

USING HERBICIDES IN FOREST VEGETATION MANAGEMENT

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An effective land manager should consider prescribed fire, mechanical, and herbicidal options for their merits. Mechanical methods are known as a dependable method of clearing a site for planting. However, use can be restricted somewhat by wet weather, poor drainage or extremes in topography. Other problems include negative impacts on erodible or fragile soils and the potential for abundant hardwood sprout development. Herbicide treatment alone or in conjunction with controlled burning has limited impact on most soils and is seldom restricted by terrain. Herbicides will control hardwood resprouting when used correctly and are generally less expensive than mechanical treatments. Herbicide use is sometimes restricted by environmental concerns, and requires technical training by the user. Making a reasonable decision as to whether the use of herbicides is appropriate requires an understanding of their effects and limitations. When integrated, these options can be very socially, environmentally, and efficaciously responsible.

For socially, environmentally, and efficaciously responsible herbicide applications, users should establish a routine practice of detailed planning and record keeping to insure successes are repeated and failures are not. A prescription documents the users attempt to condense management goals, social and biological conditions and limitations, herbicide options, expectations, and results into a plan of action. Consider the following.

THE HERBICIDE PRESCRIPTION

Clearly Define Project Objectives

Always know your crop trees or crop plants that are on the site or that you plan to restore to the site. It is unlawful to use herbicides on sites for which the product is not labeled or on crop species other than those included on the label. If our objective is to restore shortleaf pine and oak, then these species are paramount in your decisions.

Prescription Type

Site preparation means desired forms of the crop species are absent from the site. At this time, the manager has more options than any other time in the rotation. That is, management has more products, rates, application methods, timings, etc. than will occur again for many years. Failure to act appropriately at this time could mean dealing with an undesired species for many years and perhaps loss of the site to invasive exotic or native species. Release means the crop is present on the site and your actions are limited to what the crop can tolerate. That is, you may perform a woody release where unwanted woody species are targeted for control or a herbaceous release where you focus control on unwanted herbaceous plants.

Site Specific Description

Location--Always know exactly where your application will occur. That is, some herbicides have properties determined by the EPA to require special training. This designation, "RESTRICTED USE" is on the label for the entire nation. The EPA allows states to add additional restrictions and classify these products as "Limited Use". Some states vary restrictions by the county or precinct within a county. Thus, a legal application may vary from state to state and from the northern to southern end of the county. For the respective state, visit the homepage of the state regulatory agency for specific details.

Soils, Slope, and Topography--Soil texture, percent organic matter, and internal drainage may significantly impact the performance of soil-active herbicides. The capacity of a soil to bind herbicides is determined by soil texture and organic matter. Fine textured and organic soils have a large surface area relative to volume, tend to adsorb more herbicide in proportion to their content, and make less herbicide available for uptake by root systems of target vegetation. For this reason, higher rates of a herbicide are required on soils high in clay or organic content. On the other-hand, for pine release or herbaceous weed control in young stands, care must be exercised so that injury to the crop trees does not result from over-application on sandy or coarse textured soils. Generally, product labels provide a range of application rates for various soil types. Users should always read the label carefully, know the soil type, and make sure that applications are conducted according to specifications. Water moves downhill, thus slope is a determinate in which way water will run. Topography can be rough. This could preclude the use of ground applications leaving only aerial as a practical application method. Applicators must always be aware of ditches, streams, lakes, etc that might be contaminated by runoff.

Unwanted Competitors--Before prescribing any herbicide, a survey must be conducted to identify dominant weed species on the site. Usually three or four unwanted herbaceous or woody species will dominate.

Treatment and Application Procedures—Herbicides vary in numerous use and toxicity properties. Effective control means using the appropriate herbicide(s), rate, timing of application, and application method.

Specific Herbicide--Herbicide properties are product specific. Technical use properties are located on the label. When selecting a product, managers should consider the species controlled, activity (soil, foliage, stem), maximum use rates, timing of application, method of application, recommended adjuvants (surfactants, rain fastness), product mobility and volatility, environmental toxicity, and regulated use restrictions. The magnitude of this information is beyond this paper. See the label for more details.

All forest herbicides have a control spectrum composed of highly susceptible, moderately susceptible, or resistant species. A herbicide may be considered acceptable as long as resistant (relatively unaffected) species are only a minor component. Because no one herbicide controls everything, tank mixtures are commonly used. For broad-spectrum plant control, tank partners should be selected with complimentary spectrums of control. That is, one tank partner should control what the other does not. I emphasize that users should not use herbicide products and rates

to control resistance species because they will not work. Species susceptibility is addressed in herbicide labels research literature and will not be covered here.

Rate--Apply only the amount of herbicide(s) needed. Never exceed the maximum labeled rate.

Timing--Timing of application matches herbicide(s) properties with plant phenology. For example, soil-active herbicides are generally applied in the spring to early summer when rainfall required for activation and movement to roots is likely to occur. Similarly, foliar sprays are applied after full foliage development in the spring. Herbaceous plants are commonly controlled with a spring application while woody plant control is generally improved by late summer to early fall applications.

Method of Application--Several application methods are available to deliver the appropriate rate of herbicide in a safe and effective manner to the foliage, stem, soil for root uptake, or cut stump of unwanted trees and shrubs. The advantages and disadvantages of common methods of application are covered later in this paper. Always consult the product label for recommended methods of application. Additional methods may be legal as long as the label does not prohibit their use. Users considering application methods not included on the label should consult a representative of the product manufacturer before applying product.

Herbicide applications readily compliment and integrate with prescribed burning and mechanical treatments. The best herbicide treatment is always the lowest rate of least toxic herbicides required to meet management objectives. The best timing and application method introduces minimum risk to nontarget plants and animals. Always follow the instructions on the herbicide label.

Restricted or Limited Use--From a risk and toxicity point of view, herbicide properties vary greatly. Herbicides may be separated into use categories based on restrictions imposed by the EPA or a state regulatory agency. A restricted use herbicide is available for purchase and use only by certified pesticide applicators or persons under their direct supervision. This designation is assigned to a herbicide because of its relatively high degree of potential human and/or environmental hazard even when used according to labeled directions. Thus, risk to the environment, people, and wildlife can be reduced by avoiding restricted use and limited use herbicides.

Signal Word--Toxicity is characterized by the signal word. The signal word on the label applies to the most serious method or route of exposure. For example, if a herbicide has an acute oral LD50 of 368 (which triggers the signal word "Warning" and an acute dermal LD50 of >2,000 (which triggers "Caution") and is severely and irreversibly corrosive to the eyes (which warrants "Danger"), then the label signal word is "Danger". Thus, risk to the environment, people, and wildlife can be reduced by selecting herbicides with the "Warning" rather than "Danger" signal word.

To better understand the nature of the signal work, a brief explanation of EPA testing is presented. The EPA evaluates carcinogenicity, neurotoxicity, reproductive teratology (birth defects), and mutagenicity (genetic mutation) study results based on animal tests conducted during the herbicide registration and re-registration processes. The study data is used to make inferences relative to human health. Please consider the example, risk to cancer (carcinogenicity) from a herbicide. The EPA considers how strongly carcinogenic the herbicide is (its potency) and the likelihood of human

exposure. The herbicide is evaluated not only to determine if it causes cancer in laboratory animals, but also as to the potential to cause human cancer. For any herbicide classified as a potential carcinogen, the risk depends on the extent (frequency, duration, quantity) to which a person is exposed. Results from many tests are reviewed: short-term studies, long-term cancer studies, mutagenicity studies, and structure activity concerns. The “weight-of-the-evidence” is the term used to refer to a review of a herbicide. This means the EPA’s recommendation is based on the results of all studies that are available. Clearly, the signal word captures the essence of the risk associated with a herbicide and should be a reference when selecting a herbicide. Detailed toxicity information is found on the material data safety sheet for each herbicide and in the Herbicide Handbook published by the Weed Science Society of America.

Other Variables Influencing Control

Weather—Weather extremes can influence applications and control. For example, cloud cover on the horizon may suggest the need for an adjuvant increasing rainfastness. Drought may dictate the shifting of rates for tank partners, changing of herbicides, or delayed applications. Heavy debris loads can be reduced with prescribed fire or chopping to facilitate product contact with the soil. Plants injured during thinning, may best be controlled when allowed to recover before treatment.

Stand Structure--Aerial applications are affected by stand structure. Uneven-aged stands, stratified canopies, and lower components within multistoried canopies can be difficult to cover with foliar treatments due to shielding from taller trees. Partial solutions to this problem include using larger droplet size, more total gallons of spray per acre, solid formulations, or products with both foliar and soil activity.

Probable Response

Managers should ask themselves, if the expense and risk justify the expenditure?

Impact On Other Resources

Sensitive Areas--The location of crops, endangered species, water sources, wetlands, grazing lands, dwellings, vistas, and public areas can have a direct effect on application method as well as herbicide selection. Movement of herbicide from the target area to any of these is a label violation subject to litigation. This can occur through drift of fine spray particles during application, movement of volatilized product during or after application, and movement of products in surface water. Potential problems can be avoided by using proper equipment and selecting products that do not volatilize or move with surface water.

Aerial applications should be used cautiously and avoided completely in high-risk areas. Applications should be conducted under ideal weather conditions (wind speed less than 5 mph, and temperatures lower than 85 degrees Fahrenheit). Nozzles that deliver herbicides in large droplet sizes should be used in combination with drift control agents. Also, the presence of a helicopter or fixed wing aircraft near any sensitive area is likely to draw considerable attention to a spray operation regardless of risks. Advance notification of the operation to the local population can be used to determine any objections. In such cases alternative application methods or mechanical treatments may be advisable. Foliar ground applications are generally less prone to drift than aerial. However, similar precautions should be used. At times it may be advisable to treat buffer areas surrounding a tract by hand or other ground methods and broadcast treat only the interior portion of the site.

Soil-active products in liquid or granular form can be applied from the ground with little risk of drift. Products that will move with surface water should not be used on sloped sites draining into water supplies or any other sensitive area.

Wildlife Considerations--Land managers should be aware of possible impacts of herbicides on wildlife. Wildlife is often featured as a forest management objective, and certain animal as well as plant species are protected under the Endangered Species Act.

Normally, impacts on wildlife due to direct exposure to forestry herbicides are negligible. Forestry herbicides are not highly toxic to animals, are applied at relatively low rates, and do not persist for long periods in the environment.

Herbicides impact wildlife primarily by affecting habitat. This impact may be positive or negative. The degree of habitat modification depends upon the component of vegetation at which the treatment is directed and the type of application. Some herbicides primarily control woody species, some control herbaceous grasses and forbs, while others can temporarily eliminate nearly all vegetation on a site when broadcast at highest labeled rates. Even in the most extreme case the effects are temporary. Sites treated with broadcast applications generally revegetate within a year after treatment. The land manager should select treatments based on his objectives. Herbicide applications can be manipulated to favor wildlife.

A COMPARISON OF INDIVIDUAL STEM AND AREA METHODS OF APPLICATION

Unwanted woody plants may be controlled using methods of application that focus on the individual weedy stem or the area wherein weeds grow. Each approach has advantages and disadvantages and should be studied carefully before making a selection.

INDIVIDUAL STEM METHODS OF WOODY PLANT CONTROL

Unwanted woody rootstocks may be controlled on an individual basis using sprays to the base of the stem (basal bark treatment), to the stump (cut stump treatment), in an incision (injection method), to the soil (spot gun treatment), and on the foliage (foliar spray).

Individual stem methods of application have the advantage of: (1) being very selective with only the specific tree receiving herbicide, (2) offering minimum environmental impact with only the unwanted trees receiving the appropriate rate of herbicide directly to the stem or roots, and (3) low-to-high visibility.

Visibility varies with the method used (Table 1). For example, all application methods may be used during the growing season. Unfortunately, this timing produces a brown skeleton silhouetted against a background of green plants that brings attention to the controlled tree. In contrast, the low volume basal bark method may be used on dry bark any season of the year. During winter months, deciduous trees lack leaves and when treated there is no brown phase and the skeleton is hardly noticed until spring, when other plants green-up and treated

trees do not. Still less conspicuous is the cut stump method. Here, trees are cut and allowed to fall to the ground where they are concealed by surrounding vegetation. There is no standing skeleton to attract attention.

Individual stem methods of application are ideal for conditions involving (1) low maintenance, (2) short (<8-ft tall) or sparse (<300 rootstocks/acre) stems, (3) small acreage and (4) sensitive areas. Unfortunately, these methods are often labor intensive and therefore, expensive than area methods.

Table 1. A comparison of specific characteristics of individual stem methods of applying herbicide.

Individual Stem Method	Timing of Application	Visibility of Application
Spotgun	Spring-early summer	High, leaving skeletons
Low volume basal bark	Any time the bark is dry	Low, leaving skeletons
Cut Stump	Active growth; no heavy sap flow	Low, with no skeletons
Inject	Active growth; no heavy sap flow	High, leaving skeletons
Foliar Spray	Late summer early fall	High, leaving skeletons

AREA METHODS OF WOODY PLANT CONTROL

Area methods of application focus on the area to be treated not the individual stem. Herbicide is applied to the area knowing roots or leaves are in the treated area for uptake of the product. Herbicide may be applied from the air with a helicopter or airplane (aerial application) or from the ground (ground application) using a skidder, tractor, four wheeler, or backpack and spotgun. Area methods of application may be either broadcast to cover the entire area without skips or gaps or banded to cover continuous restricted strips within the total area.

Area methods have the advantage of being well suited for large tracts, tall trees (>8-ft tall), and high stem density (>500 rootstocks per acre). These methods may be highly visible with a high potential for environmental impact. Aerial applications are low in labor and cost as compared to individual stem treatments.

Table 2. A comparison of specific characteristics of area methods of applying herbicide.

Individual Stem Method	Timing of Application	Visibility of Application
Spotgun	Spring-early summer	High, leaving skeletons
Foliar Spray	Late summer early fall	High, leaving skeletons
Granule	Spring-early summer	High, leaving skeletons

LOW VOLUME BASAL BARK APPLICATION FOR INDIVIDUAL STEM CONTROL

The Concept

A basal bark treatment consists of applying a herbicide mixture to the base of the unwanted stem (individual stem) or rootstock (multiple stems). The herbicide mixture consists of the herbicide mixed with a carrier. The carrier moves the herbicide through the bark and to the cambium for translocation throughout the unwanted plant.

Method of Application

The applicator sprays the herbicide mixture to the lowest 12-18 inches of the bark around the entire stem. This is best achieved by starting at ground line and moving up with each pass of the wand as you move around the stem, with any excess spray occurring at the top of the treated area to then soak in as it runs down the stem. Spray until the bark is saturated but without runoff on the ground.

Age and Size of the Tree

Small trees approximately 5-inches in dbh or 6-inches in ground line diameter usually have young thin, smooth bark requiring less spray than old thick, coarse bark of larger trees. Small stems are more easily controlled than larger older stems.

Timing

Do not spray when the bark is wet. To check the bark for excessive moisture, press the bark with your thumb. If moisture is visible, the bark is too wet. Also, spray a test tree and if the oil-herbicide mixture turns white then the bark is too wet. Under either of these two conditions, do not spray.

Expected Performance

Applications can be made successfully any time of the year. Treatments are often most effective during late summer, fall and winter when trees are moving food reserves to the roots. Least effective control can be expected during early spring when energy reserves are moving from the root to shoot tips.

Necessary Equipment

Backpack hand-pump sprayer with a wand fitted with an adjustable cone nozzle is recommended. Adjust the size of the cone spray to accommodate the size of the stems being treated.

Some products labeled for low volume basal bark sprays are Garlon 4 Ultra (Remedy Ultra), Pathfinder II and Stalker herbicides. For Garlon 4 Ultra (also Remedy Ultra), prepare a 20-30% mixture of product with diesel, kerosene, or basal oil. Pathfinder II is ready-to-use (requires no mixing). Stalker should be mixed 8-12oz of product with diesel or penetrating oil per gallon of mixture.

Some basal oils appropriate for mixing with the above herbicides are diesel, kerosene, Basal and Brush Oil by Helena, Bark Oil (Blue) by Aquamix, and Bark Oil EC (Blue) by Aquamix.

CUT STUMP APPLICATIONS FOR INDIVIDUAL STEM CONTROL

The Concept

A cut stump treatment consists of applying a herbicide mixture to the recent cut surface of a tree stump taking care to treat the cambium area and the edge of the stump. The herbicide mixture consists of the herbicide and a carrier. When cut, the tree develops a callus layer at the site of injury. The carrier moves the herbicide through the developing callus layer where the herbicide moves throughout the plant for control.

Method of Application

Before applying herbicide, remove sawdust from stumps. On a stump 4-inches tall, apply the herbicide mixture to the entire surface of small stumps and to the cambium (conducting tissues of the tree) located near the bark on large stumps. Apply sufficient herbicide mixture for the volume to soak the entire circumference of the stump surface, running over the top 2-inches of the stump edge. For large trees, exposed roots may be treated also. Because some herbicides are soil active, care must be taken to avoid nontarget plant damage through soil movement. Control can be achieved without treating the soil with herbicide.

Age and Size of the Tree

Small trees are more readily controlled than large trees, but the technique works on all trees.

Timing

Best control results from applications immediately after the tree is cut. For oil-based sprays, control will decline over the next two days. Do not treat stumps more than two days old. For water-based sprays, treat stumps immediately. Control will decrease if treatment is delayed for more than one hour. Cut and treat stumps during periods of active growth, commonly after full leaf expansion, but not during heavy sap flow.

Expected Results

Cut stump treatments are effective any time of the year except during periods of very active growth (heavy sap flow).

Necessary Equipment

Backpack hand-pump sprayer with a wand fitted with an adjustable cone nozzle works well. For small projects, a squirt bottle or paintbrush is adequate.

Some oil-based products labeled for cut stump treatment are Garlon 4 Ultra (Remedy Ultra), Pathfinder II and Stalker. For Garlon 4 Ultra (Remedy Ultra) prepare a 20-30% mixture of product and oil. Pathfinder II is ready-to-use (requires no mixing). For Stalker, prepare a gallon of mixture containing 8-16oz of product in diesel or penetrating oil. Some penetrating oils appropriate for mixing with the above herbicides are Basal and Brush Oil by Helena, Bark Oil (Blue) by Aquamix, and Bark Oil EC (Blue) by Aquamix.

Garlon 3A (undiluted), Pathway (undiluted), Accord Concentrate (50%-100% solution), Accord XRT (40%-50% solution), Transline (50% solution) and Stalker (8-16oz or 6.25%-12.5%) are water-based herbicides labeled for cut stump treatments.

INJECTION FOR INDIVIDUAL STEM CONTROL

The Concept

Stem injection, including hack-and-squirt, consists of making an incision in the side of a tree and placing a measured amount of herbicide in the incision. The herbicide is moved by the cambium tissues throughout the tree for control.

Method of Application

A hatchet, machete, ax, or tree injector is used to make evenly spaced incisions in a tree. The incision forms a pocket where concentrated or diluted herbicide is applied. The incision temporarily holds herbicide while it soaks into the tree.

Because some herbicides are soil active, avoid applying or spilling herbicide on the tree trunk or onto the soil where rain can wash the herbicide to the roots of nontarget surrounding plants.

Age and Size of the Tree

Stems less than 2-inches in diameter are difficult to inject and should be generally considered too small for stem injection. Trees \geq 2-inches in diameter are more readily controlled than large trees, but the technique works on all sizes. Edge-to-edge incisions may be needed for large or difficult to control species.

Timing

Best results can be expected when trees are injected during periods of active growth, commonly after full leaf expansion, but not during heavy sap flow. Avoid injecting trees when rainfall seems imminent or during extreme drought.

Necessary Equipment

A hatchet, machete, or ax may be used to make an incision at a comfortable height for the user. The squirt bottle is used to apply herbicide into the incision. In this example, the squirt bottle can be a thoroughly cleaned reusable plastic bottle or a newly purchased plastic bottle. Either bottle should be dedicated and labeled for herbicide use only. In this approach, the user fills the squirt bottle with herbicide, makes an incision in the tree and squirts the herbicide in the incision. The hypo-hatchet is another hatchet approach that eliminates the need for a separate squirt bottle. In this example, the hypo-hatchet comes with a tube and lid that fits the herbicide jug. Each time the hypo-hatchet strikes the tree, a piston in the head of the hatchet opens and closes dispensing herbicide from the jug into the incision. The Jim-Gem is a basal injector. In this example, herbicide is poured into the tube of the injector and dispensed through the blade at the end of the injector with each pump of the handle. To use, the applicator stabs the base of the tree, making an incision, and pumps the handle, releasing herbicide into the incision.

Velpar L, Stalker, Garlon 3A, Pathway, Transline, Accord XRT and Accord Concentrate are all labeled for individual tree injection. Always follow the herbicide label. Some suggestions follow.

Table 1. Herbicide name, undiluted or diluted mixture to be injected, herbicide per incision and spacing of incisions, timing of application for tree injection.

HERBICIDE	MIXTURE	INCISIONS	TIMING
Velpar L Hexazinone	undiluted	1 ml/incision 4-inch intervals	summer
Stalker Imazapyr	8-12oz/gal of mix	1 ml/incision ≤1-inch interval between cut edges	periods of active growth, but not during heavy sap flow
Garlon 3A Triclopyr	50% or undiluted	1 or 0.5 ml/incision slightly overlapping and continuous	periods of active growth and after full leaf expansion
Pathway Picloram+2,4-D	undiluted	1 ml/incision/ inch of dbh	any season
Transline Clopyralid	50% or undiluted	1 or 0.5 ml/incision 3-4 inches between centers	periods of active growth and after full leaf expansion
Accord XRT II Glyphosate	40-100% solution	1 ml/incision 2-3 inches of dbh	periods of active growth and after full leaf expansion
Accord Concentrate Glyphosate	25-100% solution	1 ml/incision 2-3 inches of dbh	periods of active growth and after full leaf expansion

SPOTGUN APPLICATION FOR INDIVIDUAL STEM CONTROL

The Concept

Spot Velpar L to the soil, beneath the canopy, and within the root zone of an unwanted tree for root uptake and control. Velpar L is the only herbicide labeled for spot applications to the soil for control of forest trees and shrubs. Be aware that the roots of nontarget species in the treatment area are at risk to herbicide uptake and plant death.

Method of Application

Using a handgun applicator, apply Velpar L to the soil. Adjust the amount of herbicide delivered to the soil based on size and dimension of the tree to be controlled. Because Velpar L is soil active, spot the soil on the uphill side of stems on slopes allowing plenty of room between the spot and the roots of nontarget surrounding plants. All small stems of susceptible species that have roots in the treated area will be killed also.

Age and Size of the Tree

The amount of herbicide needed varies with tree size or dimension. For example, apply Velpar L at the rate of 2-4 ml for each inch of DBH. Direct the treatment to the soil within 3-feet of the root collar of the plant to be controlled. When a large stem requires more than one delivery of Velpar L, make application evenly spaced around the stem. For multi-stemmed brush, apply Velpar L at the rate of 2-4 ml per 3-feet of canopy width. For tall, slender brush types, apply 4-8 ml per 3-feet of height. Base the rate on whichever canopy dimension is greater (width or height). Difficult to control species or stems on clay soils should receive the higher dose of herbicide.

Timing

Apply Velpar L from early spring to early summer after trees have broken bud and before full leaf expansion. Spring rainfall is needed to move the herbicide into the soil and down to the roots for uptake. Avoid soil treatments when heavy rainfall seems imminent.

Necessary Equipment

Different models of spotguns are available. A handgun, consisting of an adjustable graduated cylinder or syringe that is operated by squeezing the handle, is highly desirable. The graduations on the spotgun are not accurate, thus calibration of the spotgun should be checked. One pull of the handle will deliver the same amount of water or Velpar L, so use water to calibrate. To calibrate, pull the handle 10 times. If 20 ml are captured, the spotgun is set for 2 ml/spot. If 30 ml are captured, the spotgun is set for 3 ml/spot. Adjust the setscrew to fix the piston of the syringe to deliver the desired amount.

Table 1. Examples of Velpar L soil-applied with a spotgun for individual stem control of arborescent and shrub species. The high rate is for fine-medium textured soils and hard-to-control species. The low rate is for coarse soils and easy to control species.

3-ft Shrub Height	3-ft Shrub Crown Diameter	Per inch of Single Stem DBH
4-8mL	2-4mL	
		2-4mL

LOW VOLUME FOLIAR APPLICATION FOR INDIVIDUAL STEM CONTROL

The Concept

Spray water-herbicide-adjuvant mixture directly onto foliage of unwanted individual plants while avoiding desired plants.

Method of Application

The applicator sprays the herbicide mixture in a total volume of 5 to 30 gallons per acre, with 5 to 10 gallons per acre being common. The spray is directed to give good coverage of the foliage, growing tips and terminal leader of all sides of the tree. Leaves are sprayed to wet without drip or runoff. Nozzles, adjuvants, spray pressure and techniques that minimize drift should be used. Non-soil-active herbicides and spray shields may be used to reduce exposure to desired plants. Always follow the label.

Age and Size of the Tree

Appropriate trees are short, usually \leq 8-feet tall and readily accessible. The applicator should be able to spray the entire crown, from top to bottom and all sides.

Application Season

This method may be used anytime mature leaves are present, trees are actively growing but before autumn coloration. Late summer and early fall is common.

Necessary Equipment

Backpack hand-pump sprayer with a wand fitted with a flat or adjustable cone nozzle or a Model 30 GunJet with rollover nozzle is recommended.

Some herbicides labeled for unwanted woody plant control with directed low-volume foliar sprays are Arsenal AC, Chopper GEN2, Milestone VM Plus, Transline, Garlon 3A, Accord XRT II, Accord XRT, Accord Concentrate and Garlon 4 Ultra. See product labels for specific details on rates, timing of application, instructions for application as well as limitations and precautions. Examples of individual stem control of unwanted hardwoods while releasing pines are presented in Table 1.

Table 1. Examples of common foliar-applied herbicides for woody release of pines.

Herbicide Mixture	Product/acre	Target Competitor
Arsenal AC+ Li-700	14oz+ .25%v/v	Miscellaneous broadleaf and grass control
Arsenal AC+ Escort XP+ Li-700	14oz+ 1oz+ .25%v/v	Miscellaneous Broadleaf, grass and Rubus control

AREA METHOD OF APPLICATION:
CONTROLLING UNWANTED WOODY STEMS WITH A
SPOTGUN APPLICATION

The Concept

Apply a soil active herbicide directly to the soil in a grid. Roots of unwanted trees extending into the grid take up herbicide and are controlled. Velpar L is the only forest herbicide labeled for spot applications to the soil for control of species of forest trees and shrubs.

Method of Application

Using a handgun applicator, apply a spot of Velpar L to the soil. Adjust the amount of herbicide delivered to the soil based on soil texture and grid pattern (Table 1).

Age and Size of the Tree

The amount of herbicide needed does not vary by tree size or dimension. Rate is determined by soil texture and species susceptibility. That is, use lower rates on coarse textured soils and where the major hardwood components are susceptible species. Use high rates on fine-textured soils and where species that are partially controlled or suppressed dominate the stand.

Timing

Apply Velpar L from early spring to early summer after trees have broken bud and before full leaf expansion. Spring rainfall is needed to move the herbicide into the soil and down to the roots for uptake. Avoid soil treatments when heavy rainfall seems imminent.

Necessary Equipment

Different models of spotguns are available. A handgun, consisting of an adjustable graduated cylinder or syringe that is operated by squeezing the handle, is highly desirable. The graduations on the spotgun are not accurate, thus calibration of the spotgun should be checked. One pull of the handle will deliver the same amount of water or Velpar L, so use water to calibrate. To calibrate, pull the handle 10 times. If 20 ml are captured, the spotgun is set for 2 ml/spot. If 30 ml are captured, the spotgun is set for 3 ml/spot. Adjust the setscrew to fix the piston of the syringe to deliver the desired amount.

Table 1. Soil texture, mL/spot , grid pattern and rates for undiluted Velpar L herbicide applications to the soil with a spotgun.

Soil Texture	mL/spot	Grid (FT)	Quarts/Acre
Coarse	0.6	3 x 3	3
	2.0	4 x 4	6
	3.1	4 x 6	8
Medium/Fine	1.6	3 x 3	8
	2.8	4 x 4	8
	3.5	4 x 4	10
	5.2	4 X 6	10

AREA METHOD OF APPLICATION:
CONTROLLING UNWANTED WOODY STEMS WITH A
FOLIAR APPLICATION

The Concept

Apply a herbicide directly in an area occupied by unwanted trees. Roots or leaves of unwanted trees resident or extending into the area absorb the herbicide and are controlled.

Method of Application

Using a helicopter or skidder, apply the herbicide mixture to the area. Always follow the labeled instructions.

Age and Size of the Tree

This approach is well suited for trees of various size, dimension and age.

Timing

Usually late summer or early fall is best.

Necessary Equipment

A helicopter or skidder outfitted with dedicated and appropriate nozzles, etc. for forestry site applications.

Some herbicides labeled for unwanted woody plant control using foliar sprays are Arsenal AC, Chopper Gen II, Milestone VM, Transline, Garlon 3A, Garlon XRT, Accord XRT II, Accord XRT, Accord Concentrate, and Escort XP. See product labels for specific details on rates, timing of application, instructions for application as well as limitations and precautions. Some examples follow in Table 1. Please notice that each treatment is a herbicide mixture targeting specific competitors and containing more than one herbicide. Because no one product controls all unwanted species, mixtures are used to achieve efficient broad-spectrum control with the least amount of herbicide. Users commonly achieve broad-spectrum control by selecting tank partners with strengths that compliment the weaknesses of the other tank products, thereby reducing the holes in the spectrum of control.

Table 1. Some examples of common herbicide mixtures for aerial applications during forestry site preparation.

Herbicide Mixture	Product/acre	Target Competitor
Milestone VM+ Accord XRT II+ LI-700	7oz+ 6qts+ .5%v/v	Noncrop pine
Arsenal AC+ Accord XRT II+ Escort XP+ Nonionic surfactant	24oz+ 64oz+ 1oz+ .5%v/v	Miscellaneous Broadleaf Control
Arsenal AC+ Garlon XRT+ Nonionic surfactant	24oz+ 16oz+ .5%v/v	Miscellaneous Broadleaf Control
Chopper Gen II+ Garlon XRT+ Methylated seed oil	48oz+ 32oz+ 1-2qt	Miscellaneous Broadleaf & Waxy Control
Accord XRT II+ Garlon XRT+ Nonionic surfactant	1 gal+ 32oz+ .5%v/v	Miscellaneous Broadleaf Control
Milestone VM+ Accord XRT II+ Chopper Gen II+ LI-700	7oz+ 6qts+ 12oz .5%v/v	Noncrop pine+ Broadleaf Control

AREA METHOD OF APPLICATION:
UNWANTED WOODY STEM CONTROL WITH HERBICIDE GRANULES TO THE SOIL

The Concept

Broadcast or band-apply a soil active herbicide directly to the soil. Roots of unwanted trees extending into the treated area absorb herbicide and are controlled. Velpar ULW is the only forest herbicide formulated and labeled for the application of granules to the soil for control of forest trees and shrubs.

Method of Application

Apply Velpar ULW using appropriately modified ground or aerial equipment. Adjust the rate of herbicide delivered to the soil based on soil texture, organic matter and species susceptibility (Table 1).

Age and Size of the Tree

The amount of herbicide needed varies by soil texture and species susceptibility (tree size and vigor). That is, use lower rates on coarse textured soils and soils low in organic matter and where the major hardwood components are susceptible species. Use high rates on fine-textured soils or soils high in organic matter and where species that are partially controlled or suppressed dominate the stand. The degree and duration of control is influenced by environmental conditions at and following treatment.

Timing

Apply Velpar ULW from early spring to early summer after trees have broken bud and before full leaf expansion. Rainfall dissolves the Velpar ULW granule, releasing the active ingredient, hexazinone, into the root zone, where it is absorbed during periods of vigorous plant growth. Avoid soil treatments when heavy rainfall seems imminent.

Necessary Equipment

A modified backpack blower is recommended for ground applications. Aerial applications are best when the DuPont Simplex applicator is used. For best results, acquire blank granules for equipment calibration.

Table 1. Soil texture requirements for granules of Velpar ULW applications to the soil.

Soil Texture	Velpar ULW--Pounds per acre
Sand, Loamy Sand, Sandy Loam	1 to 2
Loam, Sandy Clay Loam, Silt Loam	2 to 3
Clay Loam, Sandy Clay, Silty Clay Loam, Silty Clay, Clay	3 to 4

AREA METHOD OF APPLICATION:
HERBACEOUS RELEASE OF PINES WITH A BAND OR BROADCAST APPLICATION

The Concept—band application

Broadcast or band-apply soil-active herbicide directly to the soil and over-the-top of newly planted seedlings. Roots of pre-emergent and roots, stems, and leaves of post-emergent unwanted herbaceous plants extending into the treated area absorb herbicide and are controlled. Arsenal AC+Oust XP, Oustar, and Oust Extra are labeled and commonly used for this application (Table 1).

Method of Application

Apply herbicide using appropriately modified ground or aerial equipment. Adjust the rate of herbicide delivered to the soil or plant based on soil texture, organic matter and species susceptibility. Always follow the labeled instructions and limitations.

Age and Size of the Herbaceous Weed

Small, rapidly growing, annual herbaceous weed are more readily controlled than established perennial weeds. The degree and duration of control is influenced by environmental conditions at and following treatment.

Timing

For post-plant herbaceous weed control, best results are achieved by applying herbicides in early spring to bareground or when post-emergent weeds are less than 3" tall. For combining fall site preparation and herbaceous weed control in a single application, mix Oust XP herbicide in the site prep tank and apply during late-June through October window for applications. Rainfall moves soil active herbicides into the root zone, where it is absorbed during periods of vigorous plant growth. Avoid soil treatments when heavy rainfall or severe drought seems imminent.

Necessary Equipment

A backpack sprayer, skidder or helicopter are recommended for applications.

Table 1. Herbicide rates for herbaceous release of pine seedlings from unwanted herbaceous plants.

Herbicide	Ounces of Product Per Treated Acre	Target Competitor
Arsenal AC+Oust XP	4+2	Grasses and Forbs
Oustar (Medium-Fine soils)	13	Grasses and Forbs
Oustar (Coarse soils)	10	Grasses and Forbs
Oust Extra	3-4	Rubus, Grasses and Forbs
Oust XP- fall site prep	3-Sep-Oct	Grasses and Forbs
Oust XP- fall site prep	4-Jun-Aug	Grasses and Forbs

KEEPING RECORDS

Guidelines for recording keeping are provided by state regulatory agencies. Records should include all the information needed for a stranger to complete the project if need be. Examples of my records are as follows:

- 1—A recipe is prepared containing all the ingredients, and their respective amounts, to be mixed. I list the dominate species to be controlled as well as the crop species.
- 2—All ingredients in the recipe are labeled by common name and EPA number. The rate per acre and in each tank is computed in advance of mixing.
- 3—The applicator's license number is listed.
- 4—For the starting and ending time of application, record the temperature, wind speed and direction. Soil temperature is recorded and a soil sample is collected.
- 5—A description of the equipment, boom, nozzles, metronome setting, MPH, GPA are recorded.
- 6—A map of the treatment area complete with written directions from the office to the site and GPS coordinates of the site, are taken.
- 7—A list of contacts should be recorded.
- 8—At completion of the project, any special observations should be made.
- 9—Project data should be collected and summarized explaining the success or failure of the project.

SUMMARY AND CONCLUSION

Vegetation control should be conducted to fit within and enhance the overall objectives of a sound forest management plan. An effective land manager should consider prescribed fire, mechanical, and herbicidal options for their merits. Making a reasonable decision as to whether the use of herbicides is appropriate requires an understanding of their effects and limitations. Herbicides and application methods can be combined to provide the broad-spectrum or selective control desired. Managers should plan for success. A herbicide prescription clearly maps the factors considered and the course taken. Records should be kept documenting successes and failures for future reference. When integrated, herbicides, prescribed fire, and mechanical treatments can be very socially, environmentally, and efficaciously responsible.