus orbiculatus*

Identification

Oriental bittersweet is a deciduous, climbing, woody vine that can grow to lengths of 60 feet. Vines can grow to 4 inches in diameter and are gray to olive in color with whitish-gray, raised lenticels. The alternate, elliptical leaves are variable in shape, bluntly toothed, and light green in color, turning yellow in fall (Figure 45). Small, inconspicuous, axillary flowers give way to round green fruit which ripen and split to reveal showy scarlet berries that persist into winter (Figure 46). It closely resembles American bittersweet (*Celastrus scandens*) but can be distinguished from it because American bittersweet has flowers and fruits in terminals rather than axillary along the stem (Figure 47).

Habitat and Distribution

Oriental bittersweet was introduced from China around 1860 as an ornamental. It can be dispersed widely and quickly due to the berries being eaten and spread by birds. It can invade a variety of habitats including open and young forests, meadows, glades, savannas, roadsides, fencerows, old home sites, and other disturbed areas (Figure 48). It is generally found in areas of hardwood forests but has been reported in coniferous forests as well (Figure 49). Oriental bittersweet is widely spread and problematic throughout the Northeastern United States as far west as Iowa and sporadically to Louisiana. It has not been widely reported in the lower Piedmont or Coastal Plain. It is a major pest in areas of the southern Appalachians, especially the Asheville, NC region.

Impact

Prolific vine growth allows Oriental bittersweet to encircle trees and girdle them. It also can completely cover other vegetation and shade, out-compete and kill even large trees. The added weight to the trees increases susceptibility to ice storms and wind damage. Oriental bittersweet can shade and restrict growth of native understory species, shrubs, tree seedlings, and some native vines. It has also been shown to hybridize with American bittersweet, potentially leading to a loss of genetic identity.

Figure 45

Figure 46

Figure 47

Response to Disturbance
Promoted by soil disturbance
Re-sprouts vigorously after being cut
Damage encourages sprouting
Establishes rapidly after disturbance
Colonizes gaps well

Reproduction
Primary means – seed
Can produce seed in second year
Seed production (>350 fruits/plant and 3-6 seeds/fruit)
Fruit remain on vine well into winter
Seed bank less than 1 year
High germination rate (90%)
Dioecious - male and female flowers on separate plants
Insect (primarily bee) pollinated. Some wind pollination as well
Oak litter may inhibit establishment
Asexual reproduction – runners, root and root fragment sprouts, and root crown sprouting
Hybridizes

Seed Dispersal
Seed primarily dispersed by birds but also by animals, humans and water movement

Figure 48

Growth Habits
Vine
Rapid growth (greater than 10 feet/year)
Shade tolerant (20% full sun has no affect on seed germination)
Grows best in partial to full sun
Flood intolerant
Drought intolerant
Prefers open woods/disturbed areas
Cold hardy
Deciduous
Can climb supports of various sizes (does not require small diameter vertical structure to climb)

Response to Prescribed Fire
Not a control option
Not a fire hazard
Post-fire regeneration very possible
Fire may only top-kill plants, with re-sprouting following shortly after
Post fire flush of growth possible (nutrient and light availability increased due to fire)

Figure 49

Control Recommendations

Thoroughly wet all leaves with one of the following herbicides in water with a surfactant (July to October): Garlon 4, Garlon 3A, or a glyphosate herbicide as a 2-percent solution (8 ounces per 3-gallon mix).

For stems too tall for foliar sprays, apply Garlon 4 as a 20-percent solution in commercially available basal oil, vegetable oil, or crop oil (2.5 quarts per 3-gallon mix) with a penetrant (check with herbicide distributor) to the lower 16 inches of stems. Or, cut large stems and immediately treat the cut surfaces with one of the following herbicides in water with a surfactant: Garlon 4 or a glyphosate herbicide as a 25-percent solution (32 ounces per 1-gallon mix).
(See Herbicide Quick Reference page 40-42)

Japanese honeysuckle - *Lonicera japonica*

Identification

Japanese honeysuckle is an evergreen to semi-evergreen vine that can be found either trailing along the ground or climbing to heights of over 80 feet. Vines are slender, woody, and become fissured with age. It has opposite, oval shaped leaves that are entire to slightly lobed and 1 to 2.5 inches long (Figure 50). Showy, fragrant, tubular flowers that are whitish-pink to yellow in color give way to small green berries that turn black when ripened (Figure 51).

Habitat and Distribution

A native of eastern Asia, Japanese honeysuckle was first introduced into America in 1806 in Long Island, NY and since has been planted widely throughout the United States as an ornamental, for erosion control, and for wildlife habitat (deer forage). It is the most common invasive plant in the southeastern United States forests. It invades a wide variety of habitats including forest floors, forest edges, shrub and small tree canopies, floodplains, roadsides, rights-of-way, fence rows, old fields, wetlands, and disturbed areas (Figure 52). Japanese honeysuckle can thrive under a mature, closed forest canopy, but is most prolific along edges and in openings (Figure 53). It currently occurs in at least 38 states and is abundantly found throughout the Southeast.

Impact

The long growing season, due to its evergreen tendencies, helps Japanese honeysuckle compete successfully with many native species for both above and below ground resources. It can girdle shrubs and small saplings by twining around them and can form dense mats in the canopies of shrubs and trees, shading everything below. Japanese honeysuckle can also form dense thickets on the forest floor, inhibiting growth of native understory species and establishment of tree seedlings. Forest canopy gaps can be quickly invaded and closed in and forest edges can grow into a "living wall" of vegetation Forest regeneration is difficult in infested areas, because of the reduced growth and survivorship of seedlings caused by Japanese honeysuckle.

Figure 50

Figure 51

Response to Disturbance
Promoted by high light
Promoted by soil disturbance
Sprouts vigorously after cutting or fire
Most successful in early successional stages with small diameter vertical structure
Thinning activities stimulate growth
Seeds and re-sprouts can vigorously grow after site-prep or clear cutting activities, to the point of out-competing the trees.
Fast growth in a single season if conditions are favorable
Remains at low densities in mature forest until clearing or thinning, when it spread rapidly
Evergreen (somewhat semi-evergreen)
Cold tolerant

Reproduction
Primary means – Asexual and seed
High seed production (222 g seeds/plant)
Seed bank potential very low (less than one year)
High seed viability (85%) and germination rates (63%)
Insect and hummingbird pollinated
Perennial

Seed Dispersal
Bird and animal dispersed seed
Readily eaten by deer

Growth Habits
Vine
Shade tolerant
Flood tolerant
Drought tolerant
Can grow in varied habitat types

Response to Prescribed Fire
Not a control option (returns to pre-burn levels within a few years)
Not a fire hazard
Rapid re-growth after fire

Figure 52

Figure 53

Control Recommendations

Apply Escort XP with a surfactant to foliage June to August—either by broadcast spraying 2 ounces per acre in water (0.6 dry ounces per 3-gallon mix - and apply a total of 10 gallons of spray mix per acre) or by spot spraying 2 to 4 ounces per acre in water (0.6 to 1.2 dry ounces per 3-gallon mix).

Or, treat foliage with one of the following herbicides in water with a surfactant (July to October or during warm days in early winter) keeping spray away from desirable plants: a glyphosate herbicide as a 2-percent solution (8 ounces per 3-gallon mix) or Garlon 3A or Garlon 4 as a 3- to 5-percent solution (12 to 20 ounces per 3-gallon mix).

Or, cut large vines just above the soil surface and immediately treat the freshly cut stem with a glyphosate herbicide or Garlon 3A as a 20-percent solution (2.5 quarts per 3-gallon sprayer) in water with a surfactant July to October (safe to surrounding plants).

Prescribed burning in spring will reduce dense ground mats and sever climbing vines for more effective herbicide treatments to resprouting vines.

(See Herbicide Quick Reference page 40-42)

Japanese climbing fern - *Lygodium japonicum*

Identification

Japanese climbing fern is a perennial climbing fern with fronds that can reach lengths of 90 feet. Vines (rachises) are thin and wiry, and die back in winter (it remains evergreen in central and south Florida). The leaflets (pinnae) are compound and finely dissected. The overall leaflet has a triangular shape and is 3 to 6 inches in length (Figure 54). Spores occur on the fertile leaflets as a double row of dots under the margins (Figure 55). It is one of the few "vine-like" ferns that occur in the United States. It can be easily distinguished from the native American climbing fern (*Lygodium palmatum*) by leaflet (pinnae) shape. American climbing fern is palmately lobed, whereas Japanese climbing fern is pinnately compound.

Habitat and Distribution

Japanese climbing fern is native to eastern Asia and was first introduced into America during the early 1900s for ornamental purposes. Japanese climbing fern invades disturbed areas such as open forests, pine plantations, savannas, swamps, coastal hammocks, forest edges, streamsides, ditches, rights-of-way, and roadsides. It can grow in a wide range of light and moisture levels but cannot tolerate extreme drought or flooding. Fire appears to promote Japanese climbing fern abundance. While Japanese climbing fern readily invades after disturbance, it doesn't require any type disturbance before invading, and has been found in high-quality, undisturbed environments. Currently, it can be found throughout the Coastal Plain and lower Piedmont regions of the Southeastern United States. Japanese climbing fern appears to be currently expanding its range northward.

Impact

Japanese climbing fern forms dense tangled mats, which cover the ground and shrubs, shading and killing understory vegetation and tree seedlings. It can also form "walls" of fern which block any available sunlight, reducing biodiversity (Figure 56). The winter-killed vegetation creates fuel ladders, which can intensify and carry fires into the tree crowns (Figure 57). The minute spores can spread, undetected, by wind and on contaminated equipment and plant material. Contaminated pine straw bales are a major avenue of spread, causing some states to regulate the industry (Figure 58).

Figure 54

Figure 55

Response to Disturbance
Promoted by soil disturbance
Promoted by fire
Re-grows well after being cut
Readily invades disturbed areas
Does not require disturbance before invading

Reproduction
Primary means – spore
Has the ability to self pollinate
Long spore viability

Spore dispersal
Human, wind, water, and animal dispersed
Pine straw is a major method of dispersal

Growth Habits
Vine/fern
Shade tolerant
Flood tolerant
Drought intolerant
Can grow in varied habitat types
Not cold hardy
Evergreen/semi-evergreen

Response to Prescribed Fire
Not a control option
Fire hazard
Rapid re-growth after fire

Figure 56


Figure 57

Figure 58

Control Recommendations

Thoroughly wet all leaves with one of the following herbicides in water with a surfactant (July to October): Escort XP at 1 to 2 ounces per acre in water (0.3 to 0.6 dry ounces per 3-gallon mix) OR Arsenal AC as a 1-percent solution (4 ounces per 3-gallon mix) OR Garlon 3A, Garlon 4, or a glyphosate herbicide as a 2-percent solution (8 ounces per 3-gallon mix)

(See Herbicide Quick Reference page 40-42)

Cogongrass - *Imperata cylindrica*

Identification

Cogongrass is a perennial colony-forming grass up to six feet tall. The clumps of grass arise from the ground, with no apparent stem. The leaf sheaths overlap near the base. The leaves have an off-center midrib that is whitish in color, but this is a variable trait (Figure 59). Leaf margins are finely serrated giving it a sharp texture. Ligules are fringed membranes. The sharp, branched, white rhizomes are concentrated in a dense layer in the top six inches of soil (Figure 60). Flowers and seeds are in a large fuzzy panicle, giving the flowering plant a cottony or silky look. Cogongrass rarely is found as a single plant but quickly forms patches or infestations, often circular in outline (Figure 61).

Habitat and Distribution

Cogongrass is native to Southeast Asia and was first introduced into the southeast United States in the early 1900s. Initially cogongrass was planted for forage and erosion control; however it is unpalatable for livestock and not well suited for erosion control due to its aggressive behavior. Cogongrass can invade a wide variety of sites including road sides and rights-of-way, forests, pine plantations, ditches, pastures, field edges, orchards, levees, sand dunes, and waste areas (Figure 62). Cogongrass will not grow in saturated soils, but tolerates periodic flooding reasonably well. It can also tolerate saline environments and drought. It can grow in both deep shade and full sunlight. It cannot successfully invade areas that are annually cultivated. Fire stimulates growth and flower production. Cogongrass can grow in moderately cold weather, being found as far north as the Tennessee border inland and to Connecticut along the coast. Cogongrass is widespread and extremely problematic in Mississippi, Alabama, and Florida. It is currently sparsely located in Louisiana, Georgia, and South Carolina. Cogongrass' introduced range in the United States is expected to continue to expand.

Impact

Cogongrass can form dense mats that exclude all other understory vegetation (Figure 63). Cogongrass has little or no value for wildlife either as food or habitat. Desirable species are displaced and new species are prevented from establishing. Dense infestations restrict tree and shrub establishment. Cogongrass is very flammable and creates fire hazards especially in winter. The thick thatch layer dries quickly and burns very hot. Prescribed and wild fires in infested areas are more intense than in native vegetation (Figure 64), and trees can be damaged or even killed during these fires. Wildlife, including gopher tortoises and indigo snakes, and game species such as bobwhite quail and wild turkey, are negatively impacted by cogongrass and habitats may be completely lost due to heavy infestations.

Figure 59

Figure 60

Figure 61

Response to Disturbance
Promoted by high light environments
Establishes quickly on disturbed sites
Regrows quickly after soil disturbance
Promoted by fire
Re-grows after being cut
Possibly alleopathic
Resistant to most herbicides
Unpalatable

Reproduction
Primary means – seed and rhizome
Matures in less than one year
Abundant seed production (3,000/plant)
High seed germination (90%)
Low seed viability (viability declines sharply after 3 months)
Seed bank less than 6 months
Low seedling survivorship (20% in first year)
Does not self pollinate
Rhizomatous (rhizome biomass up to 16 tons/acre)
Grows well from rhizome fragments (soil transferred)


Figure 62

Seed Dispersal
Wind and soil contaminate
Seed dispersed (up to 15 miles via wind)

Growth Habits
Grass
Perennial
Full sun and deep shade tolerant
Drought tolerant
Not flood tolerant (saturated soil conditions, especially in early establishment)
Cold tolerant (as low as 7 degrees Fahrenheit)
Can grow in varied habitat types

Response to Prescribed Fire
Not a control option, but may be used to reduce thatch before chemical treatment
Fire hazard
Fire stimulates flowering


Figure 63


Figure 64

Control Recommendations

Thoroughly wet all leaves with one of the following herbicides in water with a surfactant: Arsenal AC as a 2-percent solution (8 ounces per 3-gallon mix), a glyphosate herbicide as a 2-percent solution (8 ounces per 3-gallon mix), or combination of the two herbicides. Apply before flowering in spring to suppress seed production. Apply 32 ounces per acre of Arsenal AC or 64 ounces per acre of Chopper herbicide in late fall for eradication. Mowing or careful prescribed burning of the thatch in late winter can aid herbicide treatments.

(See Herbicide Quick Reference page 40-42)

Nepalese browntop - *Microstegium vimineum*

Identification

Nepalese browntop, also called Japanese stiltgrass, is a delicate, sprawling, annual grass that is 0.5 to 3 feet in height (Figure 65). Alternate leaves are short, flat, and lance-shaped and are pale green with off-center veins (Figure 66). Stems are wiry and often multi-branched. Flowers are in delicate spikes that emerge from slender tips. Seeds are prolific and can persist into winter. Dieback begins in early fall, causing the plants to turn brown, giving it the common name, browntop.

Habitat and Distribution

Nepalese browntop is native to Asia and was accidentally introduced into America in Knoxville, Tennessee sometime around 1920. It has been used as packing material for porcelain, possibly explaining its accidental introduction. Most commonly an invader of forested floodplains, Nepalese browntop is also found in ditches, wastelands, forest edges, forested wetlands, fields, shaded roadsides, and trails (Figure 67). Floodplains along major rivers, semi-permanent streams, and wet draws are common places to find this plant. In mountainous regions, it is found below elevations of 4000 feet, and is often associated with areas of natural (e.g., flood scouring) or artificial (e.g., mowing, tilling) disturbance. Partial to deep shade is preferred and it can thrive in very low light conditions. Invaded sites often have moist, sandy or loamy soils with mildly acidic or neutral pH. Nepalese browntop can also invade drier, upland sites, but cannot tolerate periodic standing water.

Nepalese browntop is found throughout the Eastern United States, from Florida to New York. In the South, it is widespread and problematic from Kentucky, Tennessee, Virginia, North Carolina, and northern Georgia.

Impact

Nepalese browntop is capable of invading high-quality, mature floodplain forest and is very difficult to remove once established. It can disperse and invade new areas very quickly. Infestations form thick monocultural stands that alter communities, replacing the native herbaceous vegetation within three to five years after introduction. Alterations in the litter composition, pH levels, and organic soil horizon have been reported after infestations. Nepalese browntop can also negatively effect silvicultural practices by reducing growth in establishing seedlings.

It is dispersed chiefly by flood waters, but can be dispersed by animals and hikers carrying seeds on their fur/clothing. It is a prolific seeder, producing 100-1000 seeds per plant. It is very shade tolerant and can displace vegetation native to floodplains.

Figure 65

Figure 66

Response to Disturbance
Promoted by high light environments
Promoted by soil disturbance
Discouraged by fire
Establishes after fire on bare soil conditions
Does not sprout well after cutting (annual), but can regrow top portions of plant if cut early in season

Reproduction
Primary means – seed
High seed production (>1000 seeds per plant)
Low seed viability (33%)
Seed bank 3-5 years
Can self-pollinate even before flowers open
Small root system

Seed Dispersal
Animal, water, wind (short distances), human, and soil contaminate spread

Growth Habits
Grass
Annual
Very shade tolerant
Saturated soil tolerant (doesn't do well with extended flooding)
Drought intolerant
Prefers moist forested habitats
C^4 photosynthetic pathway
Cold hardy
High light tolerant (grows best ~35% full sunlight)
Does not establish well with deep litter layer

Response to Prescribed Fire
Late season fire may help in control
Not a fire hazard
Establishes after fire on bare soil conditions

Figure 67

Control Recommendations

Apply a glyphosate herbicide as a 2-percent solution in water (8 ounces per 3-gallon mix) with a surfactant in summer. Or, apply Vantage (see label) for situations that require more selective control and less impact on associated plants.

Repeat treatments for several years to control abundant germinating seeds. Mowing or pulling just before seed set will prevent seed buildup.

(See Herbicide Quick Reference page 40-42)

Garlic Mustard - *Alliaria petiolata*

Identification

Garlic mustard is an herbaceous biennial forb that is an aggressive invader of wooded areas throughout the eastern and middle United States. First-year plants are basal rosettes with green heart-shaped leaves (1-6 inches tall) (Figure 68). Second-year plants produce a 1-4 feet tall flowering stalk with small, white flowers (Figure 69). Fruits are long seeds pods (siliques) with small, hard, black seeds (Figure 70). Just below the surface, the root system often has a characteristic S-curve. Garlic mustard is most easily recognized by a garlic odor present on actively growing parts of the plant when crushed and the strongly toothed, triangular leaves in the second-year plants (Figure 71).

Habitat and Distribution

Garlic mustard invades hardwood forests, savannas, woodlots, forest edges, and roadsides. It has been reported as invading coniferous forest, but infrequently. Disturbed forests are most often invaded, but high-quality, undisturbed forests can also be invaded. Stream sides and bottomland forest are the most common habitat invaded, but slope and upland sites are also vulnerable. Garlic mustard does best in partial light but can tolerate deep shade and full sun. It grows in a variety of soils with limestone or sandstone substrates and neutral to basic pH. Infestations usually start along an edge, trail or stream and spread throughout the remaining forest.

Garlic mustard is a major invasive of northeastern and midwestern United States and southeastern Canada. It is also found in areas of the Rocky Mountains and the Pacific Northwest, from Oregon to Alaska. In the South, it occurs mostly along the major river systems, and has been recorded as far south as Marietta, Georgia.

Impact

Once introduced, garlic mustard can form dense stands that shade and compete with native understory flora, lowering native species diversity. It can quickly become the dominate vegetation once introduced. It emerges early in the growing season, competing with and shading the spring ephemerals. Garlic mustard is notable because a high shade tolerance allows it to invade high-quality mature forests, once thought to be relatively resistant to invasion. It has little or no value as a wildlife food and white-tailed deer preferentially avoid garlic mustard to feed upon the other species, possibly aiding in the dominance of garlic mustard in the landscape. It may also interfere with the larval development of two rare butterflies. Once established, garlic mustard is very difficult to remove and spreads rapidly.

Figure 68

Figure 69

Response to Disturbance
Discouraged by high light environments
Promoted by soil disturbance
Promoted by deer as they forage on its competition
Does not re-sprout well
Establishes well after disturbance
Can establish in undisturbed sites
Unpalatable to most wildlife
Rapid growth in early spring/late fall

Reproduction
Primary means – seed
Time to maturity – 2 years
No vegetative reproduction
Early spring emergence (Especially for 2nd year plants)
Abundant but variable seed production (>10,000 seeds/sq. ft. or up to 7,900 seeds/plant)
Seed bank 4-6 years, but most (88%) germinate in 1st year
Seed drop in late summer/early fall
Germinates in February or March after 50 to 105 days of cold stratification
High seedling mortality in first winter
Can self-pollinate
Insect pollinated


Figure 70

Seed Dispersal
Animal, human, and water dispersed

Growth Habits
Herbaceous forb
Flood tolerant
Shade tolerant
Sun tolerant
Grows best in 50% full sun
Drought intolerant
Prefers shaded forests
Alleopathic
Obligate Biennial

Response to Prescribed Fire
Can be a control option
Fire (growing season) reduces density of existing stand
Not a fire hazard
Potential for rapid colonization following fire

Figure 71


Figure 72

Control Recommendations

To control two generations, thoroughly wet all leaves with a glyphosate herbicide as a 2-percent solution in water (8 ounces per 3-gallon mix) during flowering (April through June). Include a surfactant unless plants are near surface waters.

In locations where herbicides cannot be used, pull plants before seed formation. Repeated annual prescribed burns in fall or early spring will control this plant, while "flaming" individual plants with propane torches has also shown preliminary success (Figure 72).

(See Herbicide Quick Reference page 40-42)

Exotic lespedezas - *Lespedeza cuneata* and *L. bicolor*

Identification

Two species of lespedeza are serious invaders in the Southeast; Chinese or sericea lespedeza (*L. cuneata)* and shrubby or bicolor lespedeza (*L. bicolor)*. Chinese lespedeza is an upright semi-woody forb, 3 to 6 feet in height with one to many slender stems. Shrubby lespedeza is very similar but usually displays more branching and is 3 to 10 feet in height. Both species have alternate, abundant, three-parted leaves. Chinese lespedeza leaflets are slender and 0.4 to 0.8 inches long whereas shrubby lespedeza leaflets are more elliptical to oval and 1-2 inches long (Figures 73 & 74 respectively). Flowers are small and whitish-yellow (Chinese) or purple (shrubby). Fruits are single-seeded, round (Chinese) or flattened (shrubby) legume pods.

Habitat and Distribution

Native to Asia and introduced into the Unites States in the late 1800s, lespedeza has been widely planted for wildlife habitat, erosion control, and mine reclamation. It grows well in meadows, prairies, pastures, old fields, roadsides, mine spoils, savannas, open forests, fence rows, ditches, highway embankments, orchards, and other disturbed habitats (Figure 75). It is resistant to drought and can tolerate moderate flooding. Because of its ability to fix nitrogen, lespedeza thrives on disturbed or nutrient poor sites. Sandy or sandy-loam soils are preferred but it can grow in a variety of soil types ranging from sandy to clayey. It can invade areas with strongly acidic to neutral pH. It currently is found throughout the eastern United States and in the South, is primarily a problem in the upper coastal plain and areas north.

Impact

Lespedeza is an extremely aggressive invader of open areas. Dense monocultural thickets are formed due to its ability to sprout from root crowns. It displaces native vegetation and, once established, is very difficult to remove due to the seed bank, which can remain viable for decades. Open areas can be quickly dominated by lespedeza, altering species diversity, wildlife suitability, and management plans. Lespedeza is fire promoted, potentially forcing managers to alter planned fire regimes in fire-adapted environments such as prairies and pine savannas (Figure 76). Tannins and other alleopathic chemicals are produced, which can inhibit growth of other plant species. On a strip mine reclamation site, lespedeza completely dominated a disturbed areas and compromised 100% aerial cover in three years.

Figure 73

Figure 74

Response to Disturbance
Promoted by high light environments
Promoted by soil disturbance
Fire encouraged
Re-sprouts vigorously after being cut
Does not fair well in absence of disturbance
Mowing promotes growth
Responds well to disturbance
Difficult to remove once established

Reproduction
Primary means – Seed and root crowns
Seed production – 300 million seeds/acre
Long seed bank (20+ years)
Can self-pollinate
Seeds usually do not remain on plant through winter
Fire scarification of seeds, increases germination rates
Insect pollinated

Seed Dispersal
Animal and human dispersed seeds

Growth Habits
Semi-woody shrub
Perennial
Somewhat shade tolerant
Full sun tolerant
Flood intolerant
Drought tolerant
Prefers open woods/grasslands
Cold tolerant
Above ground portions dieback in winter

Response to Prescribed Fire
Not a control option
Not a fire hazard
Fire scarification of seeds, increases germination rates


Figure 75

Figure 76

Control Recommendations

Thoroughly wet all leaves with one of the following herbicides in water with a surfactant (July to September): Garlon 4 as a 2-percent solution (8 ounces per 3-gallon mix), Escort XP at three-fourths of an ounce per acre (0.2 dry ounces per 3-gallon mix), Transline as a 0.2-percent solution (1 ounce per 3-gallon mix), a glyphosate herbicide as a 2-percent solution (8 ounces per 3-gallon mix), or Velpar L as a 2-percent solution (8 ounces per 3-gallon mix).

Mowing 1 to 3 months before herbicide applications can assist control.

(See Herbicide Quick Reference page 40-42)

Japanese knotweed - *Polygonum cuspidatum*

Identification

Japanese knotweed is a dense growing semi-woody shrub that can reach heights of 10 feet. The hollow, simple or little-branched stems are smooth and shiny with enlarged nodes. The alternate leaves are variable in shape, but are generally large and triangular with a flat or rounded base and pointed tip (Figure 77). Flowers are minute and greenish-white and appear in loose clusters in the axils (Figure 78). Fruit are small, dry achenes. Above ground portions of the plant die back in winter. Japanese knotweed is easily recognized by its extremely dense growth form, often occurring in large monocultural thickets (Figures 79, 80).

Habitat and Distribution

Japanese knotweed is native to eastern Asia and was first introduced into America in the 19th Century. It commonly invades disturbed areas with high light, such as road sides, ditches, wetlands, rights-of-way, open hillsides, wet meadows, yards, sandbars, islands, and stream banks. It doesn't appear to be able to invade low-light areas, such as forested understories. Japanese knotweed can grow in moist sites with a variety of soil types, salinity levels, pH, and nutrient availabilities. It is often associated with some type of soil disturbance. Japanese knotweed is found scattered throughout the United States and Canada. It is most problematic in the northeastern and Pacific northwestern United States. It is also a problem in the Mid-South and appears to be spreading its range into the upper Piedmont regions.

Impact

Reproduction occurs both by vegetative cuttings and seeds, making this plant extremely hard to eradicate. The dense patches, which emerge early in the growing season, shade and displace other plant life and reduce wildlife habitat. It doesn't appear to be a major threat to shaded environments, such as a forest understory, but could quickly invaded forest gaps created by natural or human-aided disturbance. Infestations along stream banks increase susceptibility to erosion (Figure 81). Open areas can be quickly invaded and completely dominated by Japanese knotweed (Figure 82). Control and restoration is difficult and very expensive.

Figure 77

Figure 78

Figure 79

Figure 80

Response to Disturbance
Promoted by high light environment
Promoted by soil disturbance
Re-sprouts vigorously after cutting
Invades readily after disturbance
Does not invade undisturbed sites

Reproduction
Primary means - Asexual
Vegetative reproduction (roots and shoots)
Minimal sexual reproduction
Can hybridize with giant knotweed

Seed dispersal
Wind and water dispersed seeds
Plant material water and human spread (soil contaminate)

Growth Habits
Semi-woody shrub
Perennial
Cold hardy
Full sun tolerant
Shade intolerant
Saturated soil and flood tolerant
Somewhat drought tolerant
Prefers open habitats
Above ground portions die-back in winter

Response to Prescribed Fire
Not known if fire works as a control
Not a fire hazard

Figure 81

Figure 82

Control Recommendations

Treat foliage with one of the following herbicides in water with a surfactant, Garlon 3A, Garlon 4, or a glyphosate herbicide as a 2-percent solution (8 ounces per 3-gallon mix), the ideal time to spray is after surrounding vegetation has become dormant (October-November) to avoid affecting non-target species. surrounding vegetation has become dormant (October-November) to avoid affecting non-target species. A 0.5% non-ionic surfactant is recommended in order to penetrate the leaf cuticle, and ambient air temperature should be above 65°F.

Or, cut the stem 5 cm (2 in) above ground level. Immediately apply a 25% solution of Garlon 3A, Garlon 4, or glyphosate (32 ounces per 1-gallon mix) to the cross-section of the stem. A subsequent foliar application of glyphosate may be required to control new seedlings and resprouts. Use this method in areas where vines are established within or around non-target plants or where vines have grown into the canopy. This treatment remains effective at low temperatures as long as the ground is not frozen.

(See Herbicide Quick Reference page 40-42)

Herbicide Quick Reference Guide

Arsenal AC, Chopper (Imazapyr)

MODE OF ACTION
Plant protein production inhibitor
Absorbed by both roots and foliage, and translocated throughout plant; accumulates in growing tissues and roots
SELECTIVITY
Selective; controls most hardwoods, most pines are tolerant
At higher application rates, pines will show epinasty and reduced growth
Controls some grasses except at very low application rates
SOIL ACTIVITY AND MOBILITY
Soil active; however, soil mobility is relatively low
Imazapyr appears to bind loosely to clay particles and organic matter
Soil activity expresses itself during the period of spring leaf expansion; applications made from late June through mid-September produce little or no evidence of soil activity
Application after mid-September may yield soil activity during the following spring
PERSISTENCE AND BREAKDOWN
Moderately persistent; half-life is reported to be 19-34 days, but soil residues may persist significantly longer during periods of cold weather
Decomposition is primarily by photolysis
PRIMARY FORESTRY USES
Widely used for site preparation and release in pine management
Recommended for directed foliar application or injection; may be effectively tank-mixed with other herbicides such as triclopyr or glyphosate
Tank mixes either have a broadened target spectrum or are more effective on target species than each component alone
Effects on treated vegetation appear very slowly; visual impact is low
APPLICATION TIMING
Avoid injection applications during rapid tree growth/green up in spring and early summer
Directed foliar spray made in July or August when material washed off leaves tends not to be picked up by roots of non-target plants, allows for good selectivity
Fall treatments may result in winter "carry-over" and residual soil activity the following spring
WEAKNESSES OR LIMITATIONS
Little control of blackgum, and locust; effectively releases blackberry
Broadcast applications of more than one ounce per acre will control most grasses, unless spray is intercepted by taller vegetation.
Grass control is not desirable in ROW applications

Escort XP (Metsulfuron)

MODE OF ACTION
Rapid foliar and root absorption; systemic translocation
Acts to inhibit cell division by disrupting amino acid biosynthesis
SELECTIVITY
Somewhat selective; affects many broadleaved weeds and many annual grasses
SOIL ACTIVITY AND MOBILITY
Fairly mobile in soil; soil active
PERSISTENCE AND BREAKDOWN
Broken down by chemical hydrolysis and soil microbes; rate of breakdown is influenced by soil temperature, pH, and levels of oxygen & moisture
Half-life in the South is 1 – 6 weeks (typically about 30 days)
APPLICATION TIMING
Best results achieved in early growing season with post-emergence application; best on actively growing weeds
Rapid growth enhances efficacy of the herbicide
Also effective as a pre-emergent soil application

Garlon, Pathfinder II (Triclopyr)

MODE OF ACTION
Growth regulator; readily absorbed by foliage, with some stem uptake
Translocates up and down in plants; accumulates in growing tissues and the root collar
SELECTIVITY
Semi-selective; controls many woody and broad-leaf species; grasses are tolerant
Pines are tolerant of the amine formulation after resting buds are formed in late summer; the ester formulations control pines as well as hardwoods
SOIL ACTIVITY AND MOBILITY
Generally non-mobile in soils; but, gross applications (spills) or misapplication of Garlon 3A may show some mobility and non-target root uptake and may contaminate ground water
PERSISTENCE AND BREAKDOWN
Moderately short half-life of 10-46 days with an average 30 day half-life; degraded both by soil microbes and by photolysis
Breakdown in water is photolytic and extremely rapid (10 hr half-life at 25° C)
PRIMARY FORESTRY USES
Garlon 3A is used as an injection or cut-surface treatment in site preparation and release, and as a foliar spray in rights-of-way or for hardwood control in conifer plantations
Efficacy of Garlon 3A is increased, and application rate reduced, by tank mixing with imazapyr
Some tank mixes with Glyphosate are also effective
Garlon 4 is used as a basal bark (streamline application) treatment for selective control of

individual stems in either pine or hardwood management
It may also be used as an emulsion in a water-based foliar spray for control of either pines or hardwoods
Efficacy of Garlon 4 may be enhanced and rates reduced by tank mixing with imazapyr [Chopper]
Pathfinder II is used primarily in right-of-way applications, but may also be used as a selective basal bark treatment (streamline application) in forestry applications

APPLICATION TIMING

Broadcast or directed foliar sprays may be done any time during the full-leaf season
Injection and cut-surface treatments may be done at any time other than during spring sap-flow
Basal bark treatments must generally be done during the leaf-off season to avoid contact with leaves of desirable vegetation and resultant damage

WEAKNESSES OR LIMITATIONS

Little or no control of sourwood, blackgum, and persimmon. Red maple displays top-kill, but often resprouts from the roots after 1-2 years
Currently formulated with a flammable carrier (kerosene)
Some grazing and hay harvest restrictions apply, depending upon product and application rate

glyphosate

MODE OF ACTION

Growth inhibitor; absorbed by foliage, translocates throughout the plant eventually accumulating in the roots

SELECTIVITY

Semi-selective; pines show limited tolerance if application is made after they form resting buds late in the summer
Controls most, but not all, grasses
In aquatic applications, effective only on emerged plants or shoreline vegetation

SOIL ACTIVITY AND MOBILITY

Not soil active; not mobile in soil
Glyphosate is strongly adsorbed to soil particles and organic matter; deactivated rapidly by muddy water or water with a high calcium content

PERSISTENCE AND BREAKDOWN

Decomposed by microbial activity; moderate half-life of about 60 days

APPLICATION TIMING

Glyphosate formulations generally give poor control of ash and hickory, and are weak on dogwood, sourwood, and yellow poplar Foresters is generally considered a "fall" chemical; it is generally applied after pine resting buds are formed, but before leaf coloration (early summer applications often produce top-kill followed by resprouting)
Injection may be done at any time the trees are actively growing, except in the spring during rapid sap flow
Aquatic treatments and wildlife opening rehabilitation should be done when the target vegetation is actively growing, but even here, late season application is generally best

WEAKNESSES OR LIMITATIONS

Aquatic treatments and wildlife opening rehabilitation should be done when the target vegetation is actively growing, but even here, late season application is generally best
Use caution when tank mixing glyphosate and triclopyr formulations, they may deactivate each other; make a test mix in a jar to check compatibility before attempting to tank mix these products
Glyphosate is not generally effective against submerged plants (binds to suspended soil and organic matter)
Glyphosate is not generally considered suitable for right-of-way application because it kills the grasses and leaves soil vulnerable to erosion

CAUTION

Do not mix or store glyphosate in unlined steel or galvanized containers; hydrogen gas will be produced, and may build up in dangerous quantities

Krenite (Fosamine)

MODE OF ACTION

Bud inhibitor; absorbed slowly by leaves
While laboratory testing indicates that it translocates throughout the target plant, only treated portions of the plant are affected in field applications
(An explanation for this apparently inconsistent behavior is still lacking)
When applied in the fall plants do not re-leaf the following spring – no *obvious* brownup results from its use

SELECTIVITY

Limited selectivity; controls both pines and hardwoods but not grasses

SOIL ACTIVITY AND MOBILITY

Not soil active; little or no movement in soil primarily due to its short half-life in soil (7-10 days)

PERSISTENCE AND BREAKDOWN

Relatively short half-life (7-10 days); breakdown is by soil microbes

APPLICATION TIMING

Generally applied in late summer/early fall; autumn leaf coloration masks treatment effects

WEAKNESSES OR LIMITATIONS

Absorption by leaf surfaces is slow; rainfall within 6 hours after application may make treatment ineffective
"S" formulation works best; the "S"urfactant aids leaf surface penetration
Works better in cooler climates; not very effective in long growing seasons of the deep South

Transline (Clopyralid)

MODE OF ACTION
Plant growth regulator
SELECTIVITY
Selective; controls composites, legumes, and smartweeds, while pines, most hardwoods, and grasses are tolerant
SOIL ACTIVITY AND MOBILITY
Although soil application is not recommended, clopyralid is absorbed by the roots or foliage, and soil activity from spills or misapplication can occur
Soil mobility is relatively high, especially if percolating water is present
PERSISTENCE AND BREAKDOWN
Low to moderate in persistence; aerobic half-life is 12 to 70 days
Breakdown is by soil microbes
APPLICATION TIMING
Apply when plants are actively growing
One or two applications per year for two to four years may be required to completely control old, well-established kudzu
WEAKNESSES OR LIMITATIONS
Forestry application formerly was restricted to sites adjacent to rights-of-way, wildlife openings and certain types of tree plantations.
May cause needle curling or leaf burning when used in over-the-top release sprays. This effect is made worse by surfactants

Vanquish (Dicamba)

MODE OF ACTION
Growth regulator; readily absorbed by roots and leaves
Translocates through xylem and accumulates in mature leaves
SELECTIVITY
Somewhat selective; controls most annual or perennial broadleaved weeds (including hardwoods) but may damage or kill pines
Does not control grasses
SOIL ACTIVITY AND MOBILITY
Soil active; relatively mobile if percolating water is present
PERSISTENCE AND BREAKDOWN
Relatively short half-life (2 weeks)
Breakdown, primarily by soil microbes, is strongly affected by both soil temperature and soil moisture
TOXICITY TO HUMANS AND WILDLIFE
Relatively low toxicity and Rat oral LD_{50} (technical dicamba) is 1,707 mg/kg; for Vanquish it is 3,512 mg/kg
PRIMARY FORESTRY USES
May be used for forest site preparation and rights-of-way maintenance
APPLICATION TIMING
Generally applied in spring or early summer

Velpar (Hexazinone)

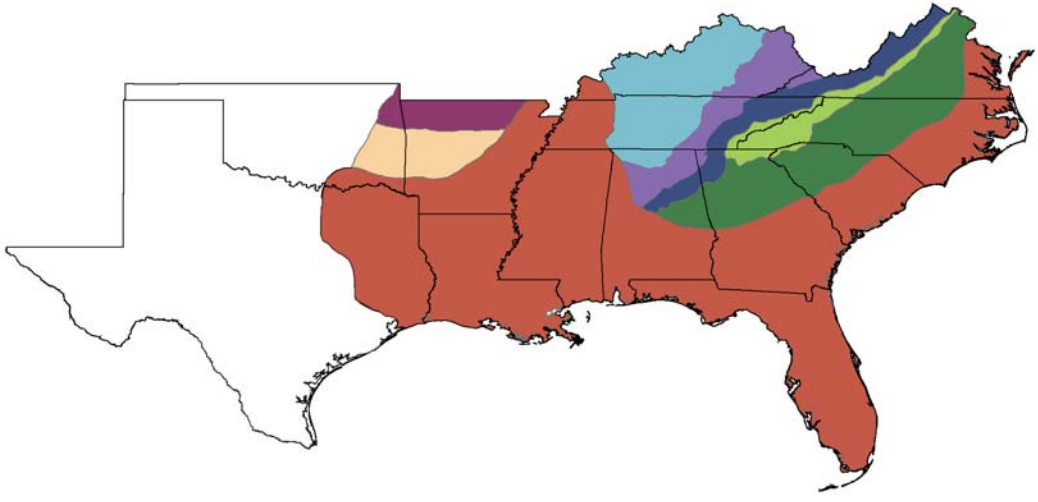
MODE OF ACTION
Photosynthetic inhibitor; readily absorbed through the roots and, to a lesser degree, through foliage (liquid formulations)
Foliar absorption can be greatly enhanced by the addition of a nonionic surfactant
Translocates upward via the xylem
SELECTIVITY
Generally selective, controlling most hardwoods
White pines are susceptible to hexazinone; loblolly pine is somewhat more susceptible than the other, generally resistant, southern yellow pines
Controls some grasses
SOIL ACTIVITY AND MOBILITY
Soil active; tends to be highly mobile in soil, especially porous soils with percolating water
Mobility is strongly influenced by soil texture; high clay or organic matter content retards movement and reduces efficacy
Application rates must be adjusted to suit soil texture
Do not apply to saturated or poorly drained soils
PERSISTENCE AND BREAKDOWN
Moderate half-life (1 – 6 months; typical = 90 days); breakdown is by soil microbes
TOXICITY TO HUMANS AND WILDLIFE
Low toxicity; rat oral LD_{50} is 1,690 mg/kg for the technical product
Velpar L has a LD_{50} of 4,120 mg/kg
APPLICATION TIMING
Used for site preparation and release in pine management, by broadcast (ULW) or soil spot (Velpar L, DF) treatment
May be used as a foliar spray or for injection (Velpar L, DF)
Hexazinone is a "spring" chemical, and is most effective when applied during periods of rapid plant growth and of frequent rainfall
APPLICATION TIMING
Soil treatments in the South are generally ineffective after mid-June
WEAKNESSES OR LIMITATIONS
Do not use where mobility in soil is likely to result in off-site movement (hillsides, etc.)
Creates a fairly rapid "brownup" which may be visually unacceptable
Broadcast treatments may cause some mortality in loblolly pine
Do not use on or under white which are very susceptible
Gives poor control of ash, yellow poplar, sourwood, hornbeam, and persimmon
Velpar L is formulated with an alcohol carrier which can cause permanent eye injury

Herbicide Quick Reference Guide

Invasive Species	Herbicides									
	Arsenal AC	Escort XP	Garlon 3A	Garlon 4	glyphosate	Krenite S	Pathfinder II	Transline	Vanquish	Velpar
Tree of Heaven	B,O		C	C,K	C,O	F				
Paulownia	B,O		C	C,K	C,O					
Tallow tree	B,O		O	C,K		F	O			
Autumn Olive	B,L			B,K	M				B	
Privet	B	H	M	K	E,M	P				
Oriental Bittersweet			C	C,K,N	C,N					
Japanese Honeysuckle		J	D	D,M	C,M					
Japanese Climbing Fern	B	I	C	C	C					
Cogongrass	C				C					
Nepalese Browntop					C					
Garlic Mustard					C					
Exotic Lespedezas		G		C	C			A		C
Japanese Knotweed			C,N	C,N	C,N					

A 0.2% foliar
B 1% foliar
C 2% foliar
D 3-5% foliar
E 3-5% foliar (dormant season only)
F 15-20% foliar
G 3/4 ounce/acre foliar
H 1 ounce/acre foliar
I 1-2 ounces/acre foliar
J 2 ounces/acre foliar
K 20% basal bark with oil and penetrant
L 10% cut stump/injection
M 20% cut stump/injection
N 25% cut stump/injection
O 20-50% cut stump/injection
P 50% cut stump/injection

States and Physiographic Regions



Appalachian/Cumberland Plateau
Coastal Plain
Ouachita Mountains
Piedmont
Blue Ridge Mountains
Interior Low Plateau
Ozark Plateau
Ridge and Valley

Species Distribution

Invasive Species	States and Physiographic regions												
	AL	AR	FL	GA	KY	LA	MS	NC	OK	SC	TN	TX	VA
Tree of Heaven	A,I,P,R	O,Z		B,P,R	A,C,I			B,P	O,Z	B,P	A,C,I,R		A,B,P,R
Paulownia	A,R	O,Z		B,R	A			B		B	A,R		A,B,R
Tallow tree	C	C	C	C		C	C	C		C		C	
Autumn Olive	A,I,P,R	O,Z		B,P,R	A,I			B,P	O,Z	B,P	A,I,R		A,B,P,R
Privet	A,C,I,P,R	C,O,Z	C	C,B,P,R	A,C,I	C	C	B,C,P	C,O,Z	B,C,P	A,C,I,R	C	A,B,C,P,R
Oriental Bittersweet	A,P,R	O,Z		B,P,R	A,C,I			B,P	O,Z	B,P	A,C,I,R		A,B,P,R
Japanese Honeysuckle	A,C,I,P,R	C,O,Z	C	C,B,P,R	A,C,I	C	C	B,C,P	C,O,Z	B,C,P	A,C,I,R	C	A,B,C,P,R
Japanese Climbing Fern	C,P		C	C,P		C	C	C		C		C	
Cogongrass	C,P	C	C	C,P		C	C	C,P	C	C,P	C	C	
Nepalese Browntop	A,I,P,R	O,Z		B,P,R	A,I			B,P	O,Z	B,P	A,I,R		A,B,P,R
Garlic Mustard	A,I,P,R	O,Z		B,P,R	A,C,I			B,P	O,Z	P,B	A,C,I,R		A,B,P,R
Exotic Lespedezas	A,C,I,P,R	C,O,Z	C	C,B,P,R	A,C,I	C	C	B,C,P	C,O,Z	B,C,P	A,C,I,R	C	A,B,C,P,R
Japanese Knotweed	A,R			B,R	A,I			B,P		B	A,I,R		A,B,P,R

A - Appalachian/Cumberland Plateau
B - Blue Ridge Mountains
C - Coastal Plain
I - Interior Low Plateau
O - Ouachita Mountains
P - Piedmont
R - Ridge and Valley
Z - Ozark Plateau

Invasive Species	Response to Disturbance			
	High Light	Soil Disturbance	Fire	Re-sprout/ re-grow
Tree of Heaven	Promoted	Promoted	Negligible	Yes
Paulownia	Promoted	Promoted	Promoted	Yes
Tallow tree	Promoted	Promoted	Discouraged	Yes
Autumn Olive	Promoted	Promoted	Promoted	Yes
Privet	Promoted	Promoted	Negligible	Yes
Oriental Bittersweet	Negligible	Promoted	Negligible	Yes
Japanese Honeysuckle	Promoted	Promoted	Negligible	Yes
Japanese Climbing Fern	Negligible	Promoted	Promoted	Yes
Cogongrass	Promoted	Promoted	Promoted	Yes
Nepalese Browntop	Promoted	Promoted	Discouraged	No
Garlic Mustard	Discouraged	Promoted	Discouraged	No
Exotic Lespedezas	Promoted	Promoted	Promoted	Yes
Japanese Knotweed	Promoted	Promoted	Negligible	Yes

Invasive Species	Seed Dispersal			
	Wind	Water	Bird	Soil contaminate
Tree of Heaven	Yes	No	No	No
Paulownia	Yes	No	No	No
Tallow tree	No	Yes	Yes	No
Autumn Olive	No	No	Yes	No
Privet	No	Yes	Yes	No
Oriental Bittersweet	No	Yes	Yes	No
Japanese Honeysuckle	No	No	Yes	No
Japanese Climbing Fern	Yes	Yes	No	Yes
Cogongrass	Yes	No	No	Yes
Nepalese Browntop	No	Yes	No	Yes
Garlic Mustard	No	Yes	No	Yes
Exotic Lespedezas	No	No	Yes	Yes
Japanese Knotweed	Yes	Yes	No	No

Invasive Species	Growth Habits				
	Form	Shade tolerant	Flood tolerant	Drought tolerant	Habitat
Tree of Heaven	Tree	Yes	Yes	Yes	Disturbed areas
Paulownia	Tree	No	Yes	Yes	Disturbed areas
Tallow tree	Tree	Yes	Yes	No	Varied
Autumn Olive	Shrub/tree	Somewhat	No	Yes	Open
Privet	Shrub/tree	Yes	Yes	No	Forests
Oriental Bittersweet	Vine	Yes	No	No	Open woods / Disturbed Areas
Japanese Honeysuckle	Vine	Yes	Yes	Yes	Varied
Japanese Climbing Fern	Vine	Yes	Yes	No	Varied
Cogongrass	Grass	Yes	No	Yes	Varied
Nepalese Browntop	Grass	Yes	Yes	No	Moist forests
Garlic Mustard	Herbaceous	Yes	Yes	No	Forests
Exotic Lespedezas	Semi-woody shrub	No	No	Yes	Open woods / Grasslands
Japanese Knotweed	Semi-woody shrub	No	Yes	Somewhat	Open

Invasive Species	Prescribed Fire		
	Control option	Hazard	Post-fire
Tree of Heaven	No	No	Rapid re-growth
Paulownia	No	No	Colonizes quickly
Tallow tree	Yes	No	Re-growth possible
Autumn Olive	No	No	Colonizes quickly
Privet	Yes	No	Rapid re-growth
Oriental Bittersweet	No	No	Re-growth possible
Japanese Honeysuckle	No	No	Rapid re-growth
Japanese Climbing Fern	No	Yes	Rapid re-growth
Cogongrass	No	Yes	Stimulates flowering
Nepalese Browntop	No	No	Establishes on bare soil
Garlic Mustard	Yes	No	Seed bank survival
Exotic Lespedezas	No	No	Scarifies seeds, high rates of germination
Japanese Knotweed	Not Available	No	Not Available

Invasive Species	Reproduction				
	Primary means	Time to Maturity	Max seeds	Seed Bank	Reproductive system
Tree of Heaven	Seed and Clonal	10 Years	300,000/plant	< 1year	Perennial
Paulownia	Seed	8-10 Years	20 million/plant	Not Available	Perennial
Tallow tree	Seed	3 Years	100,000/plant	7 years	Perennial
Autumn Olive	Seed	3-5 Years	66000/plant	Not Available	Perennial
Privet	Seed and Asexual	Not Available	100s/plant	< 1year	Perennial
Oriental Bittersweet	Seed	2 Years	2200/plant	< 1year	Perennial
Japanese Honeysuckle	Asexual and Seed	Not Available	222 g seeds/plant	< 1year	Perennial
Japanese Climbing Fern	Spore	Not Available	Not Available	Not Available	Perennial
Cogongrass	Seed and Rhizome	1 Year	3000/plant	< 6 months	Perennial
Nepalese Browntop	Seed	1 Year	1000/plant	3-5 Years	Annual
Garlic Mustard	Seed	2 Years	7900/plant	4-6 years	Biennial
Exotic Lespedezas	Seed and roor crowns	Not Available	300 million / acre	20+ years	Perennial
Japanese Knotweed	Asexual (mainly)	N/A	N/A	N/A	Perennial

Management Recommendations

Invasive Species	Silviculture Treatment					
	Harvest Activities	Prescribed Fire	Internal Road Construction	Mechanical Site Prep	Tree Planting	Release Treatments (Intermediate Treatments)
Tree of Heaven	b,d,e	d	d,e	b,d,e	d,e	b,d,e
Paulownia	a,b,d,f	d,f,i	d,f	b,d,f	d,f	b,d,f
Tallow tree	b,d,f,j	c,d	d,f,j	d,f,j	d,f	b,d,f,j
Autumn Olive	d,h	b,h	d,h	h	h	b,d,h
Privet	d,h,j	c,d,h	d,h,j	d,h,j	d,h	b,d,h,j
Oriental Bittersweet	b,d,h	d,h	d,h	b,d,h	d,h	b,d,h
Japanese Honeysuckle	d,h	c,d,h	d,h,j	c,h,j	d,h	b,d,h,j
Japanese Climbing Fern	d,f	b,f,g	d,f,j	d,f,j	d,f	b,d,f,j
Cogongrass	a,b,e,f	b,e,f,g	d,e,f	d,e,f	d,e,f	b,d,e,f
Nepalese Browntop	d,f,j	c,f	d,f,j	f,j	f	b,d,f,j
Garlic Mustard	d,f	c,d,f	d,f	c,f	c,d,f	b,d,f
Exotic Lespedezas	b,d,h	a,b,d,h	d,h	b,d,h	d,h	b,d,h
Japanese Knotweed	d,e,j	d	d,e,j	b,e,j	e	d,e,j

a - Conduct control measures before initiating silviculture treatment
b - Species is promoted by treatment, follow-up control measures may be needed
c - Treatment can reduce species population levels
d - Follow-up treatment by monitoring site for new infestations
e - Clean any equipment that contacts soil (plant is rhizome spread)
f - Clean all equipment thoroughly (plant is seed or spore spread)
g - Perform with caution, species increases fire risk
h - Monitor fencerows, edges, and SMZs for new infestations (bird dispersed)
i - Response of invasive depends upon timing of treatment, see species page for details
j - Species may be found in wetland, see herbicide table for label information

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