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Professional Hardwood Notes
Technical Information on Hardwood Silviculture for Foresters

Site Preparation for Natural Regeneration of Hardwoods

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One aspect of forest sustainability is regenerating the stand to desired species once the stand is harvested. Usually the species present in the overstory are more desirable than those in the understory and midstory. If management is not performed to adjust the regenerating species composition prior to the harvest, these understory and midstory species likely will be the composition of the future stand. Management actions should be taken to encourage reproduction of favored species and discourage the undesirable trees and other vegetation.

Site preparation is a silvicultural treatment specifically designed to encourage the regeneration and growth of desired species. Normally, site preparation treatments are administered directly before, during or after a harvest. This publication provides specific information on how and why site preparation treatments are often needed in naturally regenerated hardwood stands to develop future stands of favored species.

In closed-canopy forests that have not been disturbed for many years, most of the sunlight is intercepted by the upper canopy, limiting the light that filters through to the ground. The species that can grow and survive in those limited light conditions are the shade-tolerant species of maple, beech, dogwood, sourwood, blackgum and others; these are some of the least valuable timber species. This situation is acute in the regeneration of undisturbed oak forests where the shade-tolerant species are prevalent in the understory. Oak seedlings grow slowly in the understory, if they are even present. Most oaks are intermediate or intolerant of shade. If a complete harvest is conducted, faster-growing, intolerant species often outgrow the oaks as well as established seedlings of shade-tolerant species. Site preparation can be used to control these rapidly growing intolerant species as well as sprouts of established shade-tolerant species. Because of these numerous sources of competition, site preparation is often required to promote the desired species and control the more undesirable species to obtain a favored species composition in the newly regenerating stand.

Several treatments or methods can be used with site preparation to improve the number of desirable stems and species when the overstory is harvested. One example is the oak shelterwood treatment (Stringer 2006) pioneered by Loftis (1990; 2004) for use in upland hardwoods to favor the regeneration and perpetuation of oaks. The midstory is removed several years prior to harvesting the overstory so more sunlight filters to the ground. Care should be taken to avoid canopy gaps in the overstory allowing direct sunlight to reach the ground, supporting the growth

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of shade-intolerant species rather than the slower-growing oaks. The shade-tolerant understory is also controlled to provide more resources, particularly sunlight, and less competition for the oak seedlings. Both of these management actions increase the probability of oaks becoming a component of the future overstory by developing greater oak size and numbers before the overstory or shelter is removed. Therefore, oak has a head start in growth over its competitors that is lacking if site preparation is not conducted.

Reproductive mechanisms

Most hardwoods reproduce from seed; from root, seedling or stump sprouts; or from advance reproduction, i.e., seedlings or saplings already present before the harvest. Each reproductive source (seeds, sprouts, advance reproduction) may favor one species over other species (Table 1).

Almost all hardwood species reproduce from sprouting. The intact root system gives stems produced from sprouting a growth advantage over those that originate from seed. The residual trees should be cut close to the ground to induce sprouting from the ground level. Sprouts originating aboveground on the stump are structurally weak and will usually break with age or be deformed.

Photo Credit: Jeff Stringer

Sprouts originating high on the stump are structurally weak. Trees should be cut as close to the ground as possible to induce sprouting near the ground level.

Although stump sprouting will occur on larger stems, the probability of sprouting diminishes with increasing stem size above 8 to 10 inches (Johnson 1977; McGee 1978). A few species that prolifically root sprout are black locust, sassafras and sweetgum. If these species are not desired in the future stands, residual stems should be treated with herbicide to ensure the root system is killed and roots will not sprout.

Poorly formed trees of preferred species that are less than 2 or 3 inches in diameter are frequently cut to encourage sprouting. The sprouts often provide a centralized stem that has better quality potential (stem form) than the initial stem and will grow faster than the original stem. The existing stem was probably barely surviving and maintaining itself under growing conditions that were less advantageous and may not be able to respond to release once favorable conditions for growth are provided.

Many stumps initially have multiple sprouts. With time, the number of sprouts per stump diminishes as they compete with each other for resources. One or more of the most dominant sprouts eventually will remain. Growth is partitioned among the multiple sprouts. If sprout clumps are thinned to fewer (one or two) sprouts, then sprout growth increases, because more energy/resources are allocated to fewer stems. Thinned sprouts grow faster with greater growth rates than unthinned sprout clumps (Rogers and Johnson 1989).

Trees will also reproduce from seed. The most critical time during a tree's lifetime is when the seed is germinating. Moisture, sunlight, temperature and soil condition must be advantageous for a germinating seed to survive. To continue growing, seeds must establish a root system as well as a shoot to create energy from photosynthesis. Thus, initial growth for many species is slow. Shoot growth from germinating seed is much slower than sprouts from intact root systems. The exceptions are yellow-poplar and black cherry, which have the inherent ability to grow fast from seed. These two species also increase their reproductive numbers after a harvest because their seed remains viable in the forest duff for four to seven years, while the seed of most other species remain viable for a short period of time, usually overwinter. The soil surface serves as a seed bank for these species. When the overstory and midstory are removed, the large number of accumulated seeds germinates, grows fast and overwhelms other species.

Table 1. Sources of reproduction and shade tolerance of some species in hardwood forests.

	Relative importance of reproduction source in relation to species regeneration potential[a]					
Species	**Seed from current seed crop**	**Seed stored in forest floor**	**Advance reproduction[b]**	**Stump sprouts[c]**	**Root sprouts (suckers) from cut trees**	**Shade tolerance**
American basswood			1	1	2	tolerant
American beech			1	3	2	very tolerant
American elm			1	3	2	intermediate
American holly		1	2	2		very tolerant
American hornbeam			1	2		very tolerant
Ash, green & white		1	1	2		intermediate
Bigtooth aspen	2		3	3	1	very intolerant
Black cherry		1	2	2		intolerant
Blackgum			1	2		tolerant
Black locust		2			1	very intolerant
Black walnut	1		1	2		intolerant
Black willow	1			2	2	very intolerant
Boxelder	2		1	1		tolerant
Buckeye	1	1	2	2		tolerant
Butternut			1	2		intolerant
Cucumbertree		1	2	2		intermediate
Eastern cottonwood	1			1	3	very intolerant
Eastern hophornbeam			1	2		very tolerant
Eastern redbud		2	1	1		tolerant
Flowering dogwood			1	2		very tolerant
Hackberry & sugarberry			1	3		intermediate
Hickories[d]			1	3		intermediate
Oaks[e]			1	2		intermediate
Persimmon		2	1	1	2	very tolerant
Red maple			1	2		tolerant
River birch	1		2	2		intolerant
Sassafras			1	2	1	intolerant
Silver maple			1	2		tolerant
Slippery elm			1	3	2	tolerant
Sourwood		2	1	1		tolerant
Sugar maple			1	2		very tolerant
Sweetgum	1			1	1	intolerant
Sycamore	1		2	2		intolerant
Yellow birch	1		2			intermediate
Yellow-poplar		1	2	2		intolerant

[a] 1 = primary source; 2 = potentially significant, but not a primary source; 3 = minor source. Relative importance of reproduction source is for sawtimber-size stands
[b] Includes seedlings, seedling-sprouts and root sprouts in a few species (i.e., species in root sprouts column)
[c] Sprouts originating from stumps of trees ≥ 2 inches dbh
[d] Hickories as a genus are mostly intermediate in shade tolerance. Mockernut and bitternut range toward the intolerant scale.
[e] Oaks as a genus are mostly intermediate in shade tolerance. The red oak family ranges toward the intolerant scale.

Sources: Burns, R.M.; Honkala, B.H. 1990. Silvics of North America. Agric. Handb. 654 (2 volumes). Washington, DC: USDA Forest Service
Johnson, P.S. 1989. Central hardwood notes. St. Paul, MN: USDA Forest Service, North Central Forest Experiment Station
Putnam, J.L.; Furnival, G.M.; McKnight, J.S. 1960. Management and inventory of southern hardwoods. Agric. Handb. 181. Washington, DC: USDA Forest Service

Some seeds germinate and grow before the overstory trees are harvested. This "advance reproduction" of seedlings 5 feet tall or greater has a better chance of becoming larger with their head start in growth over those that begin from seed or from sprouts after the harvest. Slow-growing seedlings, such as oaks and hickories, rely on advance reproduction to assert themselves in the regenerating stand.

Control of Undesirable Vegetation

Several techniques are available to deaden stems of undesirable species. Cutting, physically girdling or frilling will kill the aboveground portion of the tree, but will not control stump or root sprouting. Use of herbicides is the most dependable method to kill stumps and roots and prevent sprouting. The most effective herbicides for controlling perennial plants are those which are translocated to the roots. If the roots of the plant are killed by the herbicide, then sprouting does not occur.

Prescribed burning has often been proposed as a tool to control undesirable vegetation. Burning is non-selective and kills the aboveground portion of plants. However, burning has little impact on the underground root system. Most hardwoods have the capability to resprout prolifically after burning, as indicated in Table 1. Repeated burning on a 1- to 3-year interval may influence the decline of some species for time periods of 10 or more years, depleting the stored energy in root systems. However, the stand also has lost 10 or more years of potential growth while the composition is being adjusted to desired species. Research in eastern Kentucky suggests that single and repeated prescribed fire had little effect in promoting oak compared to other species (Alexander et al. 2008; Blankenship and Arthur 2006). Burning will aid in bringing all vegetation back to the same stage of development (bare ground) and creating seedbed conditions that may enhance germination of seed. Then seeds and sprouts have an equal opportunity to compete for resources. Research on prescribed burning to date has not indicated that burning carries any preferential species advantage and could even support sprouting and growth of undesirables at the expense of more desirable species.

Herbicide Application Methods

Most herbicides for site preparation of hardwoods are applied on a stem-by-stem basis by hand equipment such as backpack sprayers and squeeze bottle sprays. The most common treatments are directed foliar sprays, basal bark applications, tree injection and cut-stump sprays. The size of the target stem to be controlled will influence the application method used (Table 2).

Directed Foliar Sprays

Foliar spraying is one of the easiest herbicide application techniques. The herbicide is sprayed on the foliage, absorbed and transported within the plant to disrupt physiological processes that eventually kill the plant. Sometimes a surfactant needs to be mixed with the herbicide to promote adherence and spread of the herbicide spray on the foliage. Often with foliar sprays, the foliage is killed before the herbicide has a chance to be transported to other places within the plant. Thus, care must be taken to apply the herbicide during the correct time and plant stage to affect the entire plant. Otherwise, treated trees or plants will re-sprout and the herbicide treatment suspends plant growth, but does not kill it.

Proper calibration of spraying equipment and use of appropriate spray tips (full cone, adjustable cone or flat fan) on backpack sprayers are necessary for effective spraying. Inaccurate calibration often leads to either under- or over-application of the herbicide, each having consequences in desired plant control and cost. Direct foliar spraying is also the technique with the greatest chance of damage to non-target plants. Most herbicides for hardwood control are non-specific and affect most broadleaf

Table 2. Method of herbicide application that is appropriate for the size of target stem to be controlled.

Application Method	Effective Size of Target Stems
Directed foliar spray	Less than 6 feet tall
Basal bark applications	Less than 3 inches in diameter
Tree injection	All sizes greater than 1 inch in diameter
Cut stump spray	All sizes

Photo Credit: Wayne Clatterbuck

When using a backpack sprayer, Personal Protective Equipment (PPE) is necessary for safely applying herbicide.

foliage. Direct spray can harm adjacent desirable species through poor directional spraying, volatilization, drift from wind, drip from overspraying target plants and poor timing. Timing of application is at full leaf emergence in the summer through the growing season when leaves begin to senesce near the end of the growing season (early September), reducing the effectiveness of the foliar spray. The general recommendation is not to use direct foliar spraying because of the chance of affecting desirable plants.

Directed sprays can influence non-target broadleaf plants even with the best application procedures. The choice of herbicide will depend on the target species or the spectrum of target species, because many of the herbicides have different impacts on various species. This technique has more application in the release of conifers when the hardwood competition is less than 6 feet tall, not in the site preparation for hardwood regeneration unless the species controlled are small (less than 3 feet tall) and accessible with a backpack sprayer.

Basal Bark Applications

Once the plants to be controlled are larger than 6 feet tall, where foliar sprays are impractical or unsafe, basal bark treatments are often used. A streamline basal spray is most often applied on stems less than 3 inches in diameter at breast height (DBH). The streamline or thinline herbicide is sprayed in a band 1 to 2 inches wide on the lower 12 inches of the stem. Although the spray does not necessarily encircle the entire stem during application, the herbicide mixture should penetrate and spread to encircle small stems. Control of larger trees greater than 3 inches DBH and having thicker bark is more difficult for herbicide spread and penetration. Thus, a full basal treatment where the entire tree circumference is sprayed with a broader band (more herbicide) is required. To determine the efficiency and effectiveness of the herbicide application, the prescribed basal bark treatment should be tested, and the range of species and stem sizes that might be encountered should be considered.

The advantage of these treatments is that they deliver herbicide directly to the target tree with little chance of the non-target trees being affected. Applications are usually made during the later part of the winter, February and March, when leaves do

Photo Credit: Wayne Clatterbuck

A thin stream of herbicide is applied to a red maple stem as a basal bark treatment.

Photo Credit: Wayne Clatterbuck

A broader band of herbicide is applied to a large red maple sprout clump.

not hinder spraying. The herbicide is mixed with an oil carrier that allows the mixture to spread and penetrate the bark. Once inside the bark, the herbicide is translocated throughout the plant.

Cut-stump Sprays

Cut-stump treatments are particularly effective on larger stems/stumps that might have the propensity to sprout. Herbicides are applied to the freshly cut surface of the stump. Application should occur within an hour of the cut so the tree can absorb the herbicide before it tries to seal the cutting injury. Herbicide is applied from a backpack sprayer or handheld spray bottle. Only the outer 1 or 2 inches of the circumference of the stump surface should be sprayed. Most of the conducting tissue of the stump/tree is in this area. The herbicide is absorbed and translocated to the roots.

If herbicide is not applied to the stump for more than an hour after the cut, spray the bark on the outer edge of the stump surface for the entire circumference. This application would then need to penetrate the bark for the herbicide to get inside the tree and be translocated, similar to the basal bark treatments discussed earlier.

Tree Injection

Tree injectors, "hypo-hatchets" (Hypo-Hatchet® tree injector) and hack-and-squirt are all tools for application of herbicide into the tree through a cut surface. Tree injectors and hypo-hatchets have fallen into disfavor because they are difficult to use and maintain. Hack-and-squirt is simple and easy because it only uses a hatchet and a squirt bottle (or backpack sprayer) that are easily carried in the woods. The ax is used to cut through the bark of the tree (usually waist-high) into the sapwood creating a downward notch, and then the herbicide is applied via the squirt bottle into the notch. The spray/squirt should be calibrated to ensure the correct amount of herbicide is delivered. Several notches should be equally spaced around the stem of the tree, depending on the size and species of the tree and the herbicide used. On some hard-to-kill species, a continuous frill or girdle with herbicide applied within may be required.

Photo Credit: Gary Miller, USDA Forest Service

Hack-and-squirt is a method that places a measured amount of herbicide into trees through frills or small incisions in the bark.

Tree injection has the advantage that almost any size tree can be killed and that the herbicide is delivered to the inside of the target tree. The herbicide is contained, transported and broken down in the tree with little chance of movement to non-target plants. Herbicides for tree injection can be applied at most times of the year except during times of heavy sap flow in late winter and early spring before leaf emergence and during droughts in late summer. Water-soluble forms of herbicides are most commonly used to obtain the greatest movement of the herbicide within the tree.

Recent information from Londo et al. (2008) suggests that only one or two frills with injections of imazapyr solution are required to kill many hardwood species from 4 to 6 inches DBH. The method greatly reduces the time and effort required for injection if the tree species is susceptible to imazapyr. A 6-inch tree (18-inch circumference) would require six or more frills spaced 2 inches apart for effectiveness. Read the herbicide label to ascertain methodology and species effectiveness. However, a unique characteristic with imazapyr is the relatively long time it takes to kill the tree after application. After imazapyr is applied, trees will lose some foliage, remaining leaves are small and trees generally have an abnormal or sickly appearance during the first growing season. Complete effectiveness of the herbicide does not appear until the second growing season after treatment.

Continuous frills that girdle a tree or double girdling with a chainsaw can be accomplished to top-kill trees without herbicides. However, the effectiveness can be increased by using herbicides. With herbicides, the chemical is translocated to the roots, killing the roots and preventing sprouting. Girdling trees without herbicides is generally less dependable (particularly with hard-to-kill species, such as dogwood, red maple, hickories and beech), and requires more time and labor to completely girdle the tree. Additionally, safety is a consideration when walk-

ing through the woods with a chainsaw and using a chainsaw on many small-diameter trees.

Herbicides Used as Site Preparation for Natural Hardwood Regeneration

Herbicides listed are those that are commonly used to control competing or undesirable trees when conducting site preparation for natural hardwood regeneration, guiding the existing regeneration pool toward more desirable species. The herbicides listed have forestry labels. The information given is a guide that was synthesized from several sources (Moorhead 2010; Stringer 1999; Everest and Patterson 1997) and should assist in selecting the best herbicide to accomplish the objective or task.

This publication gives information on herbicides that would control undesirable woody vegetation in forested areas and that have forest-use herbicide labels. Grasses, vines and many herbaceous plants could impair the establishment and growth of regenerating tree species and require control. If herbicides are used to control these annuals and perennials in forested situations, be careful that the herbicide is labeled for use in forests. Several herbicides commonly are used in non-crop or non-timber situations for site preparation prior to reforestation. These herbicides should not be used when trees are present on the site unless they are labeled for forestry use.

The herbicide information given should not supplant the herbicide label. **Read the entire label before using any herbicide**. The label contains information for use of the herbicide, procedures for application, and personal and environmental safety considerations. The effectiveness of the herbicide in controlling different species and species tolerance to the herbicide is described on the label. When to apply the herbicide for best effectiveness is also listed. Due to the high potential for herbicide splash associated with tree injection operations, particularly hack-and-squirt, eye protection and protective clothing (personal protective equipment – PPE) should be worn during application, regardless of the herbicide used. **Danger** and **Warning** are specific words used in pesticide licensing to alert users of potential effects. The following signal words are in order of decreasing severity: Danger, Warning and Caution. For most herbicides used in forestry operations, danger and warning signal words relate to potential for eye injury. Wear PPE and approved eye protection during mixing, filling and application of herbicides. For more information on the environmental safety of herbicides, refer to McNab (1997).

1. **Common Name (Trade Name):** Imazapyr (Arsenal/Chopper)
   Recommended Time of Application: August – March
   Primary Application: Cut Stump, Tree Injection
   Mode of Action: Branched Chain Amino Acid Inhibitor
   Method and Mixture:
   Cut Stump: Use diluted solution of 6 oz. Arsenal AC + 1 gal. of water. Brush or spray onto cambium area inside the bark of freshly cut stump. Review specific herbicide labels for recommended rates.
   Tree Injection: Apply 1 ml of diluted Arsenal AC solution into frills placed at 2-inch intervals around the tree. If concentrated solution of Arsenal AC (25%), make one frill for every 3 inches in tree diameter and apply 1 ml of solution in frill.
   Species Tolerant: Hollies, winged elm, hawthorn and legumes such as black locust
   Application Exposure: Caution
   Comments: (a) Cost per gallon is relatively high, but reduced application requirements make application costs lower and cost-effective.
   (b) Effectiveness occurs in the second growing season after treatment. During the first growing season, trees will lose some foliage and appear sickly; leaves will be small and may exhibit abnormal leaf shapes and color.
   (c) Leakage from roots can damage non-target plants. Herbicide is persistent in soils and will kill seedlings. Care should be taken not to spill herbicide during application.
   (d) Especially effective on sassafras, sweetgum, red maple, sumac and oaks.

2. **Common Name (Trade Name):** Glyphosate (Accord)
Recommended Application Time: Late summer to early fall
Primary Application: Cut Stump, Tree Injection, Foliar
Mode of Action: Aromatic Amino acid Inhibitor
Method and Mixture:
Cut Stump: Use undiluted or 1:1 with water. Spray or brush on cambial area of freshly cut stump.
Tree Injection: Use undiluted or 1:1 with water. Make one frill per 2 inches of DBH; apply herbicide at rate of 1 ml per frill.
Foliar: Use a 5 to 10 percent solution for directed spray of woody brush and trees. Refer to label for rates and surfactant recommendations. Herbicide is non-selective and drift is common, which can damage desirable plants.
Species Tolerant: Hollies, hickories, red maple, blackgum, dogwood
Application Exposure: Warning: Eye irritant
Comments: (a) Non-selective and can kill non-target species.
(b) Many trade names and formulations. Read the herbicide label. Use forestry label for forestry operations.
(c) Effective control of dogwood, sweetgum and blackgum.

3. **Common Name (Trade Name):** Hexazinone (Velpar)
Recommended Application Time: Summer
Primary Application: Tree Injection
Mode of Action: Photosynthesis Inhibitor
Method and Mixture:
Tree Injection: Apply 1 ml of undiluted Velpar L in frills spaced 2 inches apart.
Species Tolerant: Yellow-poplar, hornbeam, sassafras, sumac
Application Exposure: Danger: Wear eye and protective clothing
Comments: (a) Controls hard-to-kill species including sweetgum, red maple, red oaks, hickories, honeylocust and black cherry.
(b) Danger rating for application.
(c) Will move in the soil.

4. **Common Name (Trade Name):** Picloram + 2,4-D (Tordon RTU, Pathway)
Recommended Application Time: Any time except early spring during sap flow
Primary Application: Cut Stump, Tree Injection
Mode of Action: Auxin Growth Regulator
Method and Mixture:
Cut Stump: Treat cambium layer inside bark on freshly cut stump surface with undiluted product.
Tree Injection: Apply 1 ml of undiluted Pathway or Tordon RTU in frills completely around the stem at 2-3 inch intervals.
Species Tolerant: Beech, red oak, maple, dogwood
Application Exposure: Warning: Eye irritant
Comment: Can injure or kill non-target plants, particularly yellow-poplar

5. **Common Name (Trade Name):** Triclopyr (Garlon 3A and Garlon 4)
Recommended Application Time: Any time except early spring
Primary Application: Garlon 3A --- Cut Stump, Tree Injection, Foliar
Garlon 4 --- Cut Stump, Basal Bark, Foliar
Mode of Action: Auxin Growth Regulator
Method and Mixture:

Cut Stump: Treat cambium layer inside bark on freshly cut stump surface with undiluted Garlon 3A or treat stump sides and cambial layer on cut stump surface with Garlon 4 (25% in diesel fuel).

Tree Injection: Garlon 3A only. Spray 1 ml undiluted or ½ ml in a diluted, 1:1 ratio in water in frills spaced at 3- to 4-inch intervals around the stem.

Basal Spray: Garlon 4 only. Mix 20-30% Garlon 4 with 70-80% oil. Apply as streamline (at least two streaks) across lower stem of hardwoods smaller than 3 inches DBH. Application can be at any time of year, but most effective six weeks before leaf expansion through June.

Foliar: Use as directed spray. Actions should be taken to minimize drift. The ester formulation (Garlon 4) provides better penetration and control of species with waxy leaves than the Garlon 3A amine formulation. Apply during growing season before leaf senescence and after leaf emergence (April – mid-Sept.). Use 2-4% of Garlon 4 with an oil-water emulsifier or 2-5% of Garlon 3a with surfactant according to label instructions.

Species Tolerant: Depends on formulation and application. Red maple is fairly resistant to injections of Garlon 3A, but susceptible to basal spray of Garlon 4. Legumes less susceptible to Garlon 4.
Application Exposure: Garlon 3A --- Danger: Eye irritant
Garlon 4 --- Caution
Comments: (a) The ester formulation of Garlon 4 provides better penetration of waxy leaf surfaces than the amine formulation of Garlon 3A.
(b) Garlon 4 is the suggested product to use on streamline basal spray operations.
(c) As with all directed foliar sprays, care should be taken to minimize drift to non-target species.

6. **Common Name (Trade Name):** Triclopyr (Pathfinder II)
Recommended Application Time: Any time of year
Primary Application: Cut Stump, Basal Bark
Mode of Action: Auxin Growth Regulator
Method and Mixture:

Cut Stump: Apply undiluted product to stump sides and cambial layer on freshly cut stump surface, but not to point of runoff.

Basal Spray: Apply undiluted product in spray to stems less than 6 inches in basal diameter by wetting lower 12 to 15 inches of stem. Do not apply to point of runoff.

Species Resistance: Legumes, sourwood
Application Exposure: Caution
Comments: (a) Ready-to-use product, no mixing required as with Garlon 4. Contains a petroleum-based penetrant.
(b) Can be applied any time of year.
(c) Basal spray applications for stems from 3 to 6 inches.

7. **Common Name (Trade Name):** 2,4-D (various trade names)
   Recommended Application Time: Full leaf emergence through June
   Primary Application: Cut Stump, Basal Spray, Foliar
   Mode of Action: Auxin Growth Regulator
   Method and Mixture:
   Cut Stump: Spray the bark and base of stump thoroughly, but not to point of runoff, with undiluted product. Ester formulation.
   Basal Spray: Spray and encircle the lower 18-24 inches of plant stem with undiluted product. Ester formulation.
   Foliar: Use as a directed spray. Non-selective. Can apply either amine or ester formulations, usually as a 4 percent spray.
   Species Resistance: Usually foliar applications weaker on blackgum, red maple, ash, dogwood and waxy leaf species.
   Application Exposure: Caution: moderate eye irritation
   Comments: (1) 2,4-D usually mixed with other products for broader spectrum species Control; rarely used alone.
   (2) Read label instructions carefully. Can be sold as an ester or amine formulation. Sold under various trade names. For forestry operations, make sure of forestry label.

Herbicide Statements

Personal and environmental safety --- To protect people and the environment, herbicides should be used safely. This is everyone's responsibility, especially the user. Read and follow label directions carefully before you mix, apply, store or dispose of an herbicide. According to laws regulating herbicides, they must be used only as directed by the label.

Herbicides in this publication --- Herbicides discussed in this publication were registered for the prescribed uses when printed and their use in this publication was provided as an example of herbicides that could potentially be used in site preparation of natural hardwood regeneration. Specific prescriptions must be determined by the user with a full knowledge of the application site, species involved and label information

Herbicide registrations are continuously being reviewed. Should registration of a recommended herbicide be cancelled, it would no longer be discussed, used as an example or recommended by the University of Tennessee or the University of Kentucky. Use of trade names in this publication is for clarity and information; it does not imply approval of the product to the exclusion of others, which may be of similar, suitable composition, nor does it guarantee or warrant the standard of the product.

Summary

Site preparation is commonly considered when planting trees to give them the best chance for survival and growth. The same should apply when natural regeneration will be relied upon after a forest harvest. Unfortunately, many timber harvests are conducted for short-term gain without much thought toward regeneration and future stand composition and growth. Reproduction should be surveyed and inventoried several years before the harvest to determine what is present. If desirable reproduction is present in sufficient size and number to populate the next stand, then the harvest can be conducted. If not, then site preparation should be conducted to control undesirable vegetation and to develop sufficient numbers and sizes of desirable species before the harvest. Considering the different growth rates and reproductive mechanisms of the many hardwood species, the promotion of favored species usually entails control of undesirable or competing species.

Herbicides are primarily used to control undesirable species during site preparation for natural regeneration. Various herbicides and application methods are available. Forest managers should develop prescriptions that best satisfy their management objectives during site preparation to promote the growth and development of desirable species and discourage undesirable species through the use of herbicides and various application methods. With adequate site preparation, stands should be in a condition to add value without additional management costs. Site preparation costs for natural regeneration may also qualify for reforestation tax incentives.

Literature Cited

Alexander, H.D.; Arthur, M.A.; Loftis, D.L.; Green, S.R. 2008. Survival and growth of upland oak and co-occurring competitor seedlings following single and repeated prescribed fires. Forest Ecology and Management 256:1021-1030.

Blankenship, B.A.; Arthur, M.A. 2006. Stand structure over nine years in burn and fire-excluded oak stands on the Cumberland Plateau, Kentucky. Forest Ecology and Management 225:134-145.

Everett, J.W.; Patterson, M. 1997. Brush control. Publication ANR-1058. Auburn, AL: Auburn University, Auburn Cooperative Extension System. 12 p.

Johnson, P.S. 1977. Predicting oak stump sprouting and sprout development in the Missouri Ozarks. Research Paper NC-149. St. Paul, MN: USDA Forest Service, North Central Forest Experiment Station. 11 p.

Loftis, D.L. 2004. Upland oak regeneration and management. P. 163-167 in Proceedings, upland oak ecology symposium: history, current conditions, and sustainability. Spetich, M.A. (ed.). General Technical Report SRS-73. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 311 p.

Loftis, D.L. 1990. The shelterwood method for regenerating oak in the Southern Appalachians. Forest Science 36:917-929.

Londo, A.J.,; Ezell, A.W.; Nelson, L.A. 2008. Tree injection with reduced labor requirements. Information Sheet 1573. Mississippi State, MS: Mississippi State University, Extension Service 2 p.

McGee, C.E. 1978. Size and age of tree affect white oak sprouting. Research Note SO-239. New Orleans, LA: USDA Forest Service, Southern Forest Experiment Station. 2 p.

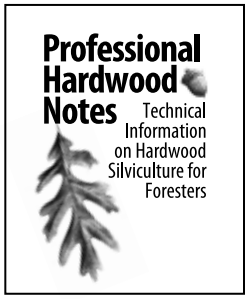
McNab, K. 1997. Environmental safety of forestry herbicides. Publication ANR-846. Auburn, AL: Auburn University, Auburn Cooperative Extension System. 4 p.

Moorhead, D.J. 2010. Forest herbicides. 2010 Georgia Pest Management Handbook. Athens, GA: University of Georgia College of Agricultural and Environmental Sciences.

Rogers, R.; Johnson, P.S. 1989. Thinning sprout clumps. Central Hardwood Notes 6.12. St. Paul, MN: USDA Forest Service, North Central Forest Experiment Station. 3 p.

Stringer, J. 2006. Oak shelterwood: A technique to improve oak regeneration. Professional Hardwood Notes. Publication SP 676. Knoxville, TN: University of Tennessee Extension. 8 p.

Stringer, J.W. 1999. Herbicides for small scale forestry operations. Forestry Fact Sheet FORFS 99-9. Lexington, KY: University of Kentucky Cooperative Extension Service, College of Agriculture. 4 p.



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