

General Principles for Controlling Nonnative Invasive Plants

The best defense against nonnative plant takeovers is constant surveillance of right-of-ways, streambanks, and internal roads and trails followed by effective control measures at the first appearance of new arrivals. Early detection and treatment will minimize efforts and costs that come with treating well-established plants or full-blown infestations. More effort is required for successful eradication of established infestations, but it still can be accomplished with proper treatments, although costs may be prohibitive. In severe cases, large-scale conversion of existing infestations is the only solution, involving eradication procedures that incorporate integrated management treatments and reestablishment of native plants. Fortunately, in southern forests native plants in the soil seed bank or plants from surrounding areas will naturally reestablish once the invaders are eliminated.

Effective Treatments

If an infestation is spotted or already occurs, then proper and aggressive eradication measures should be undertaken to avoid the inevitable spread. Continued treatment and retreatments will be necessary. Most nonnative invasive plants are perennials, having extensive tough roots and runners. This means that effective herbicide applications offer the best means of containment or eradication, because herbicides can kill roots and do so



Broadcast treatment of herbicide spray to kudzu.

without baring soil for reinvasion or erosion. To be successful with herbicide treatments:

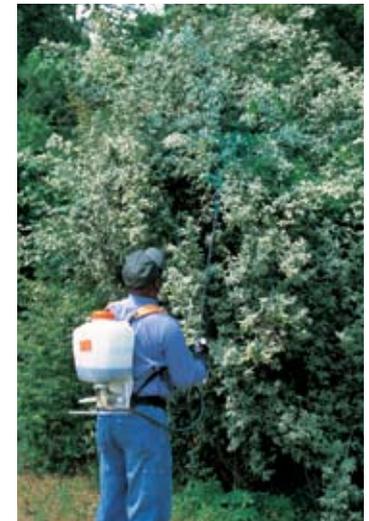
1. Use the most effective herbicide for the species.
2. Follow the application methods prescribed on the label.
3. Choose an optimum time period to apply treatments; for foliar-applied herbicides this is usually mid-summer to early fall and not later than a month before expected frost. Evergreens and semi-evergreens with leaves can be treated effectively in the winter.
4. Adhere to all label prohibitions, precautions, and Best Management Practices during herbicide transport, storage, mixing, and application.
5. Remember that some herbicides require up to a month or more before herbicidal activity is detectable as yellowing of foliage or leaves with dead spots or margins. Thus, after application, be patient; allow herbicides to work for several months before resorting to other treatment options.

Selective Herbicide Application Methods

Although treating extensive inaccessible infestations may require broadcast treatments of herbicide sprays or pellets by helicopter or tractor-mounted application systems, the best approach is usually selective applications of herbicides to target nonnative plants while avoiding or minimizing application to desirable plants. The selective methods described are directed foliar sprays, stem injection, cut-treat, basal sprays, and soil spots.

Directed Foliar Sprays

Directed foliar sprays are herbicide-water sprays aimed at target plant foliage to cover all leaves to the point of run off, usually applied with a backpack sprayer (use low pressure, drift retardants, and spray shields to avoid drift). Herbicide application by directed foliar spray is the most cost-effective method for treating most types of invasive plant species. With this method, herbicides are thoroughly mixed in water,



Directed foliar sprays with a backpack sprayer.



A spray shield fashioned from a used gallon milk jug (bottom removed and cap bored.)



Spray gun with swivel that holds two tips—narrow and wide angle.

often with a non-ionic surfactant, and applied to the foliage and growing tips of woody plants or to completely cover herbaceous plants. Foliar sprays are usually most effective when applied from midsummer to late fall, although spring and winter applications have use on specific plants and situations. Selective treatment is possible because the applicator directs the spray towards target plants and away from desirable plants. The addition of a water-soluble dye can assist in tracking treatment and detecting spray drift on desirable plants. Although dyes are messy and short-lived as a visible marker, they are helpful in training and tracking critical applications. Another safeguard is to only use foliar active herbicides, because directed sprays of soil-active herbicides can damage or kill surrounding plants when their roots are within the treatment zone. Never use herbicides with soil activity to treat invasive plants under desirable trees or shrubs.

Directed sprays are usually applied with a backpack sprayer and a spray wand equipped with a full cone, flat fan, or adjustable cone spray tip. These tips and spraying pressures of 20 to 30 pounds per square inch can ensure



Higher spray heights achieved with narrow-angle nozzle, wand extension, and higher pressure.

productivity with only a few fine droplets that may drift to surrounding plants. To safeguard surrounding plants from damage by spray drift, suspend applications during windy conditions. A spray shield that attaches to the end of the wand can further minimize drift. Adding a drift retardant to the spray mixture can eliminate drift although effectiveness may be diminished.

Plants up to 6 feet tall can be treated with this equipment, while the addition of a commercially available wand extension can slightly increase height capabilities. To treat plants up to about 18 feet tall, use higher spray pressures with a straight-stream or narrow flat fan tip.

Directed foliar sprays are also applied using wands on hoses attached to spraying systems mounted on all-terrain vehicles, trucks, or tractors. Also, a spray gun with a narrow flat fan tip can replace a wand for some applications. Another useful alternative for treating different sized woody plants is a spray gun with a swivel that holds two tips—narrow and wide-angled—that can be quickly changed during application.

Stem Injection

Stem injection (including hack-and-squirt) involves herbicide concentrate or herbicide-water mixtures applied into downward incision cuts spaced around woody stems made by an ax, hatchet, machete, brush ax, or tree injector. Tree injection, including the hack-



A



B

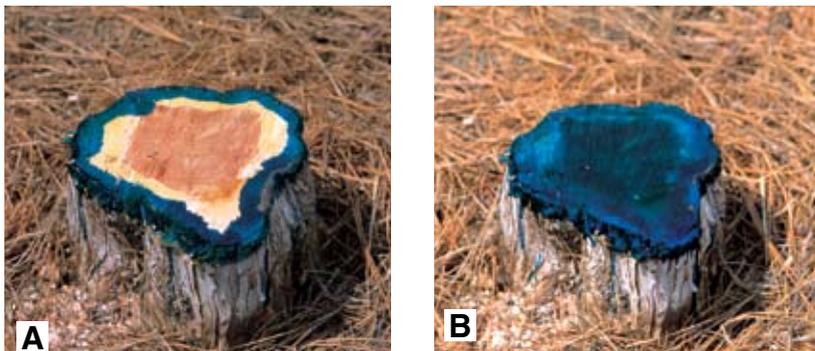
Stem injection using a hatchet and spray bottle for hack-and-squirt (A) and a tree injector (B).

and-squirt technique, is a selective method of controlling larger trees and shrubs (more than 2 inches in diameter) with minimum damage to surrounding plants. It requires cuplike downward incisions spaced around the stem with a measured amount of herbicide applied into each of the incisions. Special tree injectors are available to perform this operation, or a narrow-bit ax, hatchet, or machete along with a spray bottle can be used in sequence to perform the hack-and-squirt method. Completely frilling the stem with edge-to-edge cuts or injections is required for very large stems or difficult-to-control species. The herbicide should remain in the injection cut to avoid wasting herbicide on the bark and to prevent damage of surrounding plants. All injected herbicides can be transferred to untreated plants by root grafts and uptake of root exudates. Herbicides with soil activity can damage nearby plants when washed from incisions into the soil by unexpected rainfall soon after application. Avoid injection treatments if rainfall is predicted within 48 hours.

Tree injection treatments are most effective when applied in late winter and throughout the summer. Heavy spring sap flow in spring can wash herbicide from incision cuts, making this an ineffective period.

Cut-Treat

Cut-treat involves herbicide concentrates or herbicide-water mixtures applied to the outer circumference of freshly cut stumps or the entire top surface of cut stems, applied with a backpack sprayer, spray bottle, wick, or paint brush. Freshly cut stems and stumps of woody stems, including canes and bamboo, can be treated with herbicide mixtures to prevent resprouting and to kill roots. Cutting is usually by chainsaw or brush saw, but can be accomplished by handsaws or cutting blades. To minimize deactivation of the herbicide, remove sawdust from stumps before treatment. Treat stems and stumps as quickly as possible after cutting with a



Cut-treat the circumference of large stems (A) and the entire top of small stems (B).

backpack sprayer or utility spray bottle for spray applications or a wick applicator, lab wash bottle, or paintbrush for small stems. Add a non-ionic surfactant to the mix to aid in penetration, if permitted by the label.

For stumps over 3 inches in diameter, completely wet the outer edge with the herbicide or herbicide mixture. Completely wet the tops of smaller stumps and all cut stems in a clump. Apply a basal spray mixture of herbicide, oil, and penetrant to stumps that have remained untreated for over 2 hours or use Pathfinder II and wet stump sides too.

The most effective time for the stump spray method is late winter and summer. Although winter treatments are slightly less effective than growing season applications, the absence of foliage on cut stems and branches produces some offsetting gains in application efficiency.

Basal Sprays

Basal sprays are herbicide-oil-penetrant mixtures sprayed or daubed onto the lower portion of woody stems, usually applied with a backpack sprayer or wick applicator. Full basal treatments require that the lower 12 to 20 inches of target woody stems be completely wetted on all sides with an oil-based spray mixture. Application is to smooth juvenile bark. Full basal sprays are usually effective in controlling woody stems less than about 6 inches in diameter or larger diameters of susceptible species, before bark becomes thick, corky, and furrowed. The appropriate equipment for this treatment is a backpack sprayer with a wand or spray gun fitted with a narrow-angle flat fan, cone, or adjustable tip. A wick applicator can also be used. Herbicides that are soluble in oil (mainly Garlon 4) are mixed with a commercially available basal oil, vegetable oil, crop oil, diesel fuel, or kerosene often adding a special penetrant. Some herbicides, such as Pathfinder II and Vine-X, are sold ready-to-use with these ingredients.

A modified method, streamline basal sprays, is effective for many woody species up to 2 inches in diameter, as well as trees and shrubs up to 6 inches in diameter if the species is susceptible. Equipment for this



Basal sprays applied by spray gun and straight-stream nozzle to low stem.



Basal spray mixture applied by a wick applicator to safeguard nearby plants.

treatment is a backpack sprayer with a spray gun and a low-flow straight-stream or narrow-angle spray tip. To prevent waste, maintain pressure below 30 pounds per square inch with a pressure regulator. At this pressure, an effective reach of 9 feet is possible while bark splash is minimized. For treating stems less than 2 inches in diameter, apply the stream of spray up-and-down single stems for about 6 to 8 inches, or apply across multiple stems creating 2- to 3-inch-wide bands. This same multiple-band treatment can be effective on larger stems. Direct the spray stream to smooth juvenile bark at a point about 4 to 18 inches from the ground. Stems that are thick barked or near 3 inches in diameter require treatment on all sides.

Applications are usually in late winter and early spring, when leaves do not hinder spraying the stem. Summer applications are effective but more difficult. Avoid ester herbicide formulations on hot days to prevent vapor drift injury to nontarget plants.

Soil Spots

Soil spots are Velpar L herbicide applied as metered amounts to the soil surface around target woody stems or in a grid pattern for treating many stems in an area; they are usually applied with a spot gun or with a backpack sprayer equipped with a straight-stream nozzle. Spots of soil-active herbicide (mainly Velpar L) are applied to the soil surface in grid patterns or around target woody stems. This method requires exact amounts and



Soil spots applied as metered herbicide amounts to the soil surface.

prescribed spacings that are specified on the herbicide label or label supplements. It is only effective on specific nonnative plant species and usually only when applied in spring and early summer. Equipment is a special spot gun, utility spray bottle, or a backpack sprayer with a spray gun equipped with a straight-stream spray tip.

Selecting an Effective Herbicide

Only herbicides registered by the U.S. Environmental Protection Agency for forestry use and noncroplands in the Southern States will be discussed here, although herbicides for other “land use areas,” such as right-of-ways, pastures, and rangelands, may be just as effective or may contain the same active ingredient. The herbicides that will be identified by trade name (and common active-ingredient name) are:

Foliar active (mostly) herbicides

Glyphosate herbicides (glyphosate) such as: Accord Concentrate, Gly-Flo Herbicide, and etc.
 Garlon 3A (triclopyr)
 Garlon 4 (triclopyr)
 Krenite S (fosamine)
 Pathfinder II (triclopyr)
 Milestone VM (aminopyralid)

Foliar and soil-active herbicides

Arsenal AC (imazapyr)
 Escort XP (metsulfuron)
 Pathway (2,4-D + picloram)
 Plateau (imazapic)
 Tordon 101 (2,4-D + picloram)
 Tordon K (picloram)
 Transline (clopyralid)
 Vanquish (dicamba)
 Velpar L (hexazinone)

Because nonnative invasive plants are usually difficult to control, selecting the most effective herbicide(s) is important. Often herbicides that have both soil and foliar activity are most effective with the least number of applications. However, applying herbicides with soil activity can damage desirable plants when their roots are present within the treatment zone or when herbicides move downhill to untreated areas following heavy rainfall. Garlon herbicides are mainly foliar active, but they have some soil activity at high rates or when mixed with oils. Garlon 4 and Vanquish can volatilize at high temperatures and their residues can move by air currents to affect surrounding plants; therefore, avoid application on days when temperatures exceed 80° F. If possible, also avoid applications when rainfall is anticipated within 8 hours, unless soil activation is needed, and during periods of severe drought as effectiveness can be reduced during these times.

When possible, use selective herbicides that target specific nonnative species, such as Transline that controls mainly legumes and composites, and minimize damage to surrounding desirable plants even though they receive herbicide contact. Minimizing damage to desirable cohorts can also be achieved by making applications when the cohorts are dormant. For example, apply basal sprays to the bark of invasives in late winter before most other plants emerge, or foliar spray evergreen or semievergreen invasives after surrounding plants have entered dormancy. Remember that desirable woody plants can be damaged through transfer of herbicides by

root exudates following stem injection and cut-treat treatments or when soil-active herbicides wash off treated stems. Damage to surrounding native plants can be minimized with care and forethought during planning and application.

Read and thoroughly understand the herbicide label and its prohibitions before and during use. Many herbicides require the addition of a non-ionic surfactant to the spray tank. Always use clean water in a herbicide mixture and mix spray solutions thoroughly before applying. Do not mix in the sprayer but in a bucket with a stirring stick—stirring for several minutes or more—before transferring to the sprayer. Water that is highly basic (pH greater than 6) and contains high amounts of calcium and magnesium interferes with glyphosate herbicide effectiveness, requiring the addition of ammonium sulfate or appropriate additives. When changing from a water-based mix to an oil-based mix in a backpack sprayer, thoroughly evacuate the water from the pump and run a small amount of oil through the pumping system before filling with the oil-based mix, otherwise, a white sludge will clog the sprayer. And, always wear personal protective equipment prescribed on the label and in supplementary materials.

Other Treatments for an Integrated Approach

Overgrazing is a way to reduce the vigor of palatable invasive plants like kudzu, but this rarely yields eradication and may spread seeds (as with tropical soda apple). Mechanical treatments and prescribed burning can assist eradication measures, but are limited in effectiveness. Prescribed burning cannot control rootcrowns or rhizomes of perennial plants and usually only deadens small aboveground shoots, providing only temporary aboveground control. In a similar way, cutting woody plants (by chainsaw and brush saw felling or brush mowing) and mowing vines and herbs without killing roots remove only aboveground plant parts. Mechanical root raking and disking can actually intensify and spread infestations of invasive plants with runners by chopping them into resprouting segments and transporting them on the equipment. Fireplows can also spread invasive plant rhizomes and roots.



Overgrazing for kudzu control.

However, root raking, piling, brush mowing, or burning may be the only way to start controlling dense infestations of multiple woody invasive plants. Small infestations may respond to hand pulling, grubbing with a stout hoe, or shrub pulling with newly introduced devices. Hand pulling or grubbing may be the quickest and easiest way to halt invaders when first spotted and stop them from gaining a foothold. String trimmers can reduce infestation densities and injure thick waxy leaves to improve herbicide uptake and effectiveness.



Hand pulling privet.

Although ineffective by themselves to achieve eradication, both mechanical and burning treatments can give added kill of herbicide-weakened plants and have a place in an integrated pest management program. The stumps and stems of nonnative trees, shrubs, and bamboos can be treated with herbicides immediately after cutting to kill roots. Resprouts of trees, shrubs, and vines that are topkilled by burning or brush mowing can be more easily treated with foliar sprays, often the most cost-effective way to use herbicides. Herbicide applications should be delayed after burning, disking, or mowing to permit adequate resprouting of target plants and, thereby maximizing herbicide uptake and effectiveness. Prescribed burning can also destroy invasive plant seeds (and bulbils of air yams) and often stimulate germination for efficient herbicide



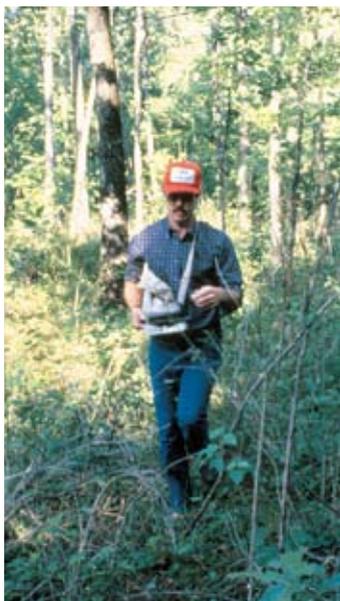
Prescribed burn.



Wildland disk.

control treatments. Burning can prepare the site for effective herbicide applications by clearing debris and revealing application hazards, such as old wells and pits. Disking and root raking, if applied correctly, can dislodge herbicide-damaged woody roots and large runners, leaving them to dry and rot. With mechanical and burning treatments, take precautions, such as burning in late winter or spring leaf-out, to minimize the period of bare soil. The most effective time for controlling woody invasive plants and their germinants with fire is after plants have initiated growth in spring.

An eradication program for infestations of invasive plants usually requires several years of treatment and many more years of surveillance to check for rhizome sprouts, root sprouts, seed germination, or new invasions. Following these steps in a planned manner and with persistence is the only successful strategy to safeguard land access, productivity, native plants, and suitable habitats for wildlife.



Sowing native plant seed.

The Rehabilitation Phase

Rehabilitation is the most important final phase of an integrated invasive plant eradication and reclamation program. The rehabilitation phase requires establishment and/or release of fast-growing native plants that can outcompete and outlast any surviving nonnative plants while stabilizing and protecting the soil. If the soil seed bank remains intact, native plant communities may naturally reinitiate succession after eradication of nonnative plants. Light-seeded native species are usually present in the seed bank while heavier seeded plants will gradually be deposited on a site by birds and other animals. In recent years, native plant seed and seedlings have become increasingly available for rehabilitation sowing and planting, but a limited number of

species and absence of well-developed establishment procedures often hinder use. Tree nurseries operated by State forestry agencies are a good source of many species of native trees and shrubs. Often it is necessary to establish fast-growing tree species during the later control phase to hinder reestablishment of shade intolerant nonnative invasive plants. Reestablishing native grasses and forbs is equally important. These species are available from commercial nurseries specializing in native plants, utilizing local sources when possible. Native plant seeds will require proper treatments to assure timely germination. Seedling native plants can be also collected and transplanted from suitable field sites. Their establishment will be more challenging than the commonly available nonnative plants so often used for soil stabilization and wildlife food plots. Constant surveillance, maintaining forest vigor with minimal disturbance, treatment of new unwanted arrivals, and finally rehabilitation following eradication are critical to preventing and controlling invasions on a specific site.



Containerized native plants for rehabilitation plantings.

Prescriptions for Specific Nonnative Invasive Plants

The following are herbicide prescription summaries for prevalent invasive plants, detailing mainly selective application treatments. These prescriptions have been assembled from published research results, unpublished trials, State reports, weed council manuals, magazines, and Web sites. In general, very few species-specific experiments have been reported that compare a full array of treatments for nonnative invasive plant species. But until further specific understanding is gained, we must proceed with current knowledge and technology to combat this invasion. Herbicides are mentioned in order by effectiveness when comparative information is available or alphabetically when such information is lacking. Remember to follow the label-specified maximum herbicide amounts that are permissible for an acre of land when using selective application treatments.

Nonnative Trees

Nonnative tree species hinder reforestation and management of right-of-ways and natural areas as well as dramatically altering habitats. Some occur as scattered trees while others form dense stands. Most spread by prolific seed production and abundant root sprouts. They can be eliminated with herbicides by stem injection, cut-treat, and soil spots, with basal and foliar sprays for seedlings and saplings. Following stem control, total elimination requires surveillance and treatment of root sprouts and plant germinants that originate from the soil seed bank.



Tree-of-Heaven, *Ailanthus*

Tree-of-heaven or ailanthus (*Ailanthus altissima*) is a deciduous tree to 80 feet (25 m) tall with long pinnately compound leaves, gray slightly fissured bark, and large terminal clusters of greenish flowers in early summer. Flowers and other parts of the plant have a strong odor.

Viable seed are produced by 2- to 3-year-old plants. Immature appearing seeds are capable of germination. Root sprouts may appear after the main stem is deadened, and root segments left in soil after pulling treatments will sprout. Tree-of-heaven sprouts have been found to have 10 to 14 feet (3 to 4 m) of first year height growth, while seedlings can grow 3 to 6 feet (1 to 2 m) in the first year. This vigorous growth can continue for 4 or more years.

* Nontarget plants may be killed or injured by root uptake.

† Transline controls a narrow spectrum of plant species.

Recommended control procedures:

Large trees. Make stem injections and then apply Garlon 3A, Pathfinder*, Pathfinder II, or Arsenal AC* in dilutions and 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 basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene (2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II 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.



Silktree, *Mimosa*

Silktree or mimosa (*Albizia julibrissin*) is a small legume tree to 10 to 50 feet (3 to 15 m) tall that reproduces by abundant seeds and root sprouts. It has feathery deciduous leaves, smooth light-brown bark, and showy pink blossoms that yield dangling flat pods. Seedpods float and seed remain viable for many years.

Recommended control procedures:

Large trees. Make stem injections using Arsenal AC* or Garlon 3A in dilutions as 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 basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene (2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II 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—Garlon 3A, Garlon 4, or glyphosate herbicide as a 2-percent solution (8 ounces per 3-gallon mix)
- July to September—Transline† as a 0.2- to 0.4-percent solution (1 to 2 ounces per 3-gallon mix)



Princesstree, Paulownia

Princesstree or paulownia (*Paulownia tomentosa*) is a deciduous tree to 60 feet (18 m) tall with large heart-shaped leaves that are fuzzy hairy on both sides and pecan-like nuts in clusters (containing many tiny winged seeds) following showy pale-violet flowers in early spring. Stump sprouts and root sprouts may eventually emerge after main stems are deadened.

Recommended control procedures:

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 basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene (2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II 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-gallon mix); a glyphosate herbicide, Garlon 3A, or Garlon 4 as a 2-percent solution (8 ounces per 3-gallon mix).



Chinaberrytree

Chinaberrytree (*Melia azedarach*) is a deciduous tree growing to about 50 feet (15 m) tall. It has lacy, many-divided leaves that are dark green and blue flowers in spring that yield round yellow fruit that persist during winter. Stump sprouts and root sprouts may eventually emerge after main stems are deadened.

Recommended control procedures:

Trees. Make stem injections using Arsenal AC* , Pathway* , Pathfinder II, or Garlon 3A 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 basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene (2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II to young bark as a basal spray.

*Nontarget plants may be killed or injured by root uptake.

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



Tallowtree, Popcorn tree

Tallowtree or popcorn tree (*Triadica sebifera*, formerly *Sapium sebiferum*) is a deciduous tree growing to 60 feet (18 m) tall that has heart-shaped leaves turning scarlet in fall, long drooping flowers in spring, and bundles of white waxy “popcorn-like” seeds in fall and winter. Three-year-old plants can produce viable seed and small seedlings can be easily hand pulled. Burning results in abundant seedlings.

Recommended control procedures:

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 the herbicides to stem and stump tops immediately after cutting (at least a 10-percent solution for Garlon 3A). Ortho Brush-B-Gone (triclopyr) and Enforcer Brush Killer (triclopyr) are effective for treating cut stumps and readily available to homeowners in retail garden stores. 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 basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene (2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II 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).



Russian Olive

Russian olive (*Elaeagnus angustifolia*) is a small thorny tree to 35 feet (10 m) tall that has microscopic silvery scales covering leaves, twigs, and fruits. Leaves are long and narrow with entire margins. Bark is fissured and reddish brown. Olive-like fruit are yellow and appear in late summer to fall.

Recommended control procedures:

Trees. Make stem injections using Arsenal AC* or Garlon 3A in dilutions and cut spacings specified on the herbicide label (anytime except March and April). For felled trees, apply the herbicides to stem and stump tops immediately after cutting.

Saplings. Apply Garlon 4 as a 20-percent solution in basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene (2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II 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 in water (4 ounces per 3-gallon mix); a glyphosate herbicide, Garlon 3A, or Garlon 4 as a 2-percent solution in water (8 ounces per 3-gallon mix) for directed spray treatments that have limited or no soil activity.

Nonnative Shrubs

Nonnative shrubs often occur with nonnative tree species and present similar problems. Herbicide control options are similar to trees, with the exception that foliar sprays can be used more often and are more effective. All are shade tolerant with bird-dispersed seeds resulting in scattered plants under existing forest canopies (except nonnative roses), which requires additional surveillance within the interior of forest stands.



Silverthorn, Thorny Olive

Silverthorn or thorny olive (*Elaeagnus pungens*) is an evergreen, densely bushy shrub 3 to 25 feet (1 to 8 m) in height. It has long limber projecting shoots, scattered thorny, dense alternate leaves silver scaly in spring on both top and bottom becoming dark green above and silvery beneath by midsummer. Oblong fruit red and brown scaly appear in spring.

Recommended control procedures:

- Thoroughly wet all leaves with Arsenal AC* or Vanquish* as a 1-percent solution in water (4 ounces per 3-gallon mix) with a surfactant; Garlon 3A and Garlon 4 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, diesel fuel, or kerosene (2.5 quarts

*Nontarget plants may be killed or injured by root uptake.

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).



Autumn Olive

Autumn olive (*Elaeagnus umbellata*) is a tardily deciduous bushy leafy shrub, 3 to 20 feet (1 to 6 m) in height, with scattered thorny branches. It has alternate leaves green above and silvery scaly beneath, with many red berries in fall having silvery scales.

Recommended control procedures:

- Thoroughly wet all leaves with Arsenal AC* or Vanquish* 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 basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene (2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II 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).



Winged Burning Bush

Winged burning bush (*Euonymus alata*) is a deciduous, wing-stemmed, bushy shrub to 12 feet (4 m) in height, multiple stemmed and much branched, canopy broad and leafy. It has small and obovate opposite leaves, green turning bright scarlet to purplish red in fall, along stems with four corky wings. Many orange fruit appear as stemmed pairs in leaf axils and turning purple in fall.

Recommended control procedures:

- Thoroughly wet all leaves with Arsenal AC* or Vanquish* 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 basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene

(2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II 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).



Chinese Privet, European Privet

Chinese privet (*Ligustrum sinense*) and European privet (*L. vulgare*) are difficult to distinguish except at flowering, both are evergreen to semievergreen. Both are thicket-forming shrubs to 30 feet (9 m) in height that are soft woody, multiple stemmed with long leafy branches and

opposite leaves less than 2 inches long. Showy clusters of small white flowers in spring yield clusters of small ovoid, dark-purple berries during fall and winter.

Recommended control procedures:

■ Thoroughly wet all leaves with one of the following herbicides in water with a surfactant (August to March): a glyphosate herbicide as a 3-percent solution (12 ounces per 3-gallon mix) or Arsenal AC* as a 1-percent solution (4 ounces per 3-gallon mix).

■ For stems too tall for foliar sprays, apply Garlon 4 as a 20-percent solution in basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene (2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II 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. 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.



Japanese Privet, Glossy Privet

Japanese privet (*Ligustrum japonicum*) and glossy privet (*L. lucidum*) are evergreen to 35 feet (10 m) in height, with an upward spreading canopies. They have thick leathery opposite leaves 2 to 4 inches (5 to 10 cm) long, and hairless leaves and stems. Clusters of small showy white flowers in spring yield small rounded green to purple fruit.

Recommended control procedures:

■ Thoroughly wet all leaves with one of the following herbicides in water with a surfactant (August through March): Arsenal AC* as a 1-percent solution (4 ounces per 3-gallon mix); Garlon 4 as a 3-percent solution (12 ounces per 3-gallon mix); or a glyphosate herbicide as a 3-percent solution (12 ounces per 3-gallon mix).

■ For stems too tall for foliar sprays, apply Garlon 4 as a 20-percent solution in basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene (2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II to young bark as a basal spray (January to February or May to October). 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. When safety to surrounding vegetation is desired, immediately treat stumps and cut stems with a glyphosate herbicide or Garlon 3A as a 20-percent solution in water (2.5 quarts per 3-gallon mix) with a surfactant.



Bush Honeysuckles

Amur honeysuckle (*Lonicera maackii*), Morrow's honeysuckle (*L. morrowii*), Tatarian honeysuckle (*L. tatarica*), and sweet-breath-of-spring (*L. fragrantissima*) are all tardily deciduous, upright, arching-branched shrubs. Amur is to 30 feet (9 m) in height and spindly in forests, Morrow's is to 6.5 feet (2 m) in height, and Tatarian and sweet-breath-of-spring are to 10 feet (3 m) in height. All are much branched

and arching in openings, multiple stemmed, with dark-green oval-to-oblong distinctly opposite leaves 0.8 to 2.4 inches (2 to 6 cm) long. Fragrant showy tubular white-to-pink or yellow paired flowers appear from May to June. Abundant paired berries are red to orange during winter. Seeds are long-lived in the soil.

Recommended control procedures:

■ Thoroughly wet all leaves with glyphosate herbicide as a 2-percent solution in water (8 ounces per 3-gallon mix) with a surfactant (August to October). Or, apply Garlon 4 as a 20-percent solution in basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene (2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II to young bark as a basal spray.

■ For stems too tall for foliar sprays, 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).

*Nontarget plants may be killed or injured by root uptake.



Sacred Bamboo, *Nandina*

Sacred bamboo or nandina (*Nandina domestica*) is an evergreen erect shrub to 8 feet (2.5 m) in height, with multiple bushy stems resembling bamboo, glossy pinnately to bipinnately compound green or reddish leaves. Early summer terminal clusters of tiny white-to-pinkish flowers yield dangling clusters of red berries in fall and winter.

Recommended control procedures:

- Thoroughly wet all leaves with glyphosate herbicide as a 1-percent solution in water (4 ounces per 3-gallon mix) with a surfactant (August to October). Or, apply Garlon 4 as a 20-percent solution in basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene (2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II to young bark as a basal spray.
- For stems too tall for foliar sprays, 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).
- Collect and destroy fruit.



Nonnative Roses

Multiflora rose (*Rosa multiflora*), Macartney rose (*R. bracteata*), Cherokee rose (*R. laevigata*), and other nonnative roses are all evergreen except multiflora and are all erect, arching, or trailing shrubs to 10 feet (3 m) in height or long, clump forming. They have pinnately compound leaves with three to nine leaflets, frequent recurved or straight thorns. Clustered or single white-to-pink flowers in early summer yield red rose hips in fall to winter.

Recommended control procedures:

- Thoroughly wet all leaves with one of the following herbicides in water with a surfactant: April to June (at or near the time of flowering)—Escort* at 1 ounce per acre in water (0.2 dry ounces per 3-gallon mix); August to October—Arsenal AC* as a 1-percent solution (4 ounces per 3-gallon mix) or Escort* XP at 1 ounce per acre in water (0.2 dry ounces per 3-gallon mix); May to October—repeated applications of a glyphosate herbicide as a 4-percent solution in water (1 pint per 3-gallon mix), a less effective treatment that has no soil activity to damage surrounding plants.

*Nontarget plants may be killed or injured by root uptake.

- For stems too tall for foliar sprays, apply Garlon 4 as a 20-percent solution in basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene (2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II 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).

Nonnative Vines

Nonnative vines are some of the most troublesome invaders because they often form the densest infestations, making herbicide applications difficult. Many of these vines overtop even mature forests and often form mixed-species infestations with nonnative trees and shrubs. Specific herbicides can be effective on certain vines while not controlling, but actually releasing any underlying nonnative trees and shrubs. In these situations, select the best herbicide or herbicide mixture for controlling all the nonnative species in a mixed-species infestation. Vine control is always difficult because foliar active herbicides must move through lengthy vines to kill large unseen woody roots and tubers. Thus, herbicides that have both soil and foliar activity are often the most effective. Only the lower foliage within sprayer reach needs to be treated with a herbicide having both foliar and soil activity. With all herbicides, spray foliage of climbing stems as high as possible and if not controlled, then cut vines before retreatment.



Oriental Bittersweet

Oriental bittersweet (*Celastrus orbiculatus*) is an attractive but very invasive deciduous, twining, and climbing woody vine to 60 feet (20 m) with drooping branches in tree crowns, forming thicket and arbor infestations. It has alternate elliptic-to-rounded leaves 1.2 to 5 inches (3 to 12 cm) long. Its axillary dangling clusters of inconspicuous yellowish flowers yield green spherical fruit that split to reveal three-parted showy scarlet fleshy covered seeds, which remain through winter at most leaf axils.

Recommended control procedures:

- 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 3-percent solution (12 ounces per 3-gallon mix).
- For stems too tall for foliar sprays, apply Garlon 4 as a 20-percent solution in basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene

(2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II as a basal spray 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).



Climbing Yams

Air yam (*Dioscorea bulbifera*), Chinese yam or cinnamon vine (*D. oppositifolia*, formerly *D. batatas*), and water yam (*D. alata*) are herbaceous, high climbing vines to 65 feet (20 m) that cover shrubs and trees in infestations. They have twining and sprawling stems with long-petioled smooth heart-shaped leaves and dangling potato-like tubers (bulbils) that appear at leaf axils and drop to form new plants. Aerial tubers spread down slope by gravity and by water. All species also have large underground tubers that make control difficult.

Recommended control procedures:

- Thoroughly wet all leaves with one of the following herbicides in water with a surfactant (July to October): Garlon 3A or Garlon 4 as a 2-percent solution (8 ounces per 3-gallon mix). Sometimes the air yams take up the herbicide; otherwise, they must be collected and destroyed (not composted).
- Cut climbing plants just above the soil surface and immediately treat the freshly cut stem with undiluted Garlon 3A (safe to surrounding plants).



Winter Creeper, Climbing Euonymus

Winter creeper or climbing euonymus (*Euonymus fortunei*) is an evergreen shrub to 3 feet (1 m) in height and woody trailing vine to 40 to 70 feet (12 to 22 m) that forms a dense ground cover and climbs by clinging aerial roots along the stem. It has leaves that are opposite, thick, and dark green or green-white variegated on green stems. Pinkish-to-red capsules split open in fall to expose orange fleshy covered seeds.

Recommended control procedures:

- Thoroughly wet all leaves (until runoff) with one of the following herbicides in water with a surfactant (July to October for successive years): Tordon 101*[‡] as a 3-percent solution (12 ounces per 3-gallon mix) or Tordon K*[‡] as a 2-percent solution (8 ounces per 3-gallon mix).

* Nontarget plants may be killed or injured by root uptake.

[‡] When using Tordon herbicides, rainfall must occur within 6 days after application for needed soil activation. Tordon herbicides are Restricted Use Pesticides.

- Or, repeatedly apply Garlon 4 or a glyphosate herbicide as a 4-percent solution (1 pint per 3-gallon mix) in water with a surfactant, a less effective treatment that has no soil activity to damage surrounding plants.

- Cut all vertical climbing stems to prevent fruiting and spread by birds.



English Ivy

English ivy (*Hedera helix*) is an evergreen vine climbing to 90 feet (28 m) that forms dense ground cover and climbs by aerial roots. It has thick dark-green leaves with whitish veins when juvenile that are heart-shaped with three to five pointed lobes, later becoming broadly lanceolate, and terminal flower clusters in summer that yield dark-purple berries in winter and spring.

Recommended control procedures:

- Thoroughly wet all leaves (until runoff) with one of the following herbicides in water with a surfactant (July to October for successive years): Garlon 3A or Garlon 4 as a 3- to 5-percent solution (12 to 20 ounces per 3-gallon mix) or a glyphosate herbicide as a 4-percent solution (1 pint per 3-gallon mix). Use a string trimmer to reduce growth layers and injure leaves for improved herbicide uptake. Cut large vines and apply these herbicides to cut surfaces.
- Or, apply Garlon 4 as a 20-percent solution in basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene (2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II as a basal spray to large vines being careful to avoid the bark of the host tree.



Japanese Honeysuckle

Japanese honeysuckle (*Lonicera japonica*) is a semievergreen to evergreen woody vine, high climbing and trailing to 80 feet (24 m), branching and often forming arbors in forest canopies and/or ground cover under canopies. It has opposite leaves and long woody rhizomes that sprout frequently and make control difficult.

Recommended control procedures:

- 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) 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.



Kudzu

Kudzu (*Pueraria montana*) is a deciduous twining, trailing, mat-forming, woody leguminous vine 35 to 100 feet (10 to 30 m) with lobed three-leaflet leaves. Large root crowns that increase in size with age are difficult to control. Prescribed burning in spring can clear debris, sever climbing vines, and reveal hazards before summer applications.

Recommended control procedures:

- Thoroughly wet all leaves (until runoff) with one of the following herbicides in water with a surfactant: July to October for successive years when regrowth appears—Tordon 101^{*†} as a 3-percent solution (12 ounces per 3-gallon mix) or Tordon K^{*‡} as a 2-percent solution (8 ounces per 3-gallon mix), either by broadcast or spot spray—spraying climbing vines as high as possible. July to September for successive years—Escort^{*} XP at 3 to 4 ounces per acre in water (0.8 to 1.2 dry ounces per 3-gallon mix)—or when safety to surrounding vegetation is desired, Transline[†] as a 0.5-percent solution in water (2 ounces per 3-gallon mix); spray climbing vines as high as possible or cut vines that are not controlled after herbicide treatment.
- For partial control, repeatedly apply Garlon 4 or a glyphosate herbicide as a 4-percent solution in water (1 pint per 3-gallon mix) with a surfactant during the growing season. Cut large vines and immediately apply these herbicides to the cut surfaces. Or, apply Garlon 4 as a 20-percent solution in basal oil, vegetable oil, crop oil concentrate, diesel fuel, or kerosene (2.5 quarts per 3-gallon mix) or apply undiluted Pathfinder II as a basal spray to large vines as a basal spray (January to April), which controls vines less than 2 inches in diameter.

^{*}Nontarget plants may be killed or injured by root uptake.

[†]Transline controls a narrow spectrum of plant species.

[‡]When using Tordon herbicides, rainfall must occur within 6 days after application for needed soil activation. Tordon herbicides are Restricted Use Pesticides.



Vincas, Periwinkles

Common periwinkle (*Vinca minor*) and bigleaf periwinkle (*V. major*) are evergreen to semievergreen (leaves always present) somewhat-woody, trailing or scrambling vines to 3 feet (1 m) long and upright to 1 foot (30 cm) that form dense ground cover. They have opposite lanceolate-to-heart-shaped leaves and five-petaled pinwheel-shaped violet single flowers. Viable seed appear to be produced only rarely.

Recommended control procedures:

- Thoroughly wet all leaves (until runoff) with one of the following herbicides in water with a surfactant (July to October for successive years): Tordon 101^{*†} as a 3-percent solution (12 ounces per 3-gallon mix), Tordon K^{*‡} as a 2-percent solution (8 ounces per 3-gallon mix), or Garlon 4 as a 4-percent solution (15 ounces per 3-gallon mix).
- Or, during the growing season, repeatedly apply Garlon 4 or a glyphosate herbicide as a 2-percent solution in water (8 ounces per 3-gallon mix) with a surfactant. In winter, herbicide treatments should be limited to warm days.



Chinese Wisteria, Japanese Wisteria

Chinese wisteria (*Wisteria sinensis*) and Japanese wisteria (*W. floribunda*) are deciduous high climbing, twining, or trailing leguminous woody vines to 70 feet (20 m) with long pinnately compound leaves and showy spring flowers. Chinese and Japanese wisterias are difficult to distinguish due to possible hybridization.

Recommended control procedures:

- Thoroughly wet all leaves (until runoff) with one of the following herbicides in water with a surfactant:
- July to October for successive years when regrowth appears—Tordon 101^{*†} as a 3-percent solution (12 ounces per 3-gallon mix), Tordon K^{*‡} as a 2-percent solution (8 ounces per 3-gallon mix), or Garlon 4 as a 4-percent solution (15 ounces per 3-gallon mix)
 - July to September for successive years when regrowth appears—Transline^{*†} as a 0.5-percent solution in water (2 ounces per 3-gallon mix) when safety to surrounding vegetation is desired
 - September to October with repeated applications—a glyphosate herbicide as a 4-percent solution (1 pint per 3-gallon mix)

Nonnative Grasses

Nonnative grasses continue to spread and increasingly reside along highway right-of-ways and thus gain access to adjoining lands. Most nonnative invasive grasses are highly flammable, increasing fire intensities, subjecting firefighters to increased risk, and spreading even faster after wildfire or a prescribed burn. Nonnative grasses have become one of the most insidious problems in the field of wildlife management on pasture and prairie lands, because they have little wildlife value and leave no room for native plants. Repeated applications of herbicides are required for control.



Giant Reed

Giant reed (*Arundo donax*) is a giant leafy reed grass to 20 feet (6 m) in height that forms thickets in distinct clumps. It has cornlike gray-green and hairless leaves jutting from stems and drooping at the ends. Erect plumelike terminal panicles of flowers and seed heads appear in late summer and persist through winter. Seed are not viable.

Recommended control procedures:

Thoroughly wet all leaves with one of the following herbicides in water with a surfactant (September or October with multiple applications to regrowth):

- A glyphosate herbicide as a 4-percent solution (1 pint per 3-gallon mix)
- Arsenal AC* as a 1-percent solution (4 ounces per 3-gallon mix)
- A combination of the two herbicides



Tall Fescue

Tall fescue (*Lolium arundinaceum*, formerly *Festuca arundinacea* and *F. elatior*) is an erect, tufted cool-season perennial grass, 2 to 4 feet (60 to 120 cm) in height. It has whitish-eared areas where leaf blades connect to the stem, and the stem has swollen nodes. Dark-green seedstalks and leaves appear in late winter, usually flowering in spring (infrequently in late summer). This grass is dormant in midsummer. Most tall fescue is infected with a fungus that can reduce weight gains and lower reproductive rates in livestock, while adversely affecting the nutrition of songbirds and Canada geese. Tall fescue monocultures are generally poor habitat for wildlife.

*Nontarget plants may be killed or injured by root uptake.

Recommended control procedures:

- On forest lands, apply a glyphosate herbicide as a 0.5-percent solution in water (2 quarts per 10 gallons mix per acre), or Arsenal AC* as a 1-percent solution (25 ounces per 20 gallons mix per acre) in spring.
- On noncroplands, apply 10 to 12 ounces of Plateau or 20 to 24 ounces of Journey per 20 gallons mix per acre (consult the label for additives) in spring. Mixing Plateau or Journey with a glyphosate herbicide will improve control but may damage associated native plants. Vantage (sethoxydim), Poast (sethoxydim), Assure (quizalofop), and Select (clethodim) may be useful on pastures, but they are usually more costly than a glyphosate mix with Plateau or Journey.
- Early spring burning—if repeated—inhibits fescue and encourages native warm-season grasses.



Cogongrass

Cogongrass (*Imperata cylindrica*) is an aggressive, colony-forming dense erect perennial grass 1 to 5 feet (30 to 150 cm) in height. It has tufts of long leaves, yellow-green blades (each with an off-center midvein and finely saw-toothed margins), and silver-plumed flowers and seeds in spring, arising from sharp-tipped branching rhizomes. Older infestations will be more difficult to control.

Recommended control procedures:

- Thoroughly wet all leaves with one of the following herbicides in water with a surfactant (September or October with multiple applications to regrowth): Arsenal AC* as a 1-percent solution (4 ounces per 3-gallon mix), a glyphosate herbicide as a 4-percent solution (1 pint per 3-gallon mix), or combination of the two herbicides.
- Repeat before flowering in spring to suppress seed production and again in successive years for eradication.



Nepalese Browntop

Nepalese browntop (*Microstegium vimineum*) is a sprawling, dense, mat-forming annual grass, 0.5 to 3 feet (15 to 90 cm) long with stems growing to 1 to 3 feet (30 to 89 cm) in height, often bending over and rooting at nodes to form extensive infestations. It has alternate, lanceolate leaf blades to 4 inches (10 cm) long with off-center veins and thin seed heads in summer and fall. Apply treatment to stop seed production.

Recommended control procedures:

- 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 also prevent seed buildup in the soil seed bank.

**Chinese Silvergrass**

Chinese silvergrass (*Miscanthus sinensis*) is a tall, densely tufted, perennial grass, upright to arching, 5 to 10 feet (1.5 to 3 m) in height. It has long, slender, and upright-to-arching leaves with whitish upper midveins and many loosely plumed panicles turning silvery to pinkish in fall.

Recommended control procedures:

Thoroughly wet all leaves with one of the following herbicides in water with a surfactant (September or October with multiple applications to regrowth):

- Arsenal AC* as a 1-percent solution (4 ounces per 3-gallon mix)
- A glyphosate herbicide as a 4-percent solution (1 pint per 3-gallon mix)
- A combination of the two herbicides

**Bamboos**

Golden bamboo (*Phyllostachys aurea*) and other nonnative bamboos (*Phyllostachys* spp. and *Bambusa* spp.) are perennial infestation-forming grasslike plants 16 to 40 feet (5 to 12 m) in height. They have jointed cane stems and bushy tops of lanceolate leaves in fan clusters on grasslike stems, often golden green.

Recommended control procedures:

- Thoroughly wet all leaves with one of the following herbicides in water with a surfactant (September or October with multiple applications to regrowth): Arsenal AC* as a 1-percent solution (4 ounces per 3-gallon mix), a glyphosate herbicide as a 4-percent solution (1 pint per 3-gallon mix), or combination of the two herbicides.

- Cut just above ground level and treat stems immediately with a double-strength batch of the same herbicides or herbicide mixture.

Nonnative Ferns

Japanese climbing fern is presently the only nonnative invasive fern in the temperate parts of the South.

**Japanese Climbing Fern**

Japanese climbing fern (*Lygodium japonicum*) is a climbing and twining, perennial viney fern to 90 feet (30 m), often forming mats of shrub- and tree-covering infestations. It has lacy finely divided leaves along green-to-orange-to-black wiry vines.

Recommended control procedures:

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) and as a mixture with a glyphosate herbicide
- Arsenal AC* as a 1-percent solution (4 ounces per 3-gallon mix)
- Glyphosate herbicide, Garlon 3A, or Garlon 4 as a 4-percent solution (1 pint per 3-gallon mix), or a combination of these herbicides

Nonnative Forbs and Subshrubs

Forbs are broadleaf herbaceous plants and subshrubs are short semi-woody plants. Control treatments are usually by foliar sprays of herbicides.

**Garlic Mustard**

Garlic mustard (*Alliaria petiolata*) is an upright biennial forb in small-to-extensive colonies under forest canopies, characterized by a faint-to-strong garlic odor from all parts of the plant when crushed (odor fading as fall approaches). It has basal rosettes of broadly arrow-point shaped leaves with wavy margins in the first year (remaining green during winter), a 2- to 4-foot (60- to 120-cm) flower stalk and terminal clusters of flowers with four white petals in the second year, and eventually dead plants with long slender seed pods after June of the second year. Stand density varies yearly depending on germination requirements of

*Nontarget plants may be killed or injured by root uptake.

seeds in the soil seed bank, with a single crop germinating over a 2- to 4-year period.

Recommended control procedures:

- 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.



Shrubby Lespedeza, Chinese Lespedeza

Shrubby lespedeza (*Lespedeza bicolor*) and Chinese lespedeza (*L. cuneata*) are perennials, with three-leaflet leaves, that remain standing dormant most of the winter and form dense stands that prevent forest regeneration and land access. Shrubby lespedeza is a much-branched legume up to 10 feet (3 m) in height with small purple-pink pealike flowers, and single-seeded pods. Chinese lespedeza is not really a shrub, but a semiwoody ascending-to-upright leguminous forb to 6 feet (2 m) in height with many leaves feathered along erect slender whitish stems that often branch in the upper half and tiny cream-colored



flowers in leaf axils during summer. Seed of both are long lived in the soil seed bank and require long-term monitoring after control treatments. Prescribed burning can promote spread of the infestation margins.

Recommended control procedures:

- 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.

*Nontarget plants may be killed or injured by root uptake.

† Transline controls a narrow spectrum of plant species.



Tropical Soda Apple

Tropical soda apple (*Solanum viarum*) is an upright, thorny perennial sub-shrub or shrub, 3 to 6 feet (1 to 2 m) in height, characterized by remaining green year-round in most southern locations. It has oak-shaped leaves, clusters of tiny white flowers, and golf-ball size fruit that are mottled green white turning to yellow in late summer to fall, which have a sweet smell attractive to livestock and wildlife. Even green fruit contain viable seeds. Report infestations to county agents for treatment under a federally sponsored eradication program.

Recommended control procedures for isolated sightings:

- Thoroughly wet leaves and stems with one of the following herbicides in water with a surfactant at times of flowering before fruit appear: Garlon 4 (or Remedy in pastures) or Arsenal AC* as a 2-percent solution (8 ounces per 3-gallon mix); Mileston VM as a 0.5-percent solution (2 ounces per 3-gallon mix) applied as 10 gallons per acre; a glyphosate herbicide as a 3-percent solution in water (12 ounces per 3-gallon mix).
- Collect and destroy fruit to prevent reestablishment.
- If mowing is used to stop fruit production, delay herbicide applications until 50 to 60 days to ensure adequate regrowth.