Elements and Tasks of an Invasive Plant Management Program

Elements and Tasks

1. **Make a plan.**
2. **Prevent entry and spread.**
3. **Make a map of locations.**
4. **Eradicate, control or contain, and monitor results.**
5. **Rehabilitate, restore, or reclaim treated lands.**

Persistently sticking to a plan of adaptive and collaborative restoration is the only successful strategy for safeguarding land access, productivity, native plants, and suitable habitats for wildlife.

1. Make a plan. Base your planned treatments on stated objectives and the best information, then schedule and acquire resources that support your plan, devise a timeline for implementation of your plan's action items, and add some "wiggle room" for contingencies. Devise both a short- or long-term plan to include both specific infestation treatment regimes and ideas for how these fit into a general land management plan. Your maps of infestation locations and priority ratings of invasive species will assist the planning process.

An eradication and rehabilitation program for specific invasive plant infestations usually requires several years of treatments and many more years of surveillance to check for rhizome and root resprouts, seed germination, or new invaders. Newer infestations and smaller plants require much less time than extensive and dense infestations.

During the treatment and retreatment phase, you must take steps to safeguard, promote, or establish desirable vegetation. To effectively combat plant invasions and restore lands, you will need to carefully plan for each step in the program by incorporating primary and contingency schedules of enactment. You should project a minimum of 4 years and up to 10 years for older infestations and when less than maximum effective treatments are used. You can use short-term plans to target specific areas, but you will need a long-term management plan for an increasingly invaded landscape. You must consider surrounding lands, particularly the degree of current infestation in those lands as well as the invasive plant management programs the owners and managers of those lands have in place. You must also consider emerging State funding assistance programs.

2. Prevent entry and spread. Do not plant invasives such as those covered in this book, others listed in the appendix "Nonnative Invasive Plant Species Not to be Used or Recommended for Wildlife Food Plots nor Bird and Butterfly Viewing Gardens," and those on your State's noxious and invasive plant lists. For wildlife food plots, soil stabilization, and ornamentals, plant only native plants of local origin when possible or noninvasive alternatives.

- Educate yourself, employees, and other users of your land about the invasive plants that pose major threats and how to prevent their entry. Learn how to identify both invasive and native plants in your area. The more native plants that you can identify, the easier you will spot the "plants out of place."
- Sanitation procedures to prevent the spread of invasives. Require those who work, hunt, and recreate on your lands, to minimize invasive plant spread by following these procedures when working in or near infested lands:
  - Inspect the site and infestation before operations, especially noting the presence or absence of invasive plant fruit, seed heads, or spore clusters under climbing fern (*Lygodium* spp.) leaves. The absence of any of these propagules means that less stringent sanitation procedures will be required. When they are present and you are working in or near the infestation, maximum sanitation techniques should be followed to prevent spread.

- When possible, avoid driving vehicles, mowers, all-terrain vehicles (ATVs), or spray equipment through infestations in seed or fruit, especially late-flowering cogongrass [*Imperata cylindrical* (L.) Beauv.], and musk thistle (*Carduus nutans* L.). This is a very common means of spread for many species.
- Brush and wipe all seeds and debris from clothes, boots, socks, and personal protective equipment. Avoid wearing cuffed pants where seed may collect. Remove seeds from boot laces and soles before moving between infested sites. Carry large contractor-size refuse bags to stand in while brushing and removing seeds or place contaminated gear within the bag for careful cleaning at a designated location.

Seeds lodged in shoe sole.

- When working in invasive plant infestations, thoroughly clean motorized equipment, especially the undercarriage and tire surfaces, where seed and plant parts are often inadvertently caught and transported. Pressure washers can be used in combination with a narrow spade, scraper, and stiff brush to remove mud, soil, and debris. The undercarriage, radiator front, and engine compartments must be inspected and washed when suspected contaminates are present. Remove excess grease and oil that trap and carry seeds, fruits, and spores. Modify vehicles and equipment in ways that will prevent buildup of debris or use the most appropriate vehicle that has the least potential for contamination.

Invasive seeds stick to mower tire.

Clean seeds and plants from equipment with pressure washer.

Wilson Faircloth

Cogongrass seeds on tractor radiator.

Excess grease traps seeds.

Invasive plants hitchhike on mowers.

Bag invasive plants for transport


Jane Hargreaves


Jane Hargreaves

- When moving cut invasive plants that have fruits and seeds offsite such as to a burn pile, always cover loads or bag before transport.
- Monitor burn pile areas for new seedlings as the fire may not consume or kill all seeds. Also, monitor any designated decontamination sites for seedlings.
- Sometimes sanitation seems almost impossible when dealing with invasive spore-forming species such as invasive climbing ferns, where spores are not easily seen. Avoid entering or working in invasive climbing fern infestations when spore clusters under special leaves are present. If entry is unavoidable, complete sanitation of all equipment, clothing, and workers is necessary to prevent potential spread. Plan entries into climbing fern infestations when spores are not present, which is October to November in the temperate parts of the region.
- Use only noncontaminated fill materials, mulches, and seeds. Inspect material sources at the site of origin for indications of contamination by invasive plants growing on or near the area.
- Regularly inspect areas where offsite fill materials have been used and areas used by visitors and lessees.
- Be careful not to disturb areas where there is a high probability of invasion. Most land disturbing activities raise the potential for establishment of aggressive plant invaders, especially when the invaders occur nearby.
- Most likely points of entry that need high-priority search and surveillance are:
  - Lands adjacent to lands you do not own, highways, county roads, and utility rights-of-way and their edges and fencerows, especially after new construction or maintenance activities
  - Internal roads, trails, and fire lines
  - Lands next to streams, rivers, and lake shores, especially after recent flooding or high-flow periods
  - Recently prepared and seeded wildlife food plots
  - Harvested, thinned, burned, or storm-damaged areas during the years following disturbance


Cogongrass-infested borrow pit.


Ben Jackson

Road maintenance can spread invasive plants.


Cogongrass invading from transmission line right-of-way.

Invasive plants spread along internal road shoulders

John McGuire


Invasive plant seeds move along streams.

3. Make a map and monitor results of locations. Identify invasive plant location sites at risk, and denote treatments and their outcomes. You must positively identify those invasive plants that are present and those poised to enter from adjacent lands, determine their locations and abundance, and record this information on a sketch map or Geographic Information System (GIS) map. Gain their Global Positioning System (GPS) locations when possible. Make the locations easy to find again by marking them with plastic flags. Monitor the locations through repeated visits and record progress or the lack of it. Agencies should map as many acres as possible with the dollars available before investing in unorganized treatments of extensive invasions, while new entries of severe invasives should be tackled early.

David J. Moorhead

Invasive plants can be transported on wildlife food-plot equipment.

The search, survey, Inventory, monitor, and surveillance method—Using the four-option *Search*, *Survey, Inventory, Monitor, and Surveillance* method, hereafter referred to as SSIMS, will help you map, monitor, and track treatments with their results at several scales.

- ***The first SSIMS option is searching.*** Start by looking at the most likely points of entry, like along roads and especially near bridges, and record any occurrence of invasive plants you find in such areas. Then widen your search as time and resources permit.
- ***The second option is survey.*** Surveys are used to sample large areas where search procedures have found numerous infestations that are too many to inventory individually. Surveys are also used to examine large tracks when the amount of invasion is unknown and access is difficult. By systematically locating plots or by band sampling across the landscape, you can record cover or number of clumps to determine the extent of occupation and acres covered. For example, 21- by 21-foot plots represent 0.001 of an acre and can be evenly spaced across a stand of trees or area. Total the percent estimated cover or number of invasive stems counted per plot, divide these by the number of plots, and then multiple times 1,000 to gain an estimate of occupation for an average acre. An estimate for the entire area can be gained by multiplying the average times the number of acres in the surveyed area. By mapping the survey plot findings, areas of highest infestation density and multiple invasive species can be identified.
- ***The third option is an inventory followed by monitoring.*** Inventories are used to record the location and area of every infestation and the treatments that you apply. This is the best approach for individual land ownerships. Inventories can map individual patches and plants or circle them as a group when they occur in close proximity to one another. The GPS locations can be taken and mapped, or a sketch map made to plan the program of treatment and restoration. Monitoring requires revisits to inventoried points at scheduled times or resurveying tracks with scattered infestation to record and track treatment effectiveness and any further invasions.
- ***The fourth option in the SSIMS method is surveillance.*** A constant task for all those who work on and or otherwise use your land. Everyone should be alert for new infestations and know how to report these when and where sighted.

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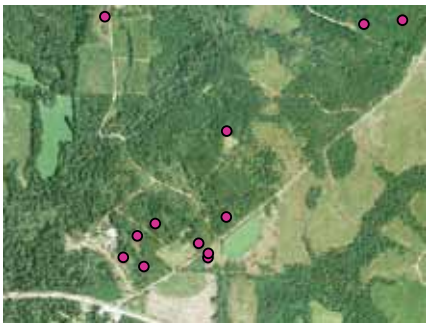
Handheld GPS Unit.



Terry Clason

Surveyed GPS locations of invasive species.

Paul Bolstad

Backpack GPS Unit.

4. Eradicate, control or contain, and monitor results. You can eradicate an infestation by eliminating every invasive plant and its seeds in the infestation, a difficult feat that requires timely and repeated use of the most effective treatments. You can control or suppress an infestation through medium effective treatments that mostly kill aboveground plant parts but that leave, even with repeated treatments, the live roots or rhizomes unharmed. You can contain an infestation by confining and restricting its spread through effective treatments that eliminate outlier plants, spots, or advancing fronts. Containment is often the only option when infestations continue to encroach from adjoining untreated lands. Remember: all treatments should be monitored for determining followup actions.

5. Rehabilitate, restore, or reclaim treated lands with resistant and resilient native or noninvasive plants. Critical to rehabilitating a site is promoting or planting desirable species that are as aggressive as the invasive species. Effective treatment schemes for rehabilitation use an integrated approach that combines treatments in an appropriate sequence and at crucial times.

Effective Treatments for Integrated Management of Nonnative Invasive Plants

A successful nonnative invasive plant management program usually involves a combination of treatment methods based on these and other available tools and resources:

1. **Herbicidal methods with selective and broadcast applications**
2. **Manual methods using hand tools**
3. **Mechanical methods using equipment**
4. **Cultural methods such as prescribed burning, water level control, planting, and seeding**
5. **Biological control methods that range from prescribed grazing to introduction of biological control agents such as insects and pathogens that feed solely on target weeds**
6. **Mulching and solarization methods**

Many methods are available to manage invasive plants and rehabilitate your site, and more are under development. A successful plan of attack depends on integrated management that considers all methods relative to the site and its invaders. These methods will be presented in greater detail.

Protect yourself with the right PPEs.

Safety First

Safety is always a top priority when working in the difficult situations often presented by invasive plant infestations and treatments. As your first line of safety, use and maintain personal protective equipment (PPE) designed for a specific task. A task as seemingly simple as surveying a site requires PPE. The following are examples of PPE-based invasive plant management tasks:

Suggested Personal Protective Equipment by Task
(herbicide applications must follow the label specified on the PPE's)

Task	Waterproof Boots	Hard Hat	Leather Gloves	Eye Protection	Safety Boots	Shin Guards	Hearing Protection	Neoprene Gloves	Appropriate Chaps
Surveying		X		X	X				
Mechanical Control			X	X	X				
Stem Injection		X	X	X	X			X	
Cut and Treat		X	X	X	X	X	X	X	X
Mixing Herbicides	X			X				X	X
Applying Herbicides				X				X	X
Girdling		X	X	X	X		X		

Required safety items for the field include a separate water container for washing, along with soap, paper towels, and trash bags as well as ample drinking water and a fully stocked first-aid kit.

Application of Herbicides

Adhere to the following precautions for safe application of herbicides:

- Take copies of all herbicide labels and material safety datasheets (MSDS) to the application site.
- An eyewash station is required for flushing accidentally splashed or sprayed herbicide from eyes.
- Take a change of clothes to the application site in case your clothes become contaminated and immediately wash off any herbicide spilled or sprayed on you.
- Always wash your hands and face thoroughly before eating, smoking, and when leaving the site.
- Always wash contaminated clothes and any clothing worn during spray applications separately from other garments.
- Adhere to any worker entry restrictions following treatment and worker notification requirements specified on the labels.

Transport of Herbicides

Adhere to the following precautions for safe transport of herbicides:

- Be sure containers are not damaged before loading or during transport.
- Take only the amount of herbicide, water, and adjuvants you need for the day.
- Do not transport herbicides in the passenger section of a vehicle.
- Do not transport herbicides in the trunk of passenger cars or in trucks with wooden beds. Use a trailer to transport herbicides when using a car.
- Secure all containers with ropes and straps to keep them from moving around. During the trip, check the containers periodically to be sure they have not shifted or spilled.
- At the application site, keep herbicide containers out of the sun. If you leave the containers in your vehicle, park in the shade. Place removed containers in shaded, cool areas. Direct sunlight can overheat herbicide containers and build pressure inside the containers. Use a tarp to shade exposed containers during transport and onsite storage.

Herbicide Spill Procedures

Follow these procedures for safely handling a spill:

- If an accident during transport results in a minor spill, administer first aid at once to anyone who may have been injured.
- Confine the spill by digging a dike around the spill area. Always take a shovel with you when hauling herbicides.
- Soak up the herbicide with an absorbent material, such as that used in automotive garages, or with clayey soil.
- Dispose of the contaminated absorbent as you would excess herbicide by spreading it on a treatment area unless local laws specify otherwise.

If a major spill occurs, follow the procedures given above and then call the manufacturer's helpline printed on the herbicide label. The manufacturer's helpline representative will tell you which authorities to notify and what further actions to take.

Remember to take to your application site a copy of the herbicide label and the MSDS provided to you at the time of purchase or found online by product name search. This is a State requirement. The herbicide label has many application details while the MSDS has more uniformly presented details, including the manufacturer's name; an emergency phone number; chemical ingredients in the formulation and their properties; health and fire fighting hazards; accident response measures; proper methods for handling, storage, transportation, and disposal; exposure controls and personal protection; and regulatory information. If an accident involves a person's physical exposure to a herbicide, the physician will need a copy of the MSDS.

Herbicide Application Methods

Most nonnative invasive plants in the South are perennials with extensive roots, tubers, or rhizomes. This means that effective herbicide applications offer the best means of containment or eradication, because herbicides can kill roots without baring soil—bared soil is susceptible to reinvasion and erosion. Decades of research has found that herbicides tested and registered with the U.S. Environmental Protection Agency (EPA) are safe to humans and other animals when stored, transported, and applied according to strict label directions. For successful herbicide treatments:

- Use the herbicide most effective for the targeted species and appropriate for safety to nontarget species and situation.
- Follow, in detail, the application methods prescribed on the label. Adhere to all label prohibitions, precautions, and safety requirements during herbicide transport, storage, mixing, and application.
- Choose the optimum time for applications. For foliar-applied herbicides to nonevergreen woody plants, the best time is usually midsummer to early fall and not later than a month before expected frost. Evergreens and semievergreens with leaves can be treated effectively in the winter. Optimum application times for many herbicides on invasive plants have not been fully researched and future findings should greatly assist to perfect prescriptions.
- Be patient. After application, herbicidal activity—detectable as yellowing of foliage or as leaves with dead spots or margins—may take a month or longer. Allow herbicides to work for several months to a year before resorting to other treatment options. Consult the herbicide label for timing of expected response of treated vegetation. But when green foliage reappears, retreatments should follow.

Selecting an Effective Herbicide

Herbicides registered by EPA for forestry use, wildlife openings, noncroplands, and fencerows in the Southern States will mainly be discussed here, although herbicides for other land use areas, such as rights-of-way, pastures, and rangelands, may be just as effective and may contain the same active ingredient. If a herbicide is not prohibited for use on a specific site, crop, or vegetation, then the broad category of noncrop areas even allows use in “nonused” lands and parks in urban and suburban environments. Some prescriptions for these other land types will also be given along with aquatic sites. Carefully read and study the herbicide label for information on specified areas of use, crops, and prohibitions. It is not necessary for the target invasive plant to be listed on the label for permitted use, except in specific States, like New Hampshire. There are a few State-specific prohibitions, such as Florida’s prohibition of picloram herbicides, i.e., Tordon use.

Herbicides are identified by trade name and active ingredient name. Many active ingredients are now sold as generic herbicides at lower costs, while customer service and product liability may be different than the brand name products listed here.

Foliar-Active (Primarily) Herbicides

Enforcer® Brush Killer (triclopyr)
Glyphosate herbicides (glyphosate concentrations commonly range from 41 to 54 percent) such as:
  Accord® Concentrate
  Glyphomax® Plus
  Roundup® Original
  Roundup Pro® Concentrate
  Rodeo® (aquatic)
Garlon® 3A (triclopyr)
Garlon® 4 (triclopyr ester)
Garlon® 4 Ultra (triclopyr ester)
Krenite® S (fosamine)
ORTHO® Brush-B-Gon® (triclopyr)
Pathfinder® II (triclopyr in oil)
Renovate® 3 (aquatic triclopyr)
Vista® XRT (fluroxypyr)

Foliar and Soil-Active Herbicides

Arsenal® AC (imazapyr)
Arsenal® PowerLine™ (imazapyr)
Chopper® Gen2 (imazapyr)
Clearcast® (imazamox aquatic)
Escort® XP (metsulfuron)
Habitat® (imazapyr aquatic)
Hyvar® X-L (bromacil)
Journey® (imazapic + glyphosate)
Milestone® VM (aminopyralid)
Outrider® (sulfosulfuron)
Overdrive® (diflufenzopyr + dicamba)
Pathway® (2,4-D + picloram)
Plateau® (imazapic)
Tordon® 101 (2,4-D + picloram, Restricted use)
Tordon® K (picloram, Restricted use)
Tordon® RTU (2,4-D + picloram)
Transline® (clopyralid)
Stalker® (imazapyr)
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 in the treatment zone or when herbicides move downslope 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 or vaporize at high temperatures, and their residues can move by air currents to affect surrounding plants; therefore, avoid application of these herbicides on days when temperatures exceed 80 °F. Avoid applications when rainfall is anticipated, unless soil activation is needed. Consult the label for the rainfast period. Delay applications during severe drought because herbicides are not as effective when plants go into stress dormancy during dry periods.

When possible, use selective herbicides that target specific nonnative species, e.g., Transline, which controls mainly legumes and composites and minimizes damage to surrounding desirable plants even though they receive herbicide contact. Minimizing damage to desirable plants also can be achieved by making applications when they 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.

Adjuvants and Additives to Herbicide Spray Solutions

Adjuvants are any product other than water added to a spray solution to improve herbicide performance and effectiveness, including delivery, retention on foliage, and foliar or bark penetration. Adjuvants may be included as part of the commercial herbicide product or sold separately as an additive you must mix with the herbicide before application. Another common additive used by professionals is a marking dye, which is not an adjuvant. Choose an adjuvant according to label recommendations and appropriate for your particular application method and field conditions. Be aware that many adjuvants are sold under invalid claims and unproven results. Before purchasing an adjuvant, ask for recommendations from reliable, certified distributors, applicators, or extension specialists. Useful adjuvants and additives include the following and are classified here according to their type of action.

Spray colorant indicates coverage.

Marking dyes and colorants, used in selective or broadcast herbicide applications, verify that the treatment was applied to the intended target. Application dyes show how well target vegetation has been covered and whether harmful contact has been made with nontarget vegetation or with the applicator. Although dyes are messy and short-lived as visible markers, they are helpful in training applicators and checking the quality of applications. Common dyes include Bullseye® Blue Spray Pattern Indicator, Hi-Light® Blue Indicator, and Blazon® Blue Spray Pattern Indicator. Bullseye is a water-soluble polymeric colorant, not a dye, and nonstaining on skin, clothing, and equipment. Bas-Oil® Red is oil-soluble and used with basal oil mixes.

Surface active agents (better known by the acronym *surfactants*) are a broad group of materials that facilitate the emulsifying, dispersing, spreading, wetting, and other surface modifying properties of liquids. Surfactants increase herbicide activity by making droplets larger on the leaf, thus improving penetration of the plant. Herbicide, weed species, and environmental conditions affect surfactant performance. Surfactants should be used with most foliar applications, except when prohibited by the herbicide label for specific uses, such as safety to desirable seeds and seedlings. Nonionic surfactants are usually recommended because they enhance wetting and retention of spray drops and do not bind with the herbicide molecule to cause deactivation. Never use household detergents as surfactants because they can deactivate many herbicides. Common surfactants include Entry II®, Big Sur 90, and Timbersurf 90. A newer type of surfactant with leaf penetrating action and rainfastness is based on organosilicones, with commonly used products being Sil Energy® and Silwet® L-77. These must be mixed exactly or they will be ineffective. They also increase the risk of injury to skin and eyes during application. Organosilicones are now commonly blended with other surfactants for additive properties.

Water conditioners are spray solution additives that enhance herbicide performance by preventing deactivation of the herbicide's active ingredient. Ammoniated salts are added to prevent loss of herbicidal activity of glyphosate and picloram when using "hard water" with greater than 200 parts per million of calcium, magnesium, and potassium. Acidifiers and buffers are additives sometimes listed on herbicide labels for use with specific water sources. Ammoniated salts, buffers, and surfactants are now blended to combine their activities in special spray additives. Common water conditioners are Choice® Weather Master, and AMSWC™ (just ammonium sulfate). Because dirt and organic debris can cause herbicide deactivation, always mix herbicides only with clean water from a filtered and treated source.

Vegetable oils, such as methylated seed oil (MSO), can increase spray drop adherence to leaves, increase herbicide penetration of leaves, and slow evaporation during and after application. Herbicides must remain in solution on a leaf for plant uptake. Vegetable oils also are mixed in basal sprays, and some vegetable oils contain emulsifying agents for this purpose. Several new formulations of herbicides come with vegetable oils. Common MSOs are Improved JLB Oil Plus and DYNE-AMIC®. A commonly used bark oil is Aqumix®.

Drift retardants thicken spray solutions to create larger drops that are less likely to drift in wind, permitting more accurate applications in light wind and continued applications in slightly windier conditions. Common drift retardants are Poly Control 2, Nalcotrol®, and Sta-Put® Deposition Aid.

Penetrants partially dissolve waxy plant surfaces to help the herbicide penetrate leaves or move through bark. Common penetrants are Cide-Kick® and Cide-Kick® II.

Defoamers dissolve foam in spray tanks to improve mixing and transfers of herbicides like Arsenal AC and Velpar® L. Common defoamers are Fighter-F®10, Foam Fighter®, and Brewer's Defoamer.

Mixing Herbicides

Always use clean water in herbicide spray solutions. Thoroughly mix all ingredients before applications. Unevenly mixed herbicide solutions will produce uneven results. For large batch mixing of 5 to 200 gallons, the mixing or application tank must have an agitation system and must be operated for a sufficient time to produce a uniform mix. Never mix herbicides in a backpack sprayer because their shape inhibits thorough mixing. Instead, always mix herbicide sprays for backpack sprayers in a separate mixing container to a point that guarantees uniformity. Mix individual batches with a stirrer in a bucket. For large batches, fill backpack sprayers from a mixing tank that has an agitation system. Fill the mixing bucket or mixing tank one-half to three-quarters full with clean water. Add herbicides at label-recommended rates, with carefully calculated and measured amounts of ingredients, stirring or agitating the mixture as you add these. For best results, add herbicide types, additives, and adjuvants in the following order: (1) water conditioners and defoamers, (2) dry flowables (like Escort XP), (3) emulsifiable concentrates (like Garlon 4), (4) water-soluble liquids (like glyphosate herbicides), (5) most adjuvants, and (6) drift retardants. Over time, dry flowables and other herbicides, along with oil additives, can settle to the bottom of a tank and must be periodically agitated as specified on the label.

Do not mix in a sprayer.

Do mix in a bucket with a stirrer.

Backpack Sprayers

Backpack sprayers vary greatly in design and capabilities, and many versions are available commercially. The most desirable components of a backpack sprayer are a streamlined shape (to make it easy for the applicator to move through dense vegetation), an impact-resistant tank equipped with a large opening (for filling), and a solid screen (to trap debris). All backpack sprayers and spray guns should have chemical-resistant seals. Viton® seals are made of the most durable materials and allow handling of both oil- and water-based mixtures. Backpacks with internal pressure regulators can help the applicator ensure uniform rates of application and minimize drift that otherwise might result from using too much pressure. Some models feature kink-resistant hoses for improved safety and reliability. Comfort and support in the design of a backpack sprayer cannot be overstated. Padded shoulder straps with harnesses that attach securely to the frame can reduce operator fatigue and accidents, especially in dense vegetation or on uneven terrain.

Steven T. Manning

Models of backpack sprayers.

Backpack sprayers come with a piston or diaphragm pump. Piston pumps must have a regulator because they generate higher pressures. An added pressure gauge on the wand handle can help the applicator maintain a spray pressure appropriate for the given treatment. Another useful addition to a backpack sprayer is a more durable metal spray wand with a more precise shutoff valve than the valve on a flexible plastic wand. Quality backpack sprayers, which are preferred by commercial applicators, usually come with a 1- to 3-year warranty.

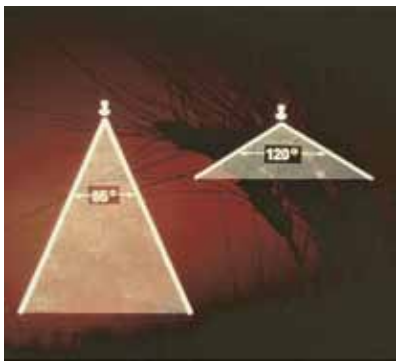
Spray Nozzles

Choosing the best nozzle will usually require that you purchase another nozzle and not use the one that comes with your sprayer. Correct nozzles can greatly improve effectiveness and efficiency. Nozzles consist of a nozzle body, a cap, and a tip with the orifice. The spray tip is the most important part of your sprayer because it breaks the liquid into droplets of the correct size and forms the spray pattern.

Tips are made of a variety of materials. Most readily available tips are made of plastic, brass, and stainless steel. Tips of harder materials initially may cost more but will pay for themselves in the long run with durability and consistent performance. Plastic tips tend to have very irregular spray patterns. Brass tips can be easily damaged during cleaning, and such damage will cause irregular spray patterns. It is a good practice to discard plastic or brass nozzles that come standard with a sprayer and replace them with tips of stainless steel designed for long-term commercial use. Stainless steel tips provide a uniform and consistent spray pattern over longer periods and are known for having fewer out-of-the-box defects.

Air induction tips are newer modifications. These tips produce large, air-filled drops that help reduce the potential for drift in winds. They work by drawing air through two holes in the nozzle sides, which blends the air with the herbicide mix. They emit a spray of large droplets filled with air bubbles and virtually no drift-prone droplets. Other nozzle alternatives include “low-drift” and “extended-range” tips that produce fewer small stray droplets and aerosols that contribute to drift compared to conventional nozzles. When choosing air induction or stainless steel nozzles, consider models with a plastic body and a steel tip, because these models are as durable as more expensive all-steel nozzles.

Low-volume directed sprays are often applied with a backpack sprayer and a spray wand equipped with a full cone, flat-fan, or adjustable cone spray tip. The tip has the orifice, which is usually identified by a four-digit number representing its spray pattern angle and flow-volume specifications; for example, an 8002 tip has a spray pattern angle of 80 degrees and a flow volume of 0.2 gallons per minute (all flow volumes are measured at 40 pounds per square inch of pressure). When your application is for invasive plants, models SS4004E (SS = stainless steel, E = even pattern); SS8004E; SS2504; and a wide-angle flooding nozzle like the Floodjet TK VS3 yield good coverage, useful flow rates, and are good additions to your toolkit. A range of tips should be carried to the field so that the best nozzle for plant heights, terrain, and weather can be selected. To purchase nozzles and spray components and parts, consult an agricultural products outlet, farm tractor dealer, or farm store. Major sources are Spraying Systems Company (630–665–5000, www.spray.com, info@spray.com); Dultmeier Sales (888–677–5054, www.dultmeier.com/div_agricultural.asp, dultmeier@dultmeier.com); and Forestry Suppliers Inc. (800–752–8460, www.forestry-suppliers.com, www.forestry-suppliers.com/c01_pages/contact.asp). These few are provided to assist the reader, while there are other manufacturers and distributors.



Spraying Systems, Inc.

Nozzle spray angles of 65 and 120 degrees.


Spraying Systems, Inc.

Even flat fan spray tip—SS4004E.


Spraying Systems Inc.

Flooding nozzle.


Steven T. Manning

Flooding nozzle spray pattern.

Sprayer Preparation

Prior to calibration of equipment and application of herbicides, applicators must properly prepare their equipment. Thoroughly clean all nozzles, screens, and filters in detergent solution, using a soft bristle brush, and then rinse. Make certain that all nozzles are the same size, prescribed for the application, and made of the same material for uniformity by all applicators and especially when several nozzles are along a short boom. Replace nozzles that do not have uniform spray patterns (often determined by spraying along a concrete surface). Check flow rates periodically by catching spray in a container over a timed period. Stay alert for dripping nozzles and use check values to prevent drips. Select an operating pressure consistent with the desired gallons per acre output and spray pattern relative to wind conditions. Check all PPE, replace faulty items, and make certain that all applicators are trained in use and maintenance of all items. Always use the appropriate PPE for each operation, and perform daily maintenance on this equipment.

Backpack Sprayer Calibration

Prescriptions for invasive plant applications are often given as percent-solutions of specific herbicides. But on herbicide labels, most prescriptions are given in herbicide volume or weight (dry herbicides) per acre. This requires calibration of a spray system using the same nozzle(s) and pressure that will be used during application. Calibration is simply the determination of how much spray volume is applied to a specified area of land. Calibration requires timing an application to a known area, which is then expressed as gallons per acre. This should be done in the treatment area because factoring in the speed of the applicator who works in those conditions is crucial for accurate calibration. Water alone should be used for calibration procedure.

- For calibrating broadcast sprays, measure the width of the spray swath in feet and multiply this measurement by the distance traveled in feet for 1 minute. Convert this result to an acre basis by dividing the square feet by 43,560 square feet per acre.
- Catch the spray from the nozzle(s) for 1 minute and measure the volume in ounces. Convert this measurement to gallons by dividing by 128 ounces per gallon.
- Gallons per acre then can be calculated by dividing the measured gallons by the part of an acre treated.

The calculated “gallons per acre” output during application will be a mixture of herbicide, water, and any additional adjuvants. The amount of herbicide prescribed per acre is specified on the label or in this book; this is the amount you should mix with the “gallons per acre” determined during calibration. For example, if a prescription calls for 2 gallons of herbicide per acre, and if your sprayer is calibrated to apply 20 gallons per acre, then, to treat 1 acre, you must mix 2 gallons of herbicide in 18 gallons of water and adjuvants. For mixing an individual batch for a 4-gallon backpack sprayer, you would divide these quantities by 5. If you need to apply more or less gallons per acre as specified on the label or dictated by vegetation conditions, the nozzle size(s) and/or pressure should be changed. Higher pressures or larger tips will increase output, while increasing pressure may increase drift potential.

You can use the same calculation methods for foliar-directed sprays and for sprayers mounted on tractors and other equipment. For foliar sprays, you will treat individual plants in the measured area (some part of an acre) and then you can refill your sprayer according to a marked pre-application level to determine the gallons applied. For calculations of mounted sprayers, you will need to consider a large calibration area and capture spray from all nozzles, both over a timed period as before.

Selective Herbicide Applications

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

Spray shield from a used gallon milk jug (bottom removed and cap bored).

Directed Foliar Sprays and Wipes

Directed foliar sprays are herbicide-water-adjuvant solutions aimed at target plant foliage to wet all leaves, applied by either low- or high-volume sprayers. Herbicide application by directed foliar spray is one of the most cost-effective methods for treating many types of herbaceous and woody invasive plant species. With this method, herbicide mixtures are applied to the foliage and especially the growing tips of woody plants, or to completely cover herbaceous plants. Foliar sprays can be applied whenever leaves are present but, for woody plant control, are usually most effective from midsummer to late fall. Winter and spring applications are also effective in controlling specific species and are often required to prevent seed formation.

Selective treatment is possible because the applicator can direct the spray towards target plants and away from desirable plants. The addition of a spray shield to the end of the wand confines spray to the target. 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 that are susceptible to the herbicide. If nontarget foliage is accidently sprayed, clip off the foliage to prevent uptake.

Spray gun with rollover valve that holds two tips.

Low-volume foliar sprays using spray tips and spraying pressures of 20 to 30 pounds per square inch can ensure productivity and limit drift to surrounding plants. 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. Wind must be minimal (less than 2 miles per hour) and used by the applicator to facilitate upper crown coverage. A handgun with a rollover valve can replace the spray wand and accommodates two tips, such as a flat fan for close spraying and a narrow flat fan or adjustable cone nozzle for tall plant spraying. This setup greatly extends applicator capabilities and productivity when invasive infestations vary in height. Sturdy metal wands can replace plastic ones for more precise applications. Small booms with multiple nozzles can replace the single-nozzle wand for better productivity and efficiency in treating large areas of low-growing invasives.

Dennis Markwardt

Directed spraying kudzu from a bucket-truck.

Steven T. Manning

High-volume directed sprays.

Directed foliar sprays can be applied in higher volumes by using spray wands attached by hoses to vehicle-mounted spraying systems that have much larger herbicide tank capacities. The high-volume directed foliar spray is the most efficient approach to large infestations of multiple invasive species where there are few nontarget plants.

Handheld weed wicks and rollers apply ultra-low volumes by wiping the herbicide mix onto the target leaf surfaces or bark; the herbicide mixture is contained in the handle. A few commercial models are manufactured in Australia and New Zealand, but devices also can be handmade from PVC tubing, fittings, and a sealed on sponge or rope wick and fitted to the wand of a backpack sprayer. Most wick systems have limited use and durability in forest and field situations, but are useful when the applicator needs to avoid applying herbicide to rare or protected plants. Similar to a weed wick applicator, a rolling sponge head is another drift-free tool option that allows application directly to targeted species.

Handmade basal bark wiper.

The THINVERT Application System uses a series of special spray nozzles to apply thin invert emulsion spray solutions (thin mayonnaise-like consistency) to greatly reduce drift and evaporation of spray particles on the plant surface. The nozzles and a combination of special oil soluble herbicide (triclopyr) and emulsifying agent have been developed and sold by Arborchem Products Company (717–766–6661, www.arborchem.com). This system combines the unique spray nozzle and spray carrier into a coordinated unit for aerial or ground applications to roadsides, rangeland, cropland, industrial sites, forests, and landscape areas. Thinvert sprays can be applied to foliage as well as stems or cut-stumps where absolutely no drift can be tolerated, such as immediately adjacent to neighboring croplands and special rare plant habitats.

Steven T. Manning

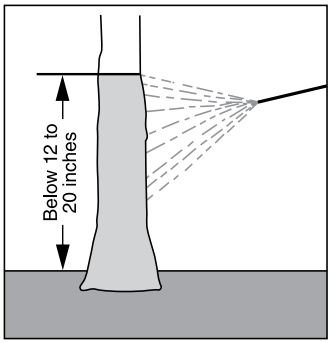
Foliar wick applicator.

Steven T. Manning

THINVERT Application System.

Basal Sprays and Wipes

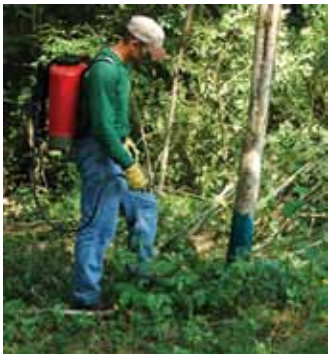
Basal sprays are herbicide-oil-penetrant mixtures sprayed on the lower portion of woody shrub, vine, and tree stems. The sprays are usually applied with a backpack sprayer or wick applicator. Basal sprays are best where most trees are less than 8 inches diameter breast height (d.b.h.), but can be used on much larger trees of susceptible species. Application is to smooth juvenile bark by thoroughly wetting the lower 12 to 20 inches of the trunk, up to 36 inches on larger trees to the groundline including the root-collar area and any exposed roots. Smaller trees and shrubs are controlled with less coverage. Avoid spray contact with desirable trees or heavy use within their root zone.



Basal spray applications.

The herbicide must be an oil-soluble ester formulation, such as Garlon 4 and Stalker, and mixed with a special basal oil product, penetrating oil, diesel fuel, fuel oil, mineral oil, vegetable oil with a penetrant, or blends of these ingredients. Appropriate oils will be specified on the label. Some oils may be prohibited for application in riparian areas and wetlands. Use an adjustable cone nozzle with a coarse spray. For less off-target spray on smaller trees, use an even flat-fan nozzle with a fairly narrow angle and low volume (such as a 4002E, oriented crosswise to the wand for a spray that lands in a vertical band on the stem).

Pathfinder II is sold ready to use as a mixture of triclopyr ester herbicide mixed with oil in the container.



Steven T. Manning

Spray dye for basal spray.

A modified method, streamlined basal sprays, is effective for many woody species up to 2 inches in groundline diameter and susceptible species up to 6 inches in diameter, such as privets. Equipment for this 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 in 2- to 3-inch-wide bands. This multiple-band treatment also can be effective on larger stems. Direct the spray stream to smooth juvenile bark about 4 to 18 inches from the ground and below branches. Stems that are thick barked or near 3 inches in diameter require treatment on all sides.

The most effective time period in most of the South for a basal spray and streamline is June through September, while winter treatments are easier when leaves do not block access and spray. Fall, winter, and late spring applications are often not as effective, though the period from February 15 to April 1 has shown acceptable results. After treating with a basal spray, wait at least 6 months before cutting dead trees, because herbicide activity within plant roots can continue for an extended period.

Streamline basal spray.

Stem Injection

Stem injection (including hack-and-squirt) involves herbicide concentrate or herbicide-water mixtures applied into downward incision cuts spaced around woody stems. Cuts are made by an ax, hatchet, machete, brush ax, cane knife, or a variety of cutting tools and even cordless drills. Tree injection is a selective method of controlling larger trees, shrubs, and vines (greater than 2 inches in d.b.h.) with minimum damage to surrounding plants. Stem injection is the fastest and most cost-effective method for nonnative trees and large shrubs. Injection treatments are sometimes not as effective in controlling multiple-stemmed species compared to the faster basal bark treatments, but may be easier in remote or rough terrain where a backpack sprayer might be impractical or cumbersome. Stem injection is physically demanding for the applicator, who must repeatedly and accurately strike target trees with a sharp tool before delivering the herbicide into the cut. For best results, sharpen tools frequently.

Cutting tools for hack-and-squirt treatment.

Cane knife.

Incisions must be deep enough to penetrate the bark and inner bark, slightly into the wood. Do not make multiple cuts directly above or below each other because this will inhibit movement of the herbicide within the stem. A complete girdle or frill of the stem is not needed or desirable. Space the injection cuts 1 to 1.5 inches apart edge to edge (or per label instructions) around the circumference of each trunk individually or within a clump at a convenient height. Use a handheld, chemical-resistant 1- to 2-quart spray bottle to apply 0.5 to 2 mL of concentrated herbicide or dilutions (prescribed on the label) into the cut. The amount will depend on the size of cut and how much the cut can hold without the herbicide running onto the bark. Apply herbicide to each cut until the exposed area is thoroughly wet. The herbicide should remain in the injection cut to avoid wasting herbicide and to prevent damage of surrounding plants. All injected herbicides can reach untreated plants by root grafts between like species, and uptake of root exudates by all species results in nontarget damage. 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.

Hack-and-squirt method.

Steven T. Manning

Penetrate the bark and inner bark, slightly into the wood.

Steven T. Manning

Apply herbicide into each cut until thoroughly wet.

Special tree injectors are available that combine the cutting operation with automated herbicide delivery. For injecting some herbicides (amine formulations), the Hypo-Hatchet® Tree injector (Forestry Suppliers Inc., 800–647–5368, www.forestry-suppliers.com) consists of a steel hatchet connected to a herbicide container (worn on belt) by tubing. The injector delivers a set amount of herbicide into the cut. Daily cleaning and lubrication of the impact piston is required maintenance, along with periodic replacement of rubber o-rings and seals. Check all hoses and fittings before use for leaks and make appropriate repairs to prevent accidental exposure of herbicide to the applicator. When working with the Hypo-Hatchet in dense infestations, be mindful of the supply tubing, which might become tangled and easily disconnected.

Hypo Hatchet® Tree Injector.

Another injector is the EZ-Ject®, which consists of a steel lance that holds 400 shells of glyphosate or imazapyr herbicides (ArborSystems, 888–395–6732, www.ezject.com). The head of the lance is placed against the base of the target woody plant, and a manual thrust jams the shell through the bark into the inner bark. As with other injection methods, these shells are spaced around each stem. The EZ-Ject is the most efficient and effective injection option for treating multi-stemmed, low-branching shrubs like privets, silverthorn (*Elaeagnus pungens* Thunb.), and bush honeysuckles (*Lonicera* spp.), as well as large entangled vines like oriental bittersweet (*Celastrus orbiculatus* Thunb.). Shell jamming has been reported as a problem when using the EZ-Ject to treat extensive infestations. Removing the herbicide shells when not in use, proper use, and daily maintenance can help prevent jamming.

Steven T. Manning

EZ-Ject® tree injector.

Tree injection can be applied at most times throughout the year, but December to the middle of January seems to be least effective in the Midsouth. Prolonged cold temperatures can freeze herbicide in the cut, resulting in poor absorption. Heavy spring sapflow can wash herbicide from incision cuts, resulting in poor control and soil transfer to nontarget plants. Prolonged and severe drought is also an ineffective period.

Cut-Treat

Cut-treat involves applying herbicide concentrates, herbicide-water or herbicide-penetrant mixtures to the outer circumference of freshly cut stumps or the entire top surface of cut stems. Applications are made with a spray bottle, backpack sprayer, wick, or paint brush. Freshly cut stems and stumps of trees, woody vines, shrubs, canes, and bamboo stems can be treated with herbicide mixtures to prevent resprouting and to kill roots. It is critical that the cut is made as low as possible to the ground, and that the stem is treated immediately after the cut is made. Invasives not treated with herbicides after cutting invariably resprout and intensify their infestation. Cutting is usually by chainsaw or brush saw but can be made by handsaws and cutting blades.

Cut-treat the circumference of large stems, and the entire top of small stems.

Steven T. Manning

A 2-quart pressured spray bottle works well for stump treatment.

Steven T. Manning

Cut stems low for treating.

To minimize deactivation of the herbicide in the cut-treat method, remove sawdust from stumps before treatment. For stumps over 3 inches in diameter, completely wet the outer edge with the herbicide or herbicide mixture. Make certain that the solution thoroughly covers the wood next to the bark of the stump. 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 gone untreated for over 2 hours. Make certain to wet stump sides and root collar to further prevent sprouting.

The most effective time for the cut-treat method has not been determined for all invasive species, while summer and fall have shown to provide good control. One-year research results show that spring cut-treat with Garlon 4 on large Chinese privet is completely effective. Although winter treatments are slightly less effective than growing season applications, the absence of foliage on some cut stems and branches produces some offsetting gains in application efficiency.

Hand Sprayers for Injection and Cut-Treat

Most commercial hand sprayers are for occasional weekend household use. If you require a model for heavier duty and continuous daily operations, consider a sprayer with chemical-resistant Viton seals and a manual handpump. A good hand sprayer also will have an adjustable mist nozzle and a large filling opening. Models with a pump compression design are good for cutting and treating, while trigger-action pumps are better suited for stem injection or soil spot treatments. A full-grip valve will prevent fingertip fatigue with prolonged daily use of finger trigger valves.

Steven T. Manning

Household use sprayer.

Handsaws or Cutting Blades

Chainsaws

A chainsaw with a 12- to 14-inch bar is best for felling most woody invasive plants since they are light weight and suited for cutting multiple stems in clumps. Professional tree saws are usually the lightest on the market and the tool of choice among contractors.

Brush Saws

Brush saws are large gasoline-powered weed eaters with a circular saw blade for cutting woody stems. While many large and expensive brush clearing saws are on the market, the high-end professional model is the preference of contractors for large projects. Special chainsaw-like tooth blades around a disc are the most efficient for cutting invasive plants and can be sharpened in the field throughout the life of the blade.

Steven T. Manning

Brushsaw clears small stems.

Steven T. Manning

Brushsaw blade with chainsaw-like teeth.

Steven T. Manning

Small chainsaw for cutting.