

Site Preparation and Competition Control Guidelines for Hardwood Tree Plantings

Jeffrey W. Stringer, Professor, Department of Forestry, University of Kentucky
Wayne Clatterbuck, Professor, Department of Forestry, Wildlife and Fisheries, University of Tennessee
John Seifert, Director, Indiana Division of Forestry, Indiana Department of Natural Resources

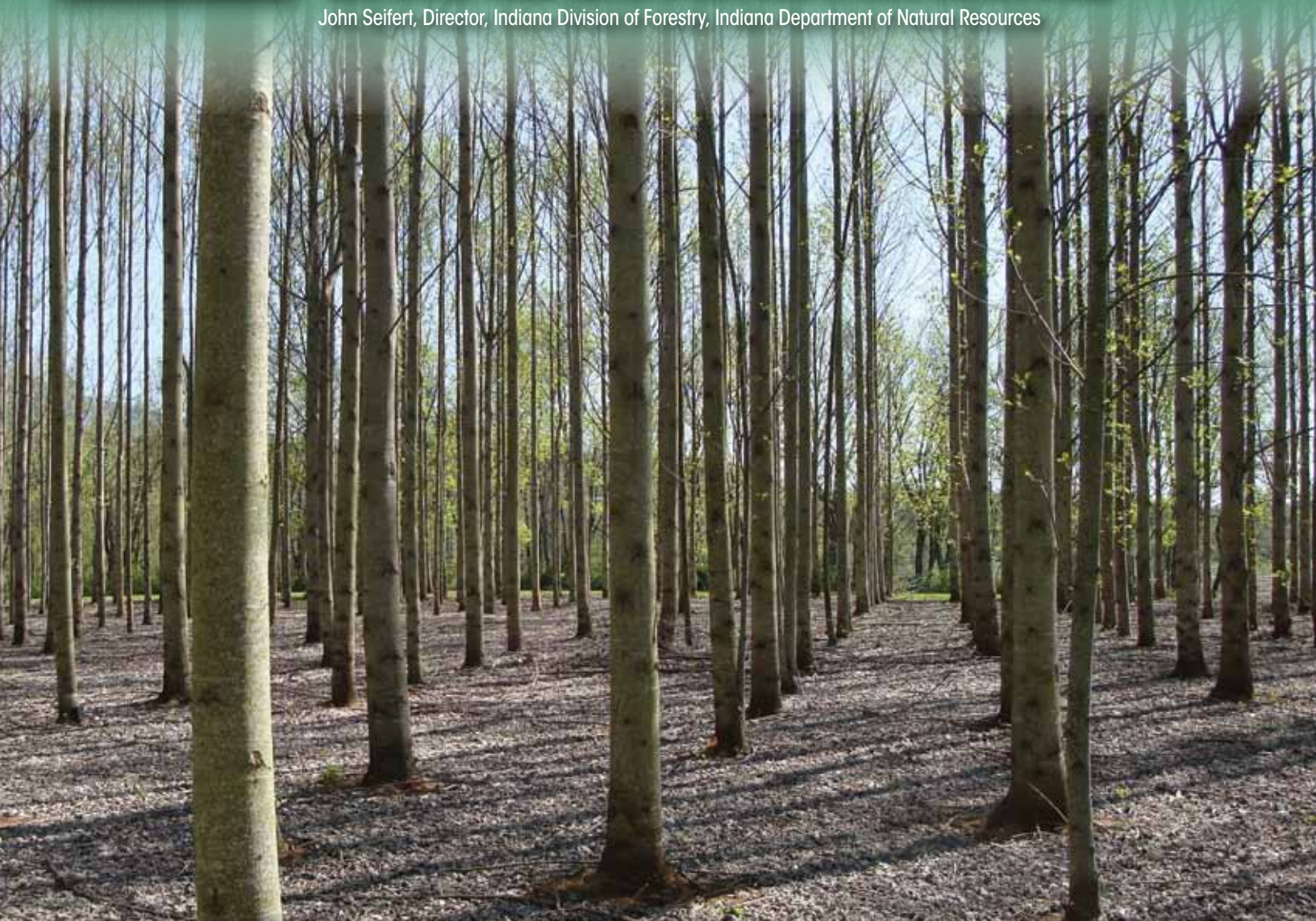


Table of Contents

Successful Tree Plantings	3
Factors Affecting Planting Success	3
Types and Sources of Competition	4
Seedling Quality and Planting Technique	5
Planting Density and Design	7
Animal Predation of Hardwood Seedlings.	10
Hardwood Specific Herbicides	11
Hardwood-Compatible Groundcovers and Use of Pre-emergent Herbicides	13
Site Preparation and Planting Guidelines	14
Prescriptions	15
Fields Currently in Row Crops (3 alternatives).	18
Fallow Crop Fields Containing Herbaceous Weeds (3 alternatives)	20
Crop Field – Multiple Years Fallow Containing Persistent Woody Species (3 alternatives)	22
Pasture (primarily fescue dominated fields) (4 alternatives).	24
Timber Harvesting Roads, Trails and Landings.	27
Post-Planting Maintenance – Second and Third Year	27
Groundcovers	30
Herbicides	32

Cover photo: A 17-year yellow-poplar plantation in East Tennessee.

Right: A black walnut planting in a pasture with competing grasses controlled in the planted rows.

All photographs are credited to the authors unless otherwise designated.



Successful Tree Plantings

Establishing a successful hardwood planting requires attention to several key elements, including proper species selection, seedling quality, proper planting technique, and short- and long-term control of competing vegetation. This publication addresses these aspects of successful hardwood plantation establishment and maintenance, with special emphasis on controlling competing vegetation. The latter is best achieved through the combined effects of proper tree density management, proper use of groundcovers and pro-active herbicide prescriptions.

Unfortunately, controlling weeds, particularly broadleaf weeds, in hardwood plantings is difficult once weeds become established. Preventing weed problems before they occur is the key to successful competition control. The use of appropriate groundcovers and the proper pre-planting treatments limit weed development prior to planting and establish proactive competition control measures after the planting. The degree of weed control required varies, depending on the species and quality of seedlings being planted, soils, past land use, weed species and planting objective(s). Because each of these factors varies considerably from one planting to another, general recommendations for weed control have to be evaluated for each site and adjusted to meet specific site requirements.

This publication presents recommendations for key factors associated with hardwood planting success. The publication also provides competition control and site preparation alternatives for a number of common planting sites and conditions. For each site and condition, several alternatives provide a range of options, allowing users to select the alternative that best fits their objectives and timetables. Recommendations were developed using results from research trials and experience with operational hardwood plantings for timber, wildlife and conservation objectives. Recommendations include the development of appropriate groundcovers, coupled with both chemical and physical controls that have proved useful in reducing competition, resulting in a successful planting.

Factors Affecting Planting Success

While hardwood plantings are undertaken for a variety of objectives, with success measured differently for each objective, ultimately a certain number of tree seedlings must survive and maintain their crown above competing vegetation. Hardwood plantings are challenged with both initial and long-term competition problems. Regardless of planting objective, development of seedlings with a vigorous single main stem in a free-to-grow condition is critical to maintaining height growth above competing vegetation. Successful hardwood plantings can only be obtained when high-quality seedlings are planted properly to limit or avoid transplant stress by reducing or eliminating competition pressure at the time of planting and maintaining this environment until the seedlings are established and producing significant height growth.

Weed competition can lead to reduced growth or mortality of hardwood seedlings through shading, moisture stress and chemical inhibition. Competition can come from both perennial and annual plants, including grasses, broad-leaved herbaceous weeds, vines, shrubs and trees. Controlling these weeds is critical for optimum hardwood growth and acceptable survival rates for most planting situations. While removal of all competition is possible, the objective is to provide a competition level that does not significantly reduce the height growth of the seedlings. Some competition is allowable, but must be carefully evaluated and managed to ensure hardwood seedlings obtain needed resources to maximize height growth.

Key factors to ensure initial survival and sustained growth include:

- understanding types and sources of weeds that can provide competition to hardwood plantings.
- proper selection and establishment of hardwood-compatible groundcovers.
- proper selection of herbicides, as well as adequate time and appropriate techniques for proper application.
- appropriate plantation design, layout and species composition that facilitate rapid tree development to achieve a closed canopy, ensuring long-term competition control.
- planting high-quality seedlings and maintaining seedling vigor before and during planting.

Types and Sources of Competition

Seed Banks and Perennial Root Systems

Often serious competition problems arise when significant amounts of weed seed are allowed to build up in the soil (seed bank) or root systems of perennial weeds are allowed to develop prior to tree planting. The abundance of weed seed or root systems present at planting is generally related to past land use.

The cultivation of a row crop directly prior to tree planting that limits or eradicates weed species reduces the seed bank and the number of perennial root systems present. Therefore, tree plantings into fields coming directly out of row cropping generally have the least amount of weed competition to deal with the first year. Also, residual weed control in row-crop fields is often obtained after the trees have been planted. While this residual herbicide activity, if significant enough, can harm hardwood tree seedlings, some residual activity can assist in competition control. Compared to crop fields, pastures are more likely to have a buildup of weed seed and roots from competing species. However, as with crop fields, the more intensive the management of the pasture, maintaining vigorous groundcover and providing annual weed removal, the less of a problem there will be with build-up of weed seed and root systems. For example, a well-tended fescue pasture that provides continuous groundcover will have less weed seed and root systems than an overgrazed, untended pasture. The worst condition relative to seed and competitive root system build-up is a crop field that has laid fallow for several years, allowing weed seed to accumulate and root systems of perennial weeds to develop unhindered.

Given a specific soil type or topographic position, past land use has a significant effect on competition development. The following is a relative rating of the competition that is expected from seeds and roots in the soil at the time of tree planting from least to most problematic.

- Cultivated row crop – soybeans
- Cultivated row crop – corn and other row crops
- Cultivated hay
- Well-tended pasture (fescue)

- Well-tended pasture (mixed fescue or non-fescue)
- Untended pasture
- Fallow crop field (one or more years fallow)
- Forests and logging sites

The topographic position of the planting and the soil also affects the degree of competition. A bottomland site with highly productive soils has the potential to generate severe competition control problems that can quickly overrun tree plantings, compared to moderately dry upland sites. Past land use, soils and topographic position must be evaluated to determine the severity of the weed-control problems.

Competition-control strategies must take into account the stored-seed and residual-root systems present prior to planting. In situations that indicate a significant amount of stored-seed and weed-root systems, killing weeds prior to planting and establishing a continuous cover are needed to effectively combat the excessive competition problem that can arise from these sources of weeds.

Seed Deposited during or after Planting

Seed blown in from surrounding areas or carried by animals or water can produce a significant competition control problem from both native and exotic species. Prior to planting, it is sometimes hard to predict which species and to what degree seed will be deposited into a planting area. Typically, experience with the area and sites involved will allow practitioners to estimate these competition problems. Obviously, areas directly adjacent to tree lines or woodlands where wind-blown species such as sycamore, sweetgum, cottonwood, maples or tree-of-heaven exist or areas where wildlife disseminates seed are at risk for seed deposition after planting. This invasion may not be counter-productive. For example, invasion of soft-mast species may be used to obtain conservation objectives for soft mast. Generally, artificial regeneration of these species is not required. However, tree plantings, particularly those of slower-growing and/or hard-mast species, can be challenged with enough pressure from invading species both of acceptable soft-mast species and of unacceptable species to overwhelm the planting.

Two preferred methods are generally used together to limit the development of weeds from deposited seed. Maintaining a dense groundcover between rows and planting spots, coupled with the use of pre-emergent herbicides around the planting spots, limit weed establishment. These methods will greatly reduce competition developing from seed deposited onto the site during or after the time of planting.

Seedling Quality and Planting Technique

Hardwood Seedling Quality

One of the factors that may increase or extend the need for intensive competition control measures is the planting of a poor-quality hardwood seedling. High-quality hardwood seedlings have large root systems with abundant first-order lateral roots. These seedlings must be stored, transported and planted correctly to have the potential to avoid, or quickly overcome transplant stress and grow in height the first year. Rapid height growth keeps the tree leaves above the competition, especially during the early and middle portion of the growing season, and lessens the amount of post-planting competition control needed. Low-quality seedlings, poor handling and/or improper planting techniques increase transplant shock and reduce first-year height growth, increasing the risk of overgrowth. Low-quality seedlings have



Severe Microstegium competition lodging planted hardwood seedlings on a bottomland site.



John Blanton

Top dieback common to seedlings undergoing transplant shock.

small root systems and/or few first-order lateral roots and/or poor root-to-shoot ratios. These seedlings undergo significant transplant shock, as indicated by small leaves, top die-back and little or no height growth.

Once this die-back occurs, significant time is needed for the seedling to regain vigor and initiate significant height growth, sometimes more than one growing season. This recovery time extends and exacerbates the need for competition control. Visual loss of planting rows can make maintenance difficult. Competing weeds can ride down tree seedlings, and problematic weed species such as vines have time to become established.

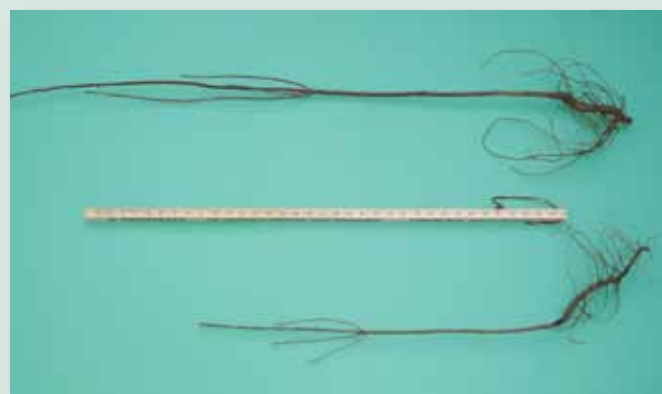
The bottom line is that weed and competition control is reduced when high-quality seedlings and correct planting procedures are used. Competition control must be increased as seedling quality and the quality of the planting effort decrease. Avoid problems with poor-quality seedlings by not planting them. Either locate nurseries that consistently produce high-quality seedlings or properly cull poor seedlings before planting. If questionable-quality seedlings are planted, evaluate the planting frequently and be prepared to extend competition control measures until seedlings are free to grow.

A high-quality seedling is generally regarded as a large seedling where the roots and the aboveground

parts of the seedling (shoots) are in balance, giving the seedling the capacity to grow in height and prosper during the growing season immediately after planting. If the roots and shoots are not in balance, i.e., roots are not supporting the top, the seedling strives for equilibrium by (1) suspending top growth so that the root grows to support the existing top, (2) the top dies back to a level where the roots can support the top or (3) both. In these situations, height growth does not commence to any great extent in the growing season following planting, allowing competition to gain a greater influence on



Small oak seedlings that are not suitable for planting. These seedlings (top) have not attained the minimum size for root-collar diameters (RCD) or the number of first-order lateral roots (FOLR) to grow successfully with competing vegetation. The seedling at the bottom has an adequate RCD, but its root system does not have an adequate number of FOLRs.



Oak bare-root seedlings with excellent top and root balance, root-collar diameters exceeding 3/8 inch and a large number of first-order lateral roots.

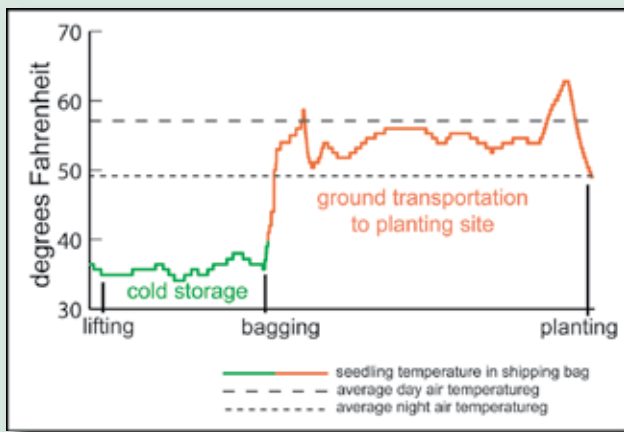
the site. This affects present and future growth and even survival of planted seedlings.

Most seedlings experience shock after lifting from the nursery and transplanting to field sites because of the disturbance to the root system. Research from the nursery industry indicates that more than 50 percent of the seedling's roots are left in the soil after uplifting. Seedlings are planted with less than 50 percent of the roots they had in the nursery. Also, the nursery environment is much more favorable to the growth of the seedlings (irrigation and fertilization) when compared to the harsh environment of a planting site where seedlings must compete with residual vegetation for sunlight, moisture, nutrients and space. Thus, control of competing vegetation is necessary to give seedlings a foothold after planting.

Frequently, large seedlings are prescribed for hardwood plantings (large seedlings will dominate the site sooner) and root systems are pruned for ease of planting. Root pruning usually adds greater seedling stress to an already diminutive root system. Although root pruning will stimulate greater root initiation at the cut surface, this root growth is usually at the expense of top or shoot growth. Thus, to keep root systems of transplanted seedlings intact, larger seedlings require larger holes. Root pruning should be done judiciously only to facilitate the planting of the seedling, taking care not to further increase seedling root stress.

Larger seedlings, with balanced root-to-shoot ratios, will outperform smaller seedlings. Several research initiatives are underway to define what constitutes a high-quality, plantable seedling that will have creditable height growth after planting. Although the specifications will probably vary by species, most researchers and practitioners agree that hardwood seedlings with root-collar diameters of at least 3/8 inch and preferably larger, a minimum of five first-order lateral roots and a balanced root system in relation to the shoot or top of the seedling will increase the probability of planting success.

For a hardwood planting to be successful, two processes must take place. First, a planted seedling must have the capacity to grow once planted. All the correct procedures from nursery operations and management, to seedling storage and transportation, to eventual planting must be followed rigorously.



Temperature of hardwood seedlings in cold storage and during transportation and field storage prior to planting. Red indicates excessive seedling temperatures.

Second, the planting site must be in a condition that will allow the seedling to compete, grow and thrive, i.e., control of competing vegetation. These two processes must work together for the planting to be successful. Generally, paying attention to only one of these aspects (i.e., planting poor seedlings even with the best weed control or planting high-quality seedlings with poor weed control) will be detrimental to the planting.

Transportation, Storage and Planting

Unfortunately, the best-quality seedlings grown in a nursery can be severely degraded by poor treatment. Poor handling and planting can produce transplant shock and delays in developing rapid height growth. Causes of vigor loss are storage at greater than 36 degrees F, root desiccation, improper planting of large seedlings (planting too shallow or in holes or slits not capable of holding the large root system) and planting after bud break. All of these issues can be overcome through proper storage, shipping and planting with appropriate equipment designed for hardwoods.

Obtain and plant seedlings directly from the nursery or from proper cold storage. Allowing bags of seedling to attain temperatures of greater than 40 or 50 degrees for even short periods of time (one or two days) can dramatically reduce vigor or cause winter dormancy to be broken.

Equipment designed for pine planting, including many mechanical planters and hand implements such as dibble bars, is often not appropriate for many hardwood species. Often the roots of hardwood seedlings are larger than the planting holes or slits that can be effectively made using these implements. Large root systems should not be j-rooted, wrapped or bundled to match a small planting hole. Pruning root systems to “fit” small holes or slits should be viewed as a last resort. Reducing root-system volume, especially if it entails removing portions of the main root, reduces overall root carbohydrate (food reserves) that may be needed to produce required top growth. Adjusting the planting hole with the use of appropriate equipment is the proper way to address this problem. Manually planting hardwoods may require the use of a planting spade or auger. An auger can be used effectively if the ground contains little clay. Soils high in clay content will tend to generate a hole that has compacted sides from the spinning auger bit, restricting future root development and/or causing poor root architecture.

Mechanical planting using tree planters or subsoilers can be fatal to tree seedlings if the slit is not fully closed and the soil firmed around root systems. Loose, friable soil works best for mechanical planting requiring late-spring planting dates. Seedling storage then becomes critical. Soils high in clay may not be suitable for mechanical planting. Also, mechanical planters should be large enough and have shoes that are designed for hardwoods. Wide shoes provide for a sufficiently sized hole to allow hardwoods to be placed into the planting slit.

Planting Density and Design

Planting design is generally dictated by planting objectives and/or operational requirements associated with the tending of the planting. Regardless the planting design, spacing will affect long-term competition problems. Generally, long-term competition can be reduced by providing a planting density (spacing) that allows the trees to quickly occupy the site through crown closure. The trees are then fully occupying the site and are regulating weed and tree invasion and competition.

Planting Densities for Timber Production

The higher the planting density, the faster canopy closure occurs. Higher planting densities

also allow for some mortality while still maintaining adequate stocking. Target density for high-quality timber production is approximately 800, 1-0 or 2-0 seedlings per acre. While only 50 to 60 trees are likely to be required at the end of a typical sawtimber rotation, the purpose of the remaining trees is to ensure that the hardwoods start to dominate the site as quickly as possible and to provide “trainer” trees for improved stem form and value. Higher densities reduce the need for long-term control of weeds while providing beneficial tree-to-tree competition. The 800 trees per acre can be achieved through the use of an 8- by 7-foot spacing. Eight feet between rows provides the minimum space necessary if equipment is needed to access or move through the planting. Data from successful northern red oak, black walnut and yellow-poplar 1-0 plantings on agricultural land indicate that crown closure can typically occur during the fifth or sixth growing season with ground-line diameters of 2.25 to 3.00 inches. Spreading the planting to a 12- by 12-foot spacing doubles the age required for crown closure when stem ground-line diameters are approximately 7 to 8 inches. The 800 tree-per-acre guideline has been found to provide a good balance between economics and biological requirements of developing forest stands.

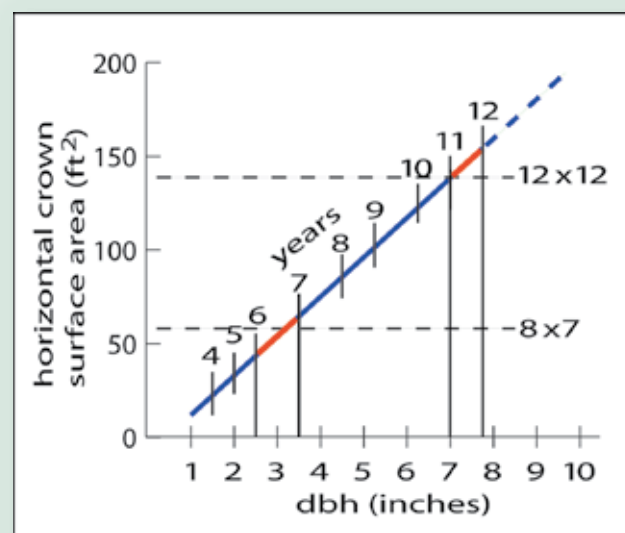
There are instances when expensive, “improved” grafted or containerized trees are available. The cost of establishing this planting stock generally prohibits the planting of a large number of these seedlings per acre. If only grafted or containerized stock is planted, a wide spacing is generally used and intensive weed control is required. One alternative is to plant fewer widely spaced improved seedlings and fill-in around the grafted or containerized trees with 1-0 bare-root seedlings of the same or different species. These “extra” trees are relatively cheap compared to the containerized or grafted trees and will reduce long-term competition problems. If the correct species are chosen, they may also act as trainer trees to assist with developing bole quality in these plantings.

A recommendation of 800 seedlings per acre is designed to produce forested conditions as rapidly as economically possible, reducing plantation care over the long term. Canopy shading resulting from these plantation densities significantly improves natural branch shedding compared to the wide spacing typically used for conservation plantings. Corrective pruning requirements for the purpose of high-quality timber production are reduced or eliminated.

Spacing between rows may need to be adjusted to suit operational constraints. For example, if the planting is to be mowed (which is not normally required if the planting is established correctly or a failure in groundcover and weed control occurs), then row spacing must account for the width of the mowing equipment. As the distance between rows is increased, decrease the distance between trees within the row.

Planting Design for Conservation Plantings

Typically, conservation plantings for wildlife habitat, riparian buffers and similar objectives are completed with densities at or below 600 seedlings per acre. Planting densities of 50 to 250 seedlings per acre are common, and many times species for these plantings are selected to provide hard mast. Unfortunately, many hard-mast species are not particularly fast-growing or can take several years to initiate appreciable height growth after planting. Also, these plantings often have limited or no competition control prior to establishment. Some conservation plantings are aimed at producing savanna-like condi-



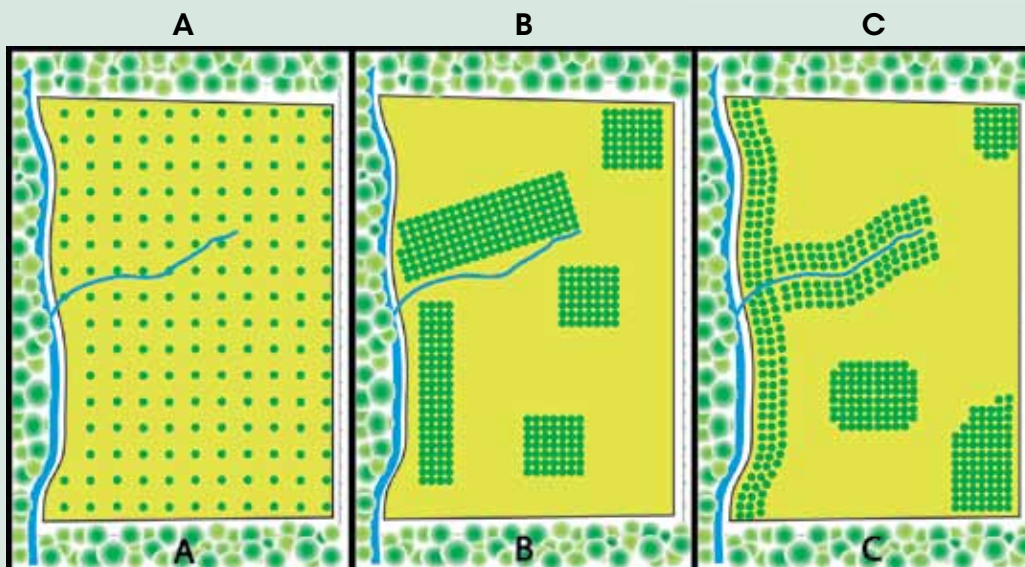
Crown closure interval for northern red oak. Blue line represents dbh/crown surface area relationship for plantation-grown northern red oak. At an 8- by 7-foot spacing (800 trees per acre) the planting will close canopy during the sixth growing season. At a 12- by 12-foot spacing (302 trees per acre), it will close during the 11th growing season.

tions that may require the co-occurrence of early and late successional habitats. Oftentimes these requirements work against the successful establishment and long-term development of trees. The wide spacing of these plantings encourages overgrowth by weeds, vines and other woody species and can be exacerbated by the requirement to limit vegetation control between widely-spaced trees. Because the trees can not quickly close canopy and start to regulate competition growth, they remain vulnerable to weed overgrowth for many years. Unfortunately, there are a large number of these hardwood plantings that have failed to meet even the most lax survival and growth standards due to excessive competition problems.



Wide spacing of hardwood seedlings and lack of proper weed control can lead to plantings at risk for low survival and growth.

A planting scheme can be strategically designed for these areas to address some of these problems. If low-density plantings are to be developed, one method of reducing the cost of competition control while providing adequate weed control and meeting tree densities targets is to group the trees within the planted area. Planting the hardwood trees in small groups forms a number of densely planted, tree-dominated areas where more intensive and cost-effective competition control and quick canopy closure can be achieved. These groups provide (1) a matrix of tree habitats and mast production, edge and early successional environments in the area and (2) conditions directly around the planted seedlings that are more economically and biologically favorable for tree establishment and long-term growth. For example, instead of planting trees on a 25- by 25-foot spacing (yielding 70 trees per acre) and distributing the trees over the entire treatment area, several small areas within the treatment area could be planted with three or four rows of trees with 4- to 8-foot spacing. The number and size of these areas could be regulated to provide the same number of hardwood seedlings per acre as would be obtained by widely spacing the seedlings across the treatment area. This planting design or similar group-planting schemes could be used to provide the necessary components for many non-timber conservation plantings. Focusing seedling competition control on a smaller area increases effectiveness and improves economic efficiency. This design also provides for some long-term timber objectives as well.



Alternative designs for conservation plantings. A: typical even distribution of trees using a systematic wide spacing throughout the conservation planting. B and C: examples of how the same number of seedlings can be established by planting in groups, thus improving the efficiency of weed control efforts and allowing for both early and late successional areas in the conservation planting.



Oak trees in single-species plantations at wide spacings tend to have many branches that do not prune well, lowering tree grade and bole quality.

Mixed-Species Plantings

Most hardwood plantings contain one species, although they could contain multi-species with proper planning. Single species hardwood plantations are similar to monospecific (one species) pine plantations where trees grow at similar rates and respond similarly to silvicultural treatments. These stands are not as diverse in composition or in vertical and horizontal structure as mixed-species stands. However, if plantations are to emulate the natural stand development patterns found in mixed stands, then several species should be planted. These stands will be much more complex to manage because of the different growth patterns of different species, but diversity will be much greater.

When choosing species assemblages for mixed-species plantings, consider four concepts:

- species-site relationships
- growth curve for each species
- light tolerance
- promoting canopy stratification through different crown forms

Planting the appropriate species on the appropriate site increases successful hardwood plantation establishment. The site to be planted and its productivity will dictate the species to be planted in a mixed stand. Secondly, inspect the growth curve of the possible species. Examining this information will give you a vision of how species might develop

together. Additionally, evaluate the light demand for each species. Will the light tolerance of each species allow the species to develop together? Finally, try to incorporate species with different crown forms (decurent and excurrent) in the planting. Most hardwood stands grown in monocultures produce stems with poor grade. Improvements in grade may be realized through promoting crown stratification by planting species with mixed crown forms to more fully occupy the growing space.

Few natural hardwood stands develop as single-species stands. Although there is little research and few examples of mixed-species hardwood plantings, they should be considered, especially if trying to emulate natural stands. Adequate planning is necessary when planting multiple-species mixtures because of differential species growth rates. Mixed stands will provide more flexible silvicultural opportunities and less risk than single-species stands.

Animal Predation of Hardwood Seedlings

Animals often browse on planted seedlings, either at the buds and leaves of developing shoots or on the stem at the base of the seedling. Nutrient-rich nursery seedlings are easy for animals to find, making them a favorite food source. As a result, animal predation on seedlings can devastate hardwood plantings, especially when wildlife populations are high.

There are a few strategies one can use to protect seedlings from animal browse. Animal repellents and fences are two direct approaches, but they come with limitations. Animal repellents are short-term, expensive solutions, if they work at all, and must be re-applied after rainfall events to reinitiate effectiveness of the repellent. Fences, whether electric or conventional, are expensive for large plantings and require maintenance. Fences that are 3 or 4 feet tall do little to prevent animals from entering the area. Taller fences (8 feet) are required, with accompanying escalation in cost.

Although little can be done to protect plantations directly from animals beyond controlling their numbers or populations through hunting or other control methods, manipulation of the plantation in ways that make the habitat conditions less suitable for predation is probably the best method.

Animals are not willing to venture to the middle of a large planting because of the absence of hiding cover. Predation is not much of a problem in large-area plantings (10 acres or more) compared to smaller-area plantings. Margins of the planting will still probably be browsed to some extent. Weed-free plantings will also deter many ground animals in larger plantings. The shape of the planting will also have some influence. Long, linear plantings have escape cover nearby, while oval or rectangular plantings that cover many acres are not as easily browsed.

Once seedlings grow in height and exceed the “browse-line,” usually 4 feet or so, the seedlings will not be as affected by animal predation. Thus, having seedlings with the capability to grow in height during the growing season after planting not only escapes weedy competition, but seedlings are also tall enough to exceed the browse pressure of animals.

Planting more suitable food sources for animals or wildlife near plantations may also alleviate predation problems. Animals prefer and more easily access these food sources compared to the seedlings in a plantation. Good weed control in the plantation would also deter many ground-dwelling animals from venturing into the plantation.

Complete elimination of predation in hardwood plantations is usually not feasible, and some predation along the plantation margins might be acceptable. Some of the factors that should be explored to deter animal predation include planting large areas compared to smaller acreages, keeping ground vegetation at a minimum, providing a more attractive and accessible food source and controlling high-density animal populations before planting, if possible.

Hardwood-Specific Herbicides

Herbicides are often needed to maintain weed control. Three operational problems are encountered with herbicides in hardwood plantings.

Broadleaf Herbicides and Trees

There are no herbicides designed to eradicate broadleaf weed competition that will not also impact or kill hardwood tree seedlings. Hardwoods are broadleaf plants, and the chemicals currently

available do not differentiate broadleaf trees from broadleaf weeds. Broadleaf weed problems should be addressed prior to planting through appropriate groundcovers and the use of herbicides to prepare the site for planting, including the use of pre-emergent herbicides. Vines pose a significant threat to hardwood seedlings, so preempting their occurrence is critical. Once vines are wrapped around hardwood seedlings, they can be extremely difficult and expensive to remove, and require rescue treatments that can harm seedlings. If broadleaf weed control is required after planting, it typically must be accomplished by applications that allow delivery of the chemical to target weeds, while avoiding significant contact with planted trees. Two methods are directed sprays and timing the application so that it is completed when the seedlings are not susceptible to the chemical being used. Both require operational finesse. Covering the site with the appropriate grass groundcover and the use of pre-emergent herbicides is recommended. Establishing a hardwood-compatible grass groundcover helps reduce broadleaf weed development. If the grass cover needs to be controlled after the trees are established, this can be safely accomplished with herbicides that will not harm hardwood tree seedlings.



Once vines are allowed to establish, they can be extremely difficult and expensive to control.

Changing Land Use and Herbicide Labeling

The second issue is ensuring that the herbicide is being used in the location and for the type of land use it is labeled for. Hardwood plantings commonly occur in agricultural fields that change from crop to non-crop use and eventually into a forest. This change in land use requires that the practitioner understand when herbicides specifically labeled for use in crops can be used for competition control in hardwood plantings, and when a change must be made to a herbicide that is labeled for use in non-crop areas. Further, when the planting progresses to the stage that it is designated as a forest, only herbicides that are labeled for use in forests can be applied.

Lack of Registered Herbicides for Use in Hardwood Plantings

The third problem is that of all the herbicides that, in theory, could be used in hardwood tree plantings, few are labeled for this purpose. Herbicides can be used in tree plantings if they are specifically labeled for this use or if their label contains a non-crop use allowing application on the site where the planting occurs. Unfortunately, only a limited number of herbicide producers have provided labeling for forestry use or for use in hardwood tree plantings. Thus, a number of herbicides labeled for general agriculture or industrial (right-of-way) use that have a supplemental label or appropriate non-crop labeling must be relied upon for use in tree plantings. Care must be taken when determining whether a particular agriculture or industrial herbicide can legally be used in a tree planting. The legal determination often depends upon land classification (i.e., is the area a crop field, non-crop area or forest). While the U.S. Environmental Protection Agency (EPA) has jurisdiction over herbicide labeling, there are differences among states relative to the interpretation of herbicide labels and use of the herbicide. Therefore, proper herbicide prescriptions must consider biology, operations, labeling and state regulations. A further complication is that labeling can change. While this situation makes prescribing herbicides difficult, the following can be used as general guidelines for evaluating labels for use in hardwood plantings.

Crop Herbicides

If a tree planting is to be established on a crop field, the use of a crop herbicide in this area prior

to actual tree planting is generally allowed. Crops are defined as traditional agricultural plantings of grains and vegetables (field crops) and fruit/nut trees or orchards (fruit and nut crops). Trees planted for timber, wildlife and conservation purposes are not crops as defined by EPA. An exception to this rule is a species that produces both timber and a commercial nut such as black walnut or pecan. Also, in some instances, labels will allow crop herbicides to be used in tree plantings if they are in shelterbelts or windbreaks. If the hardwood tree planting has nut production, shelterbelts or windbreaks as the primary or secondary objective and does not violate other label requirements, the herbicide can be legally used in the planting. It is unclear when a field turns from a crop to a non-crop use. Consulting with the state regulatory agency on this issue is recommended to provide a definition that will determine where a crop-labeled herbicide can legally be applied prior to or during the establishment of a tree planting.

Herbicides with Non-Crop Labeling

While many crop herbicides and those labeled for rights-of-way and industrial applications have the chemical capacity for use in tree establishment, their labeling does not specifically state that they can be used for this application. However, many herbicides labeled for use with crops and for rights-of-way and other industrial applications contain wording that allows them to be used in “non-crop areas.” Read the label thoroughly to see how non-crop areas are defined. The non-crop section of the label will describe different settings where these herbicides can be used. Besides listing specific environments where the herbicide can be used, many herbicides provide a blanket phrase that indicates that the herbicide can be used in “...other or similar non-crop areas.” The phrase “non-cropped area” generally does not refer to a forest. Herbicides used in forests must undergo testing in forest soils and the labeling will specifically indicate its use in a forest. However, hardwood tree plantings in agricultural settings are not initially forests and a crop or right-of-way/industrial herbicide with a non-crop designation can be used to control weeds prior to planting, if other provisions in the label do not prohibit its use. Care must be exercised, because many of these herbicides that can control competing weeds have not been tested for use in hardwood plantings.

An example of how carefully labels must be evaluated involves different brands of glyphosate chemicals. Many crop-use glyphosate herbicides contain non-crop uses that include areas planted in trees. One brand has specific provisions for use around tree, vine and shrub crops including "...Pine, Poplar, Eucalyptus, Christmas trees, other non-food tree crops." In this case, the herbicide could not be used in a mixed hardwood tree planting in a farm setting after tree establishment, but could be used in pine or poplar plantings. Unfortunately, many agriculture herbicide labels are not clear and similar products have different labeling. Consult with your state pesticide agency if the labeling is unclear.

Forestry Herbicides

A number of herbicides have forestry labels or supplemental labels that specify their use in forests or tree plantings. Generally, these herbicides can be used in hardwood tree plantings (either forestry or conservation plantings) unless the specific use or location is not allowed. Supplemental labels are typically not found attached to the container. Ask a qualified chemical dealer or natural resource professional about supplemental labeling or use on-line sources of labeling such as Internet information provided by Crop Data Management Systems, Inc. at www.dcms.net.

Specific Labeling Requirements

No herbicide can be used if it specifically indicates on the label that it cannot be used in specific situations or areas. For example, a herbicide label may indicate that it can be used in shelterbelt tree plantings, but not on trees less than 2 years of age. In this instance, the herbicide can not be used at the time of establishment, but can be used before planting or the year after planting. The label may also indicate that the herbicide cannot be used directly adjacent to waterways and thus can not be used in a riparian planting, but could be used in upland planting. Some herbicides indicate that they can not be used in plantings established for timber production or in forested areas. In the former case, the herbicide can not be used if there is a timber objective for the planting, but it could be used in a conservation planting that does not also have a timber sub-objective. If a label indicates that the herbicide is not to be used in a forest, then the state pesticide agency must provide a definition of a forest, and determina-

tion must be made on whether the establishment of a hardwood tree planting immediately defines the area as a forest. If so, then the herbicide cannot be used after trees have been established. If a hardwood planting is not deemed to immediately constitute a forest, then application can occur during and directly after planting up to a point when the planting is considered a forest (if all other provisions in the label allow for its usage). These label provisions indicate that careful attention must be paid to specifics in the labeling indicating which environments or land uses (crop, non-crop or forest) the herbicide can be legally applied.

Hardwood-Compatible Groundcovers and Use of Pre-emergent Herbicides

Because there are few herbicides that can be sprayed over the top of hardwood seedlings to control broadleaf weeds, it is useful to eradicate weeds, especially broadleaf weeds, prior to planting and to create conditions where they do not re-establish. Waiting until a broadleaf weed problem arises makes control more difficult. To avoid this problem, take steps prior to planting to reduce or eliminate competition from broadleaf weeds. One method is the use of effective groundcovers that are compatible with hardwood seedlings and are in place prior to planting (see Groundcover section). If a dense hardwood-compatible groundcover can be established prior to tree planting, the groundcover will limit the amount of weed seed that reaches the soil and/or precludes successful germination and establishment. An effective groundcover can reduce broadleaf weed competition for several years.

The groundcovers typically recommended are small grains or grasses that are used for cover crops in agricultural operations and do not generally pose threats to planted hardwoods. These covers are preferred to broadleaved groundcovers. Small grain cover is often dense and thoroughly covers the ground. Many are annual or biennial and will start to fade after hardwood seedlings become established. Also, if small grain or grass groundcovers become problematic, they can be easily removed using grass-specific herbicides with little risk to the hardwoods. Do not use grasses that will overtop and lodge onto seedlings or those like fescue with thick fibrous root mats that are allelopathic, producing chemicals in the soil that are harmful to hardwood growth. If the

proper groundcover species are selected, hardwoods can often be planted directly into the cover with no herbicide use.

In some situations, even relatively benign groundcovers can pose problems for hardwood plantings. One situation involves drought. Droughts always pose a threat to survival of tree plantings, particularly first-year plantings. Certainly bare-clay ground, with a high shrink/swell potential, can lead to significant losses during severe droughts. There have also been a few instances when severe droughts have caused first-year seedling mortality on good silt loam soils when winter wheat was being used as a groundcover. If conditions indicate the onset of a severe drought, grass or small grain covers can be killed to avoid this problem. The dead material will cover the ground so that soils are not exposed to direct sunlight while reducing seedling competition for soil moisture. If a broadleaf groundcover is being used, its eradication under these circumstances can be difficult in a hardwood planting.

Pre-emergent herbicides can be used in conjunction with appropriate groundcovers or in the absence of groundcovers to stop the development of broadleaf weeds and problematic grasses. In many instances, effective competition control requires the use of both pre-emergent herbicides and appropriate groundcovers.

Site Preparation and Planting Guidelines

Site preparation prescriptions are grouped by common planting condition:

- fields currently in row crops
- fallow crop fields containing herbaceous weeds
- crop fields _ multiple years fallow containing persistent woody species
- pastures (primarily fescue-dominated, well or minimally maintained)
- timber harvesting roads, skid trails and landings

Under each condition, two or more site-preparation prescriptions are listed in the order of effectiveness for controlling competition. Each alternative provides a general competition control prescription with a timeline. Recommendations are given for either groundcover establishment, herbicide use or a combination. Subsequent sections on herbicides and

groundcovers should be referenced and information on specific herbicides or groundcovers should be used to build a complete prescription for a specific planting condition.

Each alternative provides information for a fall/early-winter planting option and a late-winter/spring planting option. Often, hardwood seedlings are not available for a fall or early-winter planting. However, if seedlings are available and this planting time is operationally preferable, it is important to recognize the possibility of frost heaving and winter desiccation of seedlings. This situation is exacerbated by barren ground. The alternatives will provide cautionary statements when fall planting should be avoided. Also, the alternatives assume normal or moderate drought conditions. Adaptive management is needed to adjust the prescription if severe droughts are a possibility.

Steps for Selecting Prescriptions

This section contains site preparation prescriptions, is designed to assist in the selection of a prescription for a particular planting condition and provides details on how to implement the prescription. Use this section to become familiar with the prescriptions and to help determine the prescription that best fits the planting conditions.

1. Review the **List of Prescriptions** section below that contains a bulleted list of prescription alternatives and a brief description by planting condition. Prescriptions for each planting condition are listed according to their effectiveness (Best, Suitable and Minimal) for meeting competition control problems under a specific planting condition. Select a planting condition and then the prescription that best fits your timeline.
2. **Consult the Timing of Site Preparation Treatments for Hardwood Tree Plantings** table that shows timelines associated with each practice in each of the prescriptions.
3. After reviewing the **List of Prescriptions** and the **Timing Table**, make a final prescription selection.
4. Go to the **Prescription Details** section that follows for specific information for the selected prescription.

Prescriptions

1. Fields Currently in Row Crops

Alternative 1 – Small Grain Cover (Best for most situations) Establish small-grain cover the fall before planting to reduce weed competition over the entire planting area. Trees are planted directly into the cover.

Alternative 2 – Perennial Grass Cover (Suitable/best for wet soils) Establish benign grass cover the fall before planting. Trees are planted directly into the cover.

Alternative 3 - Pre-emergent Herbicides and Mowing (Minimal) Crop field lies fallow over winter and pre-emergent herbicides are used to control weed development.

2. Fallow Crop Fields Containing Herbaceous Weeds

Alternative 1 – Perennial Grass Cover and Herbicides (Best) Combination of mowing and herbicides is used to kill weeds prior to planting a grass cover one year in advance of the planting.

Alternative 2 – Small-Grain Cover and Herbicides (Suitable) Combination of mowing/herbicides is used to kill existing weeds prior to planting a small-grain groundcover the fall prior to planting.

Alternative 3 – Herbicides and Mowing (Minimal) This alternative is only considered when groundcover cannot be established prior to planting. Bush hogging and herbicides (including pre-emergents) are used to establish planting rows or spots in the cover.

3. Crop Fields - Multiple Years Fallow Containing Persistent Woody Species

Alternative 1 – Two Years Perennial Grass Cover and Herbicides (Best) Woody vegetation is eliminated from the field a year in advance of the planting. Perennial grass is established for one growing season prior to planting.

Alternative 2 – One Year Perennial Grass Cover and Herbicides (Suitable) Weeds are controlled and a grass groundcover is established at the end of the growing season prior to planting.

Alternative 3 – Hand-Planting under Woody Cover (Minimal) This alternative is an option when the cost or the site conditions do not allow for land clearing as provided for by Alternative 1 and bush hogging is not possible (Alternative 2).

4. Pastures (fescue-dominated field)

Alternative 1 – Pasture Replacement One Growing Season Prior to Planting (Best for fescue-dominated pasture or unmanaged non-fescue pastures) Pasture cover is eradicated the growing season before planting and replaced with an appropriate grass or small grain groundcover the fall prior to tree planting.

Alternative 2 – Pasture Replacement in the Fall Prior to Planting (Suitable for fescue-dominated pasture or managed non-fescue pastures) Pasture cover is treated the fall before planting and replaced with a grass or small-grain groundcover.

Alternative 3 – Winter Pasture Burndown (Suitable for fescue-dominated pastures only and winter/spring planting) Use this alternative when fescue cannot be eradicated the growing season or the fall before planting. Fescue is mowed/scalped in late fall prior to planting and herbicide is applied in late winter prior to tree planting in spring.

Alternative 4 – Herbicide Control (Minimal – late-winter/spring planting) – This alternative is only appropriate where no cultural work can be completed prior to the planting season. The entire area is treated directly before tree planting in late-winter/spring and again during the growing season.

5. Timber Harvesting Roads, Trails and Landings

Establish a seed bed, fertilize and lime for a small grain cover. Tree planting can occur directly in the cover.

Table 1. Timing of Site Preparation Treatments for Hardwood Tree Plantings

	Pre-Plant			Fall planting	Winter	Late winter - spring planting	Post-plant		
	Two years prior to planting	Growing season prior to planting	Fall prior to planting				Early spring	Early growing season	Mid growing season
Field Currently in Row Crops									
1			Small grain cover	x ¹		X ²	*Pre-emergent ³		*Pre-emergent
2			Grass cover	x		X	*Pre-emergent		*Pre-emergent
3						X	Pre-emergent		Pre-emergent
Fallow Crop Field with Herbaceous Weeds									
1		Bush hog	a. Post-emergent b. Grass cover	x		X	Pre-emergent		Pre-emergent
2		Bush hog	a. Post-emergent b. Grain cover	x		X	Pre-emergent		Pre-emergent
3			a. Post-emergent b. Bush hog			X	Pre-emergent		Pre-emergent
Crop Field - Multiple Years Fallow Containing Persistent Woody Species									
1	a. Bush hog b. Postemergent c. Grass cover			X		X			
2		a. Bush hog b. Post-emergent	Grass cover	x		X	*Pre-emergent		
3		Woody post-emergent		X		X		*Post-emergent	

Table 1. Timing of Site Preparation Treatments for Hardwood Tree Plantings

Pasture (primarily fescue-dominated fields)									
1		a. Bush hog b. Post-emergent	Grass cover	x		X			
2		a. Bush hog							
3			Mow		Post-emergent	X	Pre-emergent		
4					Post-emergent	X	Pre-emergent		*Pre-emergent

Timber Harvesting Roads, Trails and Landings

1		Disk, fertilize grass/grain		x		X			
---	--	--------------------------------	--	---	--	---	--	--	--

1 – small x represents that fall tree planting is possible, but not preferred, with the particular site preparation prescription
 2 – capital X indicates the preferred planting period
 3 – * indicates that surveys should be accomplished to determine the necessity of this prescription



A four-wheeler with a sprayer for herbicides

Prescription Details

The following prescriptions are grouped by planting condition. Each of the prescriptions can be used to arrange a general timeline for site preparation and post-planting competition control treatments. Each prescription will indicate a general type of herbicide and groundcover. Consult the herbicides and groundcover sections that follow to select a specific herbicide and groundcover for the prescription. Practitioners should use local expertise in selecting herbicides and groundcovers as there are always conditions and situations that may preclude the use the herbicides and groundcovers listed or local experience may dictate better alternatives.

Condition: Fields Currently in Row Crops

Competition Problem: Cultivation of row crops reduces the stored seed and the root systems of perennial weeds that often contribute substantially to weed problems. Competition in these areas will come from seed deposited directly prior to or after tree planting.

Alternative 1 – Small Grain Cover (Best)

General Description

Establish small grain cover the fall before planting to reduce weed competition over the entire planting area. This cover occupies the site and hinders the development of weeds during the first growing season and into the second growing season. Trees are planted directly into the cover. Use herbicides as needed to control competition, particularly during the second and third year after tree planting. Areas between rows are not mowed unless planting access and control of weeds are necessary.

Prescription

Note: Refer to groundcover section for small grain and small grain/grass cover recommendations and for specific seeding rates and planting dates. Refer to herbicide section for information on pre-emergent applications.

Late-Summer/Fall Prior to Tree Planting: After crop harvest, establish annual small grain cover (or small grain/grass mixture) over the entire planting site. If the crop is not removed in time to allow adequate time for small grain development prior to winter, poor ground coverage may reduce weed

suppression. Allow adequate time to have small grains planted by appropriate dates for your location (typically early fall). Winter wheat or grain ryes are the most widely used small grains on moderately or well-drained sites. While small grains can be used in soils that are poorly drained, Alternative 2 and the planting of a grass cover adapted to wet soils, such as red top, may be better for these sites. Alternative 3 should be considered for droughty soils.

Planting Option:

Late-Fall Tree Planting: Tree seedlings are planted directly into the cover. No herbicide treatment is used at the time of planting. If cover is thin and significant areas of bare ground are present, apply a broadleaf pre-emergent herbicide over the entire field or in 3-foot wide strips or spots directly before the growing season while buds of the hardwood seedlings are closed.

Late-Winter/Spring Tree Planting: Tree seedlings are planted directly into the cover. No herbicide treatment is used if the cover is adequate and occupies the site. If established groundcover is thin and significant areas of bare ground are present, apply a broadleaf pre-emergent spray in strips or over the entire field after the planting slits have thoroughly closed.

First Growing Season: The cover (and the pre-emergent herbicide application if used) should keep competition in check well through the first growing season. Further competition control measures are based on the development and vigor of the weed competition and the amount of growth exhibited by the tree seedlings. If trees are growing well and their foliage can be seen from above, no further control is needed. If weed development is moderate to severe and competition is overtopping the entire tree crown or threatening to do so, herbicide application or mowing may be necessary (see Post-Planting Section).

Alternative 2 – Perennial Grass Cover (Suitable/best for wet soils)

General Description

Establish hardwood-compatible grass cover the fall before planting. Trees are planted directly into cover. Pre-emergent herbicides are applied only if grass cover is inadequate to control weed growth. Use herbicides as needed to control competition the

second and third year after tree planting. Mowing is avoided unless planting access and control of weeds are necessary.

Prescription

Note: Refer to grass groundcover sections for specific seeding rates and planting dates. Refer to the herbicide section for information on pre-emergent applications.

Late-Summer/Fall Prior to Planting: After crop harvest, establish a hardwood-compatible grass cover. Select grass species based on the soil conditions. The goal is to provide significant site occupancy to reduce weed competition.

Planting Option:

Late-Fall Tree Planting: Trees are planted into the cover. If the grass cover is adequate, no further treatments are necessary. If the grass cover is spotty, weed development around the seedlings is controlled by spraying a broadleaf pre-emergent herbicide over the entire planting or along planting rows in a 3-foot wide strip or spot directly prior to the growing season while buds are still closed.

Late-Winter/Spring Tree Planting: Trees are planted directly into the grass cover. If the grass cover is adequate, no further treatments are necessary. If the grass cover is spotty, a broadleaf pre-emergent herbicide can be sprayed directly after planting in 3-foot wide strips or spots around seedlings. The entire field also can be sprayed. If pre-emergent sprays are used, make sure the hardwood buds and planting slits are tightly closed.

After Planting – First Growing Season: The grass cover will generally provide adequate competition control between the planted trees. If applied, the pre-emergent spray will provide control around the seedlings through the middle of the growing season. Apply a second pre-emergent herbicide (grass, broadleaf or tank mix) if warranted to control late-season weeds. Mowing should only be used to access the planting or when severe competition has become established (see Post-Planting Section).

Alternative 3 – Pre-emergent Herbicides and Mowing (Minimal)

General Description

Crop field is allowed to lay fallow over the winter and pre-emergent herbicides are used to control weed development. Optionally, a grass cover can be established between rows after planting to reduce weed competition.

Prescription

Note: Refer to herbicide section for information on pre-emergent applications.

Planting Option:

Late-Fall Tree Planting: Due to the bare ground present in the planting spots, fall planting is not recommended to avoid losses from frost heaving. However, if fall-planted, no cover or herbicide spray is used at planting time. A pre-emergent herbicide (tank mix grass and broadleaf) is sprayed over the entire field or planted rows directly prior to the growing season, but while buds are tightly closed.

Late-Winter/Spring Tree Planting: Trees should be planted and pre-emergent herbicide (tank mix grass and broadleaf) applied. Since this alternative uses no established groundcover, apply pre-emergent over the entire field directly during or after planting. Make sure the hardwood buds and planting slits are tightly closed.

Option: A grass cover can be established between rows during the spring or next fall to aid in long-term competition control.

After Planting – First Growing Season: The pre-emergent spray will provide control around the seedlings through the middle of the growing season. Survey the planting to determine competition control needs at mid-growing season. Normally a second application of a pre-emergent is warranted by the middle or slightly after the middle of the first growing season. Make sure that herbicide rates do not exceed maximum annual application rates on the label, because of possible root damage to seedlings. If a cover is not established between rows (see option above), mowing is required at least once in the middle of the growing season.

After Planting – 2nd and 3rd Growing Season: Apply (tank mix grass and broadleaf) pre-emergent herbicide prior to the growing season. Mowing will often be necessary in mid- to late summer.

Condition: Fallow Crop Fields Containing Herbaceous Weeds

Competition Problem: Fallow fields (crop fields that have been fallow for one season) often contain weed seed and perennial root systems of herbaceous weeds and to some degree woody species. This leads to vigorous herbaceous weed development. Deposition of seed directly before and after planting will also occur. The buildup of seed in the soil indicates the need for the use of pre-emergent herbicides.

Alternative 1 – Perennial Grass Cover and Herbicides (Best)

General Description

A combination of mowing and herbicides are used to kill existing weeds prior to planting a grass cover over the entire planting area in the fall. Seedlings are planted in late winter or early spring. Pre-emergent herbicides are recommended to reduce weed competition in fallow fields because of the building seed banks in the soil.

Prescription

Note: Refer to grass groundcover sections for specific seeding rates and planting dates. Refer to herbicide section for information on pre-emergent and post-emergent applications.

Growing Season Prior to Planting: Assess the competition in the field at the beginning of the growing season prior to establishment of the grass cover. If the residual weed growth has reached a height that it cannot be oversprayed, then the field should be mowed at the beginning of the growing season.

Late-Summer/Fall Prior to Planting: Herbicides are required to establish a grass groundcover over the entire planting site in the fall. The selection of herbicide(s) is based on weed species present. For most herbaceous weed species, a broad-spectrum, post-emergent herbicide can generally be applied from mid-growing season to late summer. The goal of the cover is to provide significant site occupancy to reduce weed competition.

Planting Option:

Late-Fall Tree Planting: Trees are planted directly into the grass cover. A broadleaf pre-emergent herbicide should be applied to the entire field

or planting rows or spots directly before the growing season but while the hardwood buds are still closed and inactive.

Late-Winter/Spring Tree Planting: Tree seedlings are planted directly into the cover. A broadleaf pre-emergent herbicide should be applied to the entire field or in 3-foot wide strips or spots around the seedlings directly after planting. Make sure the planting slits are tightly closed. If possible, use directed strip or spot sprays of pre-emergents that avoid or limit herbicide delivery to planting slits.

After Tree Planting – First Growing Season: The grass cover will generally provide adequate competition control between planted trees. The pre-emergent spray will provide control through the middle of the growing season. Survey the planting to determine competition control needs at mid-growing season and the potential application of a second pre-emergent treatment. Mowing should be considered only if weed problems are significant and could potentially cover seedlings (see Post-Planting Section).

Alternative 2 – Small Grain Cover and Herbicides (Suitable)

General Description

A combination of mowing and herbicides are used to kill existing weeds prior to planting a small-grain groundcover over the entire planting area in the fall. Seedlings are planted in late winter or early spring. This alternative may allow more weed development in the field compared to Alternative 1. Trees are planted directly into the cover and a pre-emergent herbicide is applied. Since the small-grain cover is only effective during the first growing season in covering the site adequately, a repeated application of pre-emergent herbicides may be required in the second and third year after tree planting. Areas between rows are not mowed unless needed to access the planting or to control taller competition.

Prescription

Note: Refer to small-grain and small-grain/grass cover sections for specific seeding rates and planting dates. Refer to herbicide section for information on pre-emergent and post-emergent applications.

Growing Season Prior to Planting: Assess the competition in the field at the beginning of the

growing season prior to establishment of the small-grain or small-grain/grass cover. If the residual weed growth has reached a height that it cannot be oversprayed, then the field should be mowed at the beginning of the growing season.

Late-Summer/Fall Prior to Planting: Herbicides are required to kill existing weeds prior to establishment of the small-grain cover over the entire planting site in the fall. The selection of herbicide(s) is based on weed species present. For most herbaceous weed species, a broad-spectrum, post-emergent herbicide can generally be applied mid- to late growing season. The goal of the cover is to provide significant site occupancy to reduce weed competition.

Planting Option:

Late-Fall Tree Planting: Tree seedlings are planted directly into the cover. No herbicide treatment is used at the time of planting. A broadleaf pre-emergent herbicide is required and can be applied to the entire field, planting rows or spots before the beginning of the growing season, but while the hardwood buds are still closed and inactive.

Late-Winter/Spring Tree Planting: Tree seedlings are planted directly into the cover. A broadleaf pre-emergent herbicide should be applied to the entire field or applied in a 3-foot wide strip or spots during or directly after planting. If overspraying the seedlings, make sure the planting slits are tightly closed. If possible, use directed strip or spot sprays of pre-emergents that avoid or limit herbicide delivery to planting slits.

First Growing Season after Planting: The cover and pre-emergent herbicide should keep competition in check well through the first growing season. Further competition-control measures are based on the development and vigor of the weed competition and the amount of growth exhibited by the tree seedlings. If trees are growing well and their foliage can be seen from above, no further control is needed. If weed development is moderate to severe and competition is overtopping the entire tree crown or threatening to do so, herbicide application and/or mowing may be necessary (see Post-Planting Section).

After Planting – 2nd and 3rd Growing Season: Apply pre-emergent herbicide prior to the growing season. Mow mid- to late summer only if weeds are present that will overtop seedlings.

Alternative 3 – Herbicides and Mowing (Minimal)

General Description

This alternative provides less overall weed control than alternatives 1 and 2 and should only be considered when groundcovers cannot be established prior to planting. Bush hogging and herbicides are used to establish planting rows or spots prior to tree planting. Pre-emergent herbicides are used to control competition in the rows, spots or whole field. Once planted, mowing is used to control weeds between rows. Optionally, a grass cover crop can be established between rows after planting to reduce weed competition.

Prescription

Note: See herbicide section for specific herbicide selection and rates.

Growing Season Prior to Planting: Assess the competition in the field at the beginning of the growing season. If the residual weed growth has reached a height that it cannot be oversprayed, then the field should be mowed at the beginning of the growing season.

Fall Prior to Planting: Apply a post-emergent, broad-spectrum herbicide over the entire field. After several weeks, mow entire field or in planting rows 3 or more feet in width.

Planting Option:

Late-Fall Tree Planting: Fall planting can be an option unless bare ground is present that will exacerbate frost heaving.

Late-Winter/Spring Tree Planting: Plant as soon as possible. Apply pre-emergent herbicide (tank mix grass and broadleaf) to all areas that were bush hogged in the fall as soon as possible after planting, but after planting slits have sealed. Alternatively, a grass cover could be established between rows. If planting a grass cover between rows, do not apply pre-emergent herbicides until after grass cover has emerged or apply pre-emergent herbicide only in the planting strips prior to drilling grass.

After Planting – First Growing Season: The pre-emergent herbicide will provide control of emerging weeds through the middle of the growing season. Apply second broadleaf pre-emergent herbicide

treatment to provide late-season control. Some biennials and perennials may sprout, so the planting must be surveyed to determine if post-emergent competition control is needed. Use spot applications of post-emergent herbicides, avoiding planted hardwoods, and/or mow between rows in mid-growing season after full leaf out.

After Planting – 2nd and 3rd Year: Reapply pre-emergent herbicide (tank mix grass and broadleaf) prior to the beginning of the growing season. If no cover was established between rows, then mow between rows in mid-growing season. If trees are growing well and their foliage can be seen from above, no further control is needed. If weed development is severe and competition is overtopping the tree crowns, or threatening to do so, post-emergent herbicide application and/or mowing may be necessary (see Post-Planting Section).

Condition: Crop Fields – Multiple Years Fallow Containing Persistent Woody Species

Competition Problem: Fallow fields allow weed seed and perennial root systems of vines, shrubs and trees to become established. The vigor of the competition from these competitors will increase with number of years that the field lays fallow. Deposition of seed directly before and after planting will also occur.

Alternative 1 – Two Years Perennial Grass Cover and Herbicides (Best)

General Description

Woody vegetation must be eliminated from the field. If the woody vegetation cannot be bush hogged and disked, then clearing techniques using a bulldozer may be warranted to prepare the site for planting of a groundcover. If the woody competition can be bush hogged, then a combination of bush hogging and herbicides can be used to control woody re-sprouting. A perennial grass cover crop is established over the entire planting site one growing season in advance of the tree planting. Developing grass cover one year in advance allows time for the control of broadleaf competition from stored seed or root systems (including vines, shrubs and trees) during the growing season prior to tree planting. Control of woody stems may be particularly critical

in fields that have been fallow for several years where extensive root systems have developed. Trees are planted in the cover crop in the fall prior to planting. Pre-emergent herbicides are used to control weed development in the planting rows or spots.

Prescription

Two Growing Seasons Prior to Tree Planting:

Several techniques can be used to eliminate woody competition. The goal is to control or kill woody competition and allow for one growing season of grass cover prior to tree planting.

1. Clear the woody cover using a bulldozer (or other similar clearing techniques) on fields where the woody vegetation cannot be bush hogged and disked. The field should be prepared so that grass cover can be established for one growing season prior to tree planting. The removal of the woody vegetation occurs up to two years in advance of tree planting, depending on the severity and size of the woody vegetation.
2. For fields where the woody competition can be bush hogged and disked, eliminate woody competition by either one of two methods.
 - a. Bush hog after weeds and other competition have fully leafed out to minimize sprouting of stubble and small stumps. Broadcast herbicides on fresh-cut stubble to eliminate or reduce sprouting, using herbicides labeled for cut stubble or cut stump applications.
 - b. Bush hog prior to the growing season to late spring. Allow the root systems of the bush hogged woody competition to sprout and develop significant top growth. In late summer, apply a broad-spectrum, foliar (post-emergent) herbicide over the sprouting woody and herbaceous competition.

Grass seed should be sowed one to two weeks following control of existing competing vegetation. Grass cover should be established as soon as possible in late summer or early fall to allow adequate growth and development prior to winter.

Growing Season Prior to Tree Planting:

Allow grass cover to remain intact through the next growing season (the growing season prior to tree planting). Assess the development of woody sprouts in the grass cover. Use a directed spray of a broad-spectrum, post-emergent herbicide to control scattered sprouts of woody competition in the grass cover. A broadleaf post-emergent herbicide can be

sprayed over the entire field if the woody competition is pervasive.

Late-Summer Prior to Tree Planting: Assess the established grass cover. If the grass cover is dense enough to cause a problem with machine planting, then planting strips should be established. If not, the grass cover is left intact and trees can be planted directly into the cover. Planting strips can be established in a number of different ways, including disking or roto-tilling strips, selected use of a broadleaf pre-emergent in the spring and planting directly into these tilled rows; applying herbicides to establish rows and plant into dead groundcover; or disk rows and plant small grain cover in rows.

Planting Option:

Late-Fall Tree Planting: Trees are planted and no herbicides are used at this time.

Late-Winter/Spring Planting: If the groundcover is adequately established and no competition problems are found, trees can be planted without administering pre-emergent herbicides. If bare ground is present, apply broadleaf pre-emergent herbicides in planting rows or spots after planting slits have sealed.

After Planting – First Growing Season: The grass cover (and pre-emergent herbicide if applied) will generally provide adequate competition control between seedling rows. Survey the planting to determine competition control needs at mid-growing season.

Alternative 2 – One-Year Perennial Grass Cover and Herbicides (Suitable)

General Description

Herbaceous and perennial weeds are controlled and a grass groundcover is established at the end of the growing season prior to planting. Trees are planted directly into the cover. Pre-emergent herbicides are used to control weed development in the planting rows or spots.

Prescription

Note: Refer to grass groundcover section for specific seeding rates and planting dates. Refer to herbicide section for information on pre-emergent and post-emergent herbicide applications.

Growing Season Prior to Tree Planting: Several techniques can be used to eliminate herbaceous and

woody competition. The goal is to control or kill competition including woody perennial species and provide a grass cover prior to tree planting.

1. Use conventional clearing on fields where the woody vegetation cannot be bush hogged. Clearing should occur so that grass cover can be established prior to tree planting.
2. For fields where the woody competition can be bush hogged and full land-clearing techniques are not warranted, eliminate woody competition by either one of two methods.
 - a. Bush hog field in early summer directly after full leaf expansion of woody competition and weeds to minimize sprouting of stubble and small stumps. Broadcast herbicides on fresh-cut stubble (use herbicides labeled for cut stubble application) to eliminate or reduce sprouting.
 - b. Bush hog prior to the growing season or late spring. Allow the root systems of the bush hogged woody competition to sprout. In late summer, apply a broad-spectrum, post-emergent herbicide over the sprouting woody and herbaceous competition.

Grass seed should be sowed one to two weeks following control of existing competing vegetation. Grass cover should be established as soon as possible in late summer or early fall to allow adequate growth and development prior to winter.

Planting Option:

Late-Fall Tree Planting: Trees are planted into the grass cover. A broadleaf pre-emergent herbicide is sprayed over the entire field or in the planted rows prior to the growing season while buds are still tightly closed.

Late-Winter/Spring Tree Planting: A pre-emergent herbicide (tank mix broadleaf and grass) is sprayed over the entire field or the planted rows at the time of planting or directly after planting. Make sure planting slits are closed prior to spraying.

After Planting – First Growing Season: The grass cover will generally provide adequate competition control between seedlings. The pre-emergent herbicide will provide control around the seedlings through the middle of the growing season. Survey the planting to determine competition control needs at mid-growing season.

Alternative 3 – Hand-Planting under Woody Cover (Minimal)

General Description

Use this alternative when tree cover has developed to a size where most of the brush species are no longer present. Hand-planting under a woody cover is a marginal option when the site conditions or cost do not allow for land clearing as provided by Alternative 1 and bush hogging is not possible (Alternative 2).

Prescription

Note: Contact your local forestry professional for herbicide recommendations.

Growing Season Prior to Planting: Deaden all existing trees either with individual tree treatments, such as hack and squirt, tree injection or basal bark applications; or aerially spray the entire field. Basal bark and foliar applications can be used to treat small head-high vegetation. Contact your local forestry professional for assistance. Timing of treatment will depend on the species present and herbicide used. Generally, glyphosate-based herbicides can be administered during the middle of the growing season. Other herbicides, especially those that are triclopyr-, picloram- and imazapyr-based, are generally best when applied at the end of the growing season.

Planting Option:

Late-Fall or Late-Winter/Early-Spring Tree Planting: Hand-plant among deadened trees.

Follow-Up: The competition control problems associated with these sites are highly variable. The plantings should be surveyed to determine control needs. Pre- or post-emergent herbicides can be hand-applied where appropriate.

Condition: Pasture (primarily fescue-dominated fields)

Competition Problem: Pastures, particularly those dominated by KY 31 tall fescue, can cause problems for hardwood tree plantings and should be replaced with a cover that is more compatible with tree seedlings and conservation objectives. Weed seed and perennial root systems of broadleaf weeds are also present. Generally, the severity of the broadleaf weed competition is related to the tightness of the pasture cover and the proximity and severity of weed seed sources.

The following alternatives will be used in either:

- fescue and other cool-season, non-hardwood-compatible pasture covers, or
- hardwood-compatible pastures (see hardwood-compatible groundcovers section)

For the purposes of these prescriptions, fescue is used to describe fescue and other cool-season grasses that are not compatible with hardwood seedling development.

Alternative 1 – Replacement One Growing Season Prior to Planting (Best for Fescue-Dominated Pastures)

General Description

Fescue (or other non-compatible grass cover) is eradicated the growing season before planting and replaced with an appropriate grass or small-grain groundcover during the fall. The cover occupies the site and hinders the development of weeds during subsequent growing seasons. Use herbicides as needed to control competition, particularly during the second and third year after tree planting. Areas between rows are not mowed unless access to the planting or control of severe competition is necessary.

Prescription

Note: Refer to groundcover sections for specific seeding rates and planting dates. Refer to herbicide and fescue eradication sections for information on post-emergent herbicide applications.

Early-Spring and Growing Season Prior to Planting: For optimum control of fescue (or other cool-season, non-hardwood compatible grasses) throughout the planting area, mow pasture cover with a bush hog in late winter to early spring one year prior to tree planting. Run bush hog as close to the ground as possible. Double-mow if there is heavy buildup of cover. Alternatively, prescribed burning can also be used to remove dead foliage from cool-season grasses. Allow pasture grass to develop new young foliage. When grass foliage is approximately 6 to 10 inches high, broadcast-spray the entire planting area with a post-emergent herbicide recommended for the pasture species present (ex. glyphosate for fescue control) prior to the beginning of summer.

Late-Summer Prior to Growing Season: In late summer, survey planting area for pasture grass occurrence and the presence of other competition.

If prevalent, spot-spray grass or spray entire field a second time with the appropriate post-emergent herbicide. A grass cover, small grain cover or a combination should be established. Generally, seeding of the grass or small-grain cover should be accomplished by late summer or early fall to promote vigorous cover development with sufficient site occupancy to reduce weed competition.

Planting Option:

Late-Fall Tree Planting: Tree seedlings are planted directly into the emerging compatible grass or small-grain cover. Typically, pre-emergent broadleaf herbicide application is only warranted when the pastures were untended (increasing the prevalence of weed seed) or where established groundcover is sparse. If needed, spray broadleaf pre-emergent prior to the growing season when hardwood buds are still closed.

Late-Winter/Spring Tree Planting: Plant trees directly into groundcover. Typically, a pre-emergent herbicide is not required in areas where the fescue pasture had been well-tended. If the groundcover is sparse and/or the fescue field was untended and weedy, spray broadleaf pre-emergents over the entire field or the planted rows at the time of planting or directly after planting. Make sure planting slits and seedling buds are closed prior to spraying.

After Planting – First Growing Season: The established groundcover will generally provide adequate competition control. Survey the planting to determine competition control needs at mid-growing season.

Alternative 2 – Pasture Replacement in the Fall Prior to Planting – Winter/Spring Planting Only (Suitable for Fescue-Dominated Pastures)

General Description

Fescue or other cool-season grass is treated in the fall and replaced with a grass or small-grain groundcover. Trees are planted in late winter or early spring directly into the cover. Use herbicides as needed to control competition, particularly in the second and third year after tree planting. Areas between rows are not mowed unless needed to access the planting.

Prescription

Note: Refer to grass groundcover section for specific seeding rates and planting dates. Refer to herbi-

cide and fescue eradication sections for information on pre-emergent, post-emergent and grass-specific herbicide applications.

Late-Summer Prior to Growing Season: Bush hog entire planting area in late summer. If pasture grass is dense, two mowings may be required. Mow as close to the ground as possible. Prescribed burning can also be used to eliminate older foliage.

Fall Prior to Growing Season: Allow pasture grass to re-grow and spray entire field with appropriate post-emergent herbicide (ex. glyphosate-based herbicides for fescue) in fall before temperature consistently drops below 55 degrees during the day. Establish small grain cover by mid- to late fall.

Planting Option:

Late-Fall Tree Planting: Not compatible.

Winter/Spring Tree Planting: Plant trees directly into cover. As a directed spray, use a tank mix of grass and broadleaf pre-emergent herbicide to control grass and broadleaf seed. Avoid spray or drift into the planting slit or the entire field. Rows can be sprayed after planting and after planting slits have sealed. Survey field to determine if fescue is emerging. If so, spray in early spring with a grass-specific, post-emergent herbicide.

After Planting – First Growing Season: The small grain cover crop will generally provide adequate competition control. Survey the planting to determine competition control needs at mid-growing season.

Alternative 3 – Pasture Burndown (Minimal for Fescue-Dominated Pastures) – Winter/Spring Planting Only

General Description

The burndown alternative is used when pasture grass cannot be eradicated during the growing season or the fall before planting. The pasture is mowed/scalped in late fall prior to planting in late winter or early spring. Reduction of the dead leaf material allows emerging foliage to be exposed in late winter/early spring, increasing the time for herbicide application and grass cover establishment prior to or at the time of tree planting. Maintain weed control one to three years after planting in the rows or spots.

Prescription

Note: Refer to grass groundcover section for specific seeding rates and planting dates. Refer to herbicide section for information on pre-emergent and post-emergent applications.

Late-Fall Prior to Planting: Mowing or scalping is required to significantly remove existing pasture top growth so that new growth in the spring is exposed for herbicide applications that can be effectively applied before tree planting. The pasture should be mowed twice. The second mowing should be as close to the ground as possible in late fall.

Planting Option:

Late-Fall Tree Planting: Not compatible.

Late-Winter/Early-Spring: After cool-season pasture grass growth occurs in late winter, post-emergent (broad-spectrum or grass-specific) herbicides are applied over the entire field. Appropriate grass cover is established by drilling into the sod.

Late-Winter/Early-Spring Planting Option: Trees are planted into established cover. As a directed spray, use a tank mix of grass and broadleaf pre-emergent herbicides to control grass and broadleaf seed during tree planting. Avoid spray or drift into the planting slit or the entire field. Rows can be sprayed after planting when planting slits have sealed. After planting, survey the field to determine if fescue is emerging. If so, spray in early spring with a grass-specific, post-emergent herbicide.

After Planting – First Growing Season: The grass cover will generally provide adequate competition control between the planting rows. The pre-emergent herbicide spray will provide control around seedlings through the middle of the growing season. Survey the planting to determine competition control needs at mid-growing season. Be attentive to fescue regrowth and treat accordingly.

Alternative 4 – Herbicide Control Only - Late-Winter/Spring Planting (Minimum for Fescue-Dominated Fields) (Best for Pastures with Hardwood-Compatible Covers)

General Description

This alternative is only appropriate for situations (1) where no cultural work can be completed prior

to the planting season for cool-season grass pastures or (2) it is the best option if the pasture is composed of groundcovers compatible with hardwood seedlings. The entire area is treated directly before tree planting in late-winter/spring and again during the growing season to control grasses in the rows. Pre-emergent herbicides are used to control weed competition in the planting rows or spots.

Prescription

Note: Refer to herbicide and fescue eradication sections for information on pre-emergent and post-emergent herbicide applications.

Late-Winter/Spring: Planting is timed to allow for effective herbicide application for initial pasture grass control. Two options exist for treatment.

1. Cool-season grasses (fescue) can be left intact and sprayed with a post-emergent herbicide when blades are exposed and 6 to 10 inches tall. Spray entire field.
2. Mow entire field or at least planting rows as soon as possible in late winter. Allow cool-season grass to re-sprout and treat entire field with post-emergent herbicide to burn down pasture grass when blades are exposed and 6 to 10 inches tall.

Planting Option:

Late-Fall Tree Planting: Not compatible.

Late-Winter/Spring Planting: Plant trees and apply a grass and broadleaf pre-emergent herbicide tank mix to entire field or planting rows directly after planting. Make sure planting slits are sealed.

After Planting – First Growing Season: Survey the planting to determine competition control needs at mid-growing season. A second post-emergent, grass-specific herbicide spray is required to control fescue and/or other emerging grasses in the field or rows or spots. Mowing can be used to help control competition between rows.

Late Growing Season: Ultimate eradication of the non-hardwood-compatible pasture grass in the planting should be considered and replaced with a hardwood-compatible grass cover, typically orchard-grass (moderately or well-drained soil) or redtop (poorly-drained or wet soil). Post-emergent (broad-spectrum or grass-selective) herbicides are used to kill the fescue during or after planting.

After Planting – 2nd and 3rd Year: Re-apply appropriate pre-emergent herbicide (grass, broadleaf or tank mix) based on weed assessment prior to the beginning of the growing season. If no cover was established between rows, then mow between rows during mid-growing season. If trees are growing well and their foliage can be seen from above, no further control is needed. If weed development is severe and competition is overtopping the tree crowns, or threatening to do so, post-emergent herbicide application and/or mowing may be necessary (see post-planting section).

Condition: Timber Harvesting Roads, Trails and Landings

Competition Problem: Root systems of trees and other associated woody plants have been removed or killed during the trafficking of these areas. Removal of the duff layer and disturbance of the mineral soil have modified the soil environment. Annual and perennial herbaceous species and woody vines and shrubs will establish after the harvest. The vigor of the competition will be related to soil moisture, the degree of compaction and the removal of the A horizon.

General Description

Establish a seed bed for a small grain cover. Fertilizer and lime should also be applied. Tree planting can occur directly in the cover.

Prescription

Note: Refer to grass groundcover section for specific seeding rates and planting dates. Refer to the herbicide section for information on pre-emergent and post-emergent applications.

Late-Summer/Fall: Planting areas are disked to prepare a seed bed for planting the cover. Lime and fertilizers should be applied to enhance soils where significant top soil has been removed. Use a soil test for lime and fertilizer recommendations or use a general-purpose local recommendation. The grass/small grain combination cover is seeded in early fall.

Planting Option:

Late-Fall Tree Planting: Tree seedlings are planted directly into the cover. No herbicide treatment is used at the time of planting. If cover is thin and significant areas of bare ground are present, a 3-foot wide strip or spot of broad-spectrum, pre-

emergent herbicide should be applied around seedlings before the growing season.

Late Winter/Spring Tree Planting: Tree seedlings are planted directly into the cover. No herbicide treatment is used if the cover is dense and occupies the site. If this is not the case, a 3-foot wide strip or spot of broad-spectrum, pre-emergent herbicide should be applied during or directly after planting.

After Planting – First Growing Season: Survey the planting to determine competition control needs at mid-growing season. Spot treatment for broadleaf weeds should be used where weed height entirely covers planted seedlings.

Post-Planting Maintenance - 2nd and 3rd Years

Second and possibly third year pre-emergent herbicides should be sprayed in planting strips or spots where the ground is bare and herbicides can adequately contact soil. Overtop sprays of grass herbicides and directed sprays for broadleaf control can be administered during the first through third years as needed. Mowing should be used in combination with herbicide applications or by itself to control weed competition that becomes established between rows.

If trees are planted directly into the cover, survey the planting during the first growing season for weed development. Overtop sprays for grass control and directed sprays for broadleaf control can be administered where needed. Between rows, winter wheat can be left to seed a second year. The thick leaf mass of the winter wheat along with the second year growth provides competition control. To reduce overall competition in the planting, establish a perennial cover between the rows.

Mowing

If planting densities and cultural treatments are effective, mowing is generally not necessary and should be minimized. However, mowing should be considered when competition control treatments fail to provide adequate weed control. Specifically, mowing should only be used to:

- Prevent seed development of obnoxious, invasive or problematic weed species
- Prevent development of weeds that have the

potential to grow above 4 to 5 feet and occupy a significant portion of the planting site

- Provide access for cultural control of weeds and rescue treatments in planting rows or spots.

While mowing can be used to ward off serious competition problems and is used as a part of seedling rescue efforts, it ultimately has detrimental effects for most timber and conservation plantings. Mowing to control residual competing vegetation increases the probability of physical damage to seedlings from mowing equipment, especially if mowing occurs many times during the growing season for several growing seasons. Mowing is also a cost that reduces the overall economic yield associated with timber plantings. Generally, the vegetations mowed are moisture competitors to planted seedlings and mowing does little to alleviate moisture stress of seedlings.

Mowing should be discouraged and is one of the more ineffective methods to control competitors near planted seedlings. Further, many grasses that reduce the diversity and overall habitat and conservation value of the planting are perpetuated by mowing. Many wildlife populations are impacted by mowing, so the timing of mowing should take into consideration wildlife nesting and habitat requirements. Mowing for rescue treatments is done to expose planting rows or trees so that further control measures can be taken.

General Herbicide Recommendations for Post-Planting Maintenance

The following recommendations are used as post-planting follow-up or maintenance herbicide treatments.

General Weed Control

- 1.5 quarts Roundup Original Max™ (or other labeled glyphosate herbicide with 40 to 50 percent glyphosate) + 0.75 to 1.0 ounces Oust XP™ per acre. Avoid spraying on hardwood foliage.
- 1.5 quarts per acre glyphosate for perennial weeds applied as (1) an overspray prior to hardwood bud break in spring to control cool-season weeds, or (2) a directed application avoiding hardwood foliage at full leaf expansion in early summer. Fall spraying is not recommended unless hardwood foliage is avoided.

Precautionary 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 for hardwood tree establishment. 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.

General Broadleaf Control

- 1.5 quarts Roundup Original Max™ (or other labeled glyphosate herbicide with 40 to 50 percent glyphosate) + 2.0 quarts Simazine per acre. Avoid spraying on hardwood foliage.
- 2 quarts of Simazine per acre (pre-emergent control only)

Annual Weeds – Broadleaf and Some Grasses

- Oust XP™, 3/4-1 ounce per acre (pre- and post-emergent)

Annual Grass

- Pendulum 3.3 EC™, 2 quarts per acre for pre-emergent grasses
- Select 2EC™, 8 ounces per acre for post-emergent control of grasses

Post-Plant Rescue Treatments

Established Tree Plantings with Vine, Shrub and Tree Competition

Competition Problem: Shrub and tree species can overtop and shade out planted tree seedlings, while vines can lodge and smother planted trees. Survey the planting to determine the competing species involved and their development.

If problematic vines are present, either in the row or between rows, they should be controlled. Vines in rows can easily wrap around the planted seedlings, especially if significant tree, shrub or large herbaceous weeds are present. If surveys indicate problematic vines such as trumpet creeper, morning glory, honeysuckle or poison ivy, the planting should be treated as soon as possible. The best control can be achieved by mowing between rows directly after full leaf-out. Allow new shoots to emerge from the woody root systems and stumps and spray new foliage with a post-emergent, broad-spectrum herbicide at the end of the growing season. If individual stumps are scattered, they can be treated by applying a full-strength, broad-spectrum, post-emergent herbicide to the stump within two hours of cutting. If stumps cannot be treated right away, an ester herbicide with an oil carrier can be used (ex. Garlon® 4) to treat individual stumps.

The mowing allows access to the rows where directed sprays of a broad-spectrum, post-emergent herbicide can be administered. Avoid spraying seedlings and minimize tank pressures to maximize drop size in limiting drift to seedlings. Sometimes, cutting of trees, shrubs and vines directly adjacent to seedlings is required. This treatment should be combined with a cut-stump herbicide treatment to reduce or eliminate sprouting. Also, basal sprays can be used on individual woody plants growing around seedlings. Make sure that the basal herbicide spray does not get on the planted seedling. If significant bare soil or ground occurs around seedlings, apply a pre-emergent herbicide.

Established Tree Plantings with Broadleaf Herbaceous Weeds

Problem: Shading and lodging by tall, herbaceous, broadleaf weeds indicate that measures should be undertaken to rescue the planting. Vines and other problematic woody species can also become

established in these situations, compounding competition-control problems.

The planting should be surveyed to determine if trees are fully overtopped or will be overtopped by herbaceous weeds. If the trees are fully overtopped, an overspray of the entire planting with a broad-spectrum, post-emergent herbicide is required. Proper application rates are critical to minimize drip onto seedlings. Large drop size and low pressures are needed to ensure penetration. Once seedlings can be found, mow between rows to allow access. Use directed sprays of post-emergent herbicides around the seedlings to further reduce competing species. Again, use low pressure and large drop size to avoid drift onto hardwood seedlings. In conjunction with the post-emergent sprays, one application of pre-emergent herbicide should be applied in the rows prior to the growing season. If initial surveys show that trees are not yet overtopped, but abundant overtopping herbaceous species (ex. mare's tail, ironweed) are present, mowing should be used immediately to provide access to the planting. A directed-spray, post-emergent, broad-spectrum herbicide can then be administered around the seedlings as indicated above. Some plantings may have relatively small areas where weed growth has or will overtake the trees. In these situations, handheld sprayers or ATV-mounted wand sprayers can be used to administer sprays.

Established Tree Plantings with Grass

Problem: Grass can produce three significant problems in hardwood plantings that can lead to planting failures or significantly reduce survival and growth.

1. Shading is problematic only when tree crowns are totally covered by grass and no direct sunlight is available for their growth. If seedlings cannot be found by looking directly down on top of them, competition should be controlled.
2. Grasses of some species (ex. brown top or Japanese stilt grass) have the ability to smother or lodge trees, resulting in their immediate decline. Grass control must occur prior to significant height growth development of the competition.
3. Moisture stress can occur from grass competition during especially dry years. Grasses do not have to cover seedlings for seedling stress to occur, particularly on droughty soil.

Survey the planting to determine if a problem exists. Grass should be controlled through the use of overtop sprays of post-emergent, grass-specific herbicides and/or the directed spray of broad-spectrum, post-emergent herbicides. The type and amount of herbicide and the timing of herbicide application are determined by grass species and the site. Generally, the best control is achieved when herbicides are sprayed onto relatively young foliage less than 4 to 6 inches tall for most species.

Groundcovers

Covers used for competition control in hardwood tree plantings are grasses or small grains that provide significant ground coverage, grow less than 3 to 4 feet in height, possess no known chemical inhibition problems (allelopathy) with hardwood trees and pose no invasive threat to adjacent sites. Grasses or small grains are preferred so that broadleaf weeds can be controlled in the cover with minimal damage to the cover. Continuous or dense ground coverage is needed to reduce the niche for weed seed germination and early survival. The height requirement minimizes potential shading and lodging effects on the hardwood seedlings. Some common groundcovers and some small grains have shown allelopathic effects on hardwoods. These species or suspect species should not be used. Obviously, any species that presents a reasonable threat (such as an exotic invasive) to adjacent areas should not be used. If possible, covers should provide wildlife with forage or habitat values. However, the primary goal of the covers is to provide competition control for the hardwood seedlings. The following is a selected list of recommended covers for hardwood tree plantings. While species other than those listed can be used, those presented are commonly available and grow under a wide variety of conditions. Consult your local agriculture or natural resource professional for specific recommendations for your area.

Common Small Grain Covers

A number of small grains can work well as a cover for tree planting. Small-grain covers are easy to establish, come up quickly and provide thorough site occupancy for the first growing season after tree planting. They can be seeded in early fall prior to tree planting in late fall or early spring. Small grains can be established using both conventional and no-till techniques. Fertilization is not needed. The fol-



Mark Leopold

Seedlings planted in winter wheat.

lowing small grains are the most common and have been used operationally in hardwood tree plantings.

Winter Wheat

Winter wheat (*Triticum aestivum*) is the most common and recommended small-grain cover used in tree plantings. Wheat height growth and density is compatible with tree seedling development. For winter cover and weed exclusion purposes, planting should be completed by mid-fall using two bushels (approximately 150 lbs) per acre. Seeding can also be accomplished in late winter. One of the advantages in using this small grain is that trees can be planted directly into winter wheat. The only instance where this procedure has been problematic is when plantings are subjected to extreme growing-season droughts, resulting in increased mortality. However, if droughty conditions are developing, the winter wheat can easily be controlled around tree seedlings using a grass-specific herbicide.

Rye

Rye (*Secale cereale*) germinates quickly and provides good winter cover and weed suppression. More top growth is produced with rye than winter wheat and rye smothers weeds better. However, this same attribute may contribute to lodging of seedlings. Rye should be controlled directly around seedlings. Although rye can be seeded from late summer to late fall, for good winter cover, it should be planted by mid-fall. Winter-hardy varieties, such as Aroostook, should be considered if late planting is necessary. Seeding can also be done in late winter. Use two bushels (approximately 160 lbs) per acre regardless of planting time.

Oats

Oats (*Avena sativa*) are not as winter-hardy as rye or winter wheat. However, oats have the advantage of being able to establish easily in the spring. Planting should be completed by late winter using two bushels (approximately 120 lbs) per acre. Tree seedlings can be planted directly into oats.

Hardwood-Compatible Grass Covers

Grass covers are used as groundcovers in lieu of small grains when

- long-term or perennial groundcover is required.
- soil or site conditions are not conducive to small grains.
- significant weed competition is expected, especially when perennial root systems of woody species are present or when significant seeding of rapidly growing herbaceous species such as ironweed is present.

Traditionally, tall fescue has been the dominant groundcover in tree planting. However, research has shown depressed tree height growth where fescue is present. The presence of tall fescue is not compatible with many conservation objectives. Several grass species can be used in tree plantings. The goal is to thoroughly occupy the area between planted trees and reduce the invasion of weed species until trees are large enough to overtop weed species. The grass cover should also be compatible with hardwood species and provide some attributes that are consistent with conservation objectives. The following are commonly available groundcovers that are compatible or pose little risk to hardwood seedlings.

Orchardgrass

Orchardgrass (*Dactylis glomerata*) is a cool-season, perennial grass that grows in clumps and is more compatible with wildlife habitat requirements than fescue. Orchardgrass is more tolerant of shade, drought and heat than many other grasses and should be used as the preferred grass cover for tree plantings on moderately to well-drained sites unless a better local alternative is known. Typically, orchardgrass is seeded at a rate of one bushel (15 lbs) per acre at a depth of 1/4 to 1/2 inch into a well-prepared seed bed from late summer to mid-fall. Orchardgrass can be established using no-till techniques. However, more weed invasion into the planting area is expected compared to establishment using disking and preparation of a seed bed. Orchardgrass can also

be seeded after severe winter weather in early spring. While not necessary on most sites, incorporating 50 lbs of nitrogen fertilizer per acre prior to seeding can aid in good stand development, particularly on poor-quality sites.

While orchardgrass is the standard grass cover on many sites, it is not well-suited to wet soils and has little ability to withstand flooding. Unfortunately, many grasses such as switchgrass, big bluestem and Canada wildrye that are adapted to wet sites and can tolerate flooding also grow 4 to 6 feet or more in height. These grasses, while providing adequate cover, pose a risk to tree seedlings from shading and more significantly from lodging that can occur, particularly if the area is flooded. If a species such as switchgrass is planted, mowing is used to restrict height growth. Planting rows or spots should be established to ensure that competition and lodging from these species are minimized. Wetland species mixes are available from suppliers as an alternative to some of the common wetland species. Some of these mixes include sedges and other species that are relatively low-growing and could be considered for tree plantings. One of the best grass cover recommendations for these sites is red top.

Red Top

Red top (*Agrostis gigantea* also misnamed as *A. alba*) is a cool-season grass reaching 18 to 24 inches in height and was widely used prior to the introduction of tall fescue. Red top can tolerate flooding (up to 60 days), planting in loamy to muck soil and does not grow as tall as many grasses adapted to wetland and flooding situations. Seeding requires one bushel (14 lbs) per acre drilled or incorporated to a depth of 1/4 to 1/2 inch on a well-prepared soil. Red top is best planted in late summer to early fall or late winter to early spring.

Small Grain/Grass Combinations

Small grain and grass combination can also be used where a small grain cover is recommended. Initially the small grain will dominate. However, over time the grass will dominate. The lag in dominance of the grass will normally allow tree seedlings to gain height growth necessary to overcome the perennial grasses. Development of the grass can be significantly hindered or eliminated by small grains that produce blankets of heavy foliage such as rye. The best mix as a cover for a small-grain/grass

combination for hardwood plantings is winter wheat and orchardgrass.

Winter Wheat/Orchardgrass

Seed in early fall or late winter. Both species are broadcast together and incorporated to a depth of 1/2 inch using two bushels (150 lbs) per acre of winter wheat and 15 lbs per acre of orchardgrass. Alternatively, orchardgrass can be broadcast at 10 lbs per acre and incorporated and 1.5 bushels (115 lbs) per acre of winter wheat can be drilled at 1 to 2 inches depth.

Groundcovers and Drought

Many of the prescriptions require the establishment of a groundcover (either a hardwood-compatible grass or small grain) and the planting of hardwood seedlings directly into the cover. The cover helps to control weed development and does not generally interfere with hardwood development. However, groundcovers can be problematic to the hardwood seedlings during drought, especially when using small grain cover. If severe drought conditions are forecast, strip sprays can be used to eliminate cover directly around seedlings. All covers recommended are grass or small grains. Grass-specific herbicides can be applied to kill or chemically mow the cover with little consequence to the hardwood seedlings. Spraying the established cover leaves dead or dying plant material on the site to shade the soil and at the same time reduces moisture competition for the hardwood seedlings.

The prescriptions provided assume normal or moderate drought conditions. Adaptive management is necessary to adjust the prescription if severe droughts are a possibility.

Herbicides

A large number of herbicides can be used for preparing a site for tree planting. Refer to previous sections on non-crop labeling. Herbicide labels must be checked to ensure that they contain label provisions as follows:

- specific use in hardwood tree plantings (see list of herbicides below).
- use in non-crop areas that include the environment (land use) where the planting is to occur. Most non-crop labeling will include a wide range

Guidelines for Herbicide Selection and Application

1. When applying herbicides (especially those that could potentially injure hardwood seedlings) over the top of planted hardwood seedlings, make sure that the application takes place when the seedlings are dormant, before leaf initiation and bud swell, i.e., before the top of the seedling is actively growing.
2. Some herbicides with pre-emergent activity may have some effect on root activity of seedlings. These effects may be short-term and not have major impacts on the overall growth of the seedling or may delay early seedling growth. Residual herbicide activity in soils from areas cropped the previous year may also impact the growth of planted seedlings.
3. Make sure that herbicides are applied in accordance with label instructions, particularly the current land use.
4. Directed herbicide sprays to control broad-leaf competitors (remember that the planted hardwood seedlings are also broadleaves) invite the probability of splash or drift of herbicide to non-target vegetation. Correct use of nozzles, droplet size, spray pressures and amount of herbicide applied are essential to minimize spray or drift to non-target vegetation.
5. Herbicide application to control competing vegetation that overtops planted seedlings (overtop rescue) can be a double-edged sword. Applications of herbicides usually drip or drift through the overtopping vegetation and impact the planted seedlings. Actions to control competing vegetation before the seedlings become overtopped are encouraged. Overtop rescue is a last resort and some harmful effects to the seedlings should be expected.

of open areas, rights-of-way and other non-crop sites. The list of these areas usually does not include forests.

- specific use in forests if this is where the planting will occur.
- use in crop areas to control grass, weeds and woody species when the herbicide will be used to control these species prior to tree planting.

Do not use the herbicide:

- after the tree planting if the label specifically indicates that it can not be used around hardwood tree seedlings.
- if the label precludes its use for a specific objective of the planting (ex. the herbicide can not be used in timber-producing areas).
- if the label precludes its use on a specific site, land form or topographic position (ex. herbicide can not be used around water or in areas of poor drainage).

Herbicides Labeled Specifically for Hardwood Plantings and around Deciduous Trees

The following are herbicides that have specific labeling (regular or supplemental labeling) for use around hardwood trees before, during or after planting. (Note: other herbicides can be used if their labeling allows, see above). Herbicides are listed by brand name. The specific brand name and the common name of the active ingredient and its percent are also provided. The latter facilitates the selection of an alternative herbicide if the specific brand is no longer available due to a name change or identical herbicides have been made available under a different brand name. Regardless, always check labels to ensure that the label still provides for their use in hardwood tree plantings.

Pre-emergent – Broadleaf Control

Simazine (Simazine 4L™, simazine, 42.1 percent). Simazine provides pre-emergent control of primarily broadleaf weeds in fallow crop and non-crop areas and in established hardwood shelterbelt tree plantings. The herbicide is used for pre-emergent control of weeds prior to tree planting or directly around trees in established plantings. Application information is found in fruit and nut crops, nurseries, Christmas tree plantings and shelterbelt sections of the label. Simazine can be used in harvested crop fields, shelterbelts and tree plantings containing

nut species such as black walnut. For applying after planting, trees must be at least in their second growing season and soil must be settled around tree roots. Apply 2 to 4 quarts in 25 gallons of water per treated acre on bare ground prior to weed germination. Generally the lower rate is recommended and lower rates should be used on coarse-textured soils. Simazine can be used to establish planting rows or spots in developing covers one season in advance of tree planting or as a directed spray or an overtop spray of established trees. Weed-free conditions are maintained for 90 days with applications of Simazine.

Pre-emergent – Grass Control

Pendulum (Pendulum 3.3 EC™, pendimethalin, 37.4 percent). Pendulum provides pre-emergent control of grasses and some broadleaf weeds. The primary use is for pre-emergent control of grass directly around trees at the time of planting or in established plantings. Application information is found in the “Non-Cropland Areas Including Tree Plantations” section of label. Apply 2 to 4 qts in at least 40 gallons of water per treated acre (generally 2 quarts is recommended) on bare ground prior to grass germination. For spring applications, apply before mid-spring. Volatilization will occur and rainfall is required for activation within 30 days (less in soils with little organic matter). Pendulum 3.3 EC™ can be applied directly over seedlings (ensure that planting slit is closed), established trees or as a directed spray.

Pre- and Post-emergent Broadleaf Control

Oust (Oust XP™, sulfometuron, 75 percent). The herbicide provides pre-emergent and post-emergent control of annual and perennial broadleaf weeds. Oust is used primarily for pre-emergent and early post-emergent control of weeds in both pre and post tree-planting applications. Rates must be strictly controlled for use in hardwood tree plantings. Application information is contained in the “Forestry Hardwoods” section of the general label and in the supplemental label for herbaceous weed control in hardwood reforestation areas. Research in the Midwest has shown that applying .75 to 1.5 ounces of Oust XP™ per treated acre in soils with pH less than or equal to 7 typically provides good weed control with minimum effects on planted hardwoods. Rates can be higher on more acidic clay soils with a target of 3 ounces per acre as a maximum, unless testing indicates higher rates are acceptable. Oust is primarily recommended for broadleaf weed control,

but does have some activity on selected grasses and other non-broadleaf weeds. Broom sedge is not affected by Oust, and heavy Oust treatments can result in broom sedge establishment. Oust should be applied directly after planting when planting slits have closed, but before bud break. Apply before or just as weeds are emerging. If Oust is applied after bud break, a directed spray should be used to avoid application to hardwood buds or foliage.

Goal (Goal 2XL™, oxyfluorfen 22.3 percent). Goal provides pre- and post-emergent control of broadleaf weeds. Both applications should be conducted when seedlings are dormant, either directly after planting or before bud break in subsequent years. If post-emergent over-the-top application is used, some growth reduction and leaf spotting to hardwood seedlings may occur. As a post-emergent, over-the-top treatment, Goal should only be applied after leaves have fully expanded. Some oaks, cottonwood and sycamore are listed as showing tolerance. Applications to all hardwood species should be tested. Some states have supplemental labeling for use in deciduous tree plantings.

Pre- and Post-emergent Broadleaf and Non-native Grass

Plateau (Plateau™, imazapic, 26 percent). The herbicide provides pre-emergent and post-emergent control of annual and perennial broadleaf and non-native grasses. Plateau™ is designed and used for controlling broadleaf weeds and cool-season grasses, particularly fescue, for the establishment of native warm-season grasses and prairies. It does have post-emergent activity on young hardwood seedlings and should not be used directly prior to or during the first several years after hardwood establishment. Tolerance information is provided for hardwood species based on a 2-inch diameter. If Plateau™ is used prior to hardwood planting, wait at least one year before planting seedlings. In established plantings, Plateau™ is labeled for use up to 12 ounces per treated acre. Specific application information is contained on the general label.

Post-emergent, Broad-spectrum Control

Roundup - Glyphosate (Roundup Original Max™ glyphosate 48.7 percent). Currently the Roundup Original Max™ label and a supplemental label "For Forestry Site Preparation and Utility Sites" allow for this brand name to be used to establish and maintain hardwood tree plantings. Due to the large

number of glyphosate products on the market and the dynamic nature of label changes, check labels for permitted uses on a regular basis. Glyphosate can be used for the post-emergent control of grass and broadleaf weeds prior to planting and directed application to control weeds after planting. Normally, foliar applications are effective when weed foliage is exposed and plants are actively growing. For warm-season weeds, application can occur from full leaf-out until early fall at recommended rates, with a maximum of 4 to 7 percent solution for directed sprays (assuming at least 50 percent coverage) to as little as 1 to 2 percent spraying until foliage is wet. For cool-season plants, spraying can occur to foliage when the weather is warm enough to encourage active growth. While early fall is one of the best times to apply glyphosate for control of many weed species, operational trials have shown hardwood seedling sensitivity to fall applications. Avoid fall spraying in established young hardwood plantations unless avoidance of planted hardwoods can be ensured. Spraying of actively growing, cool-season grasses can be accomplished in late winter or early spring prior to hardwood bud break.

Post-emergent Broadleaf Weed Control

Transline (Transline™, clopyralid 40.9 percent). Transline™ provides post-emergent control of competitive, broadleaf weeds that are particularly hard to kill, such as thistle, ragweed, mare's tail and black locust. The herbicide is used primarily as a rescue treatment in hardwood plantings that contain significant broadleaf weed problems. Some short-term effects and growth losses can be expected to hardwood seedlings, depending on the rate and the hardwood species favored. Consult the label for hardwood tree tolerance. Generally, higher rates can be used with oak and walnut. Yellow-poplar is more sensitive. Lower rates should be used and the spray directed to minimize impact with species not listed as tolerant. Applied rates from the label are .5 to 1.3 pints per treated acre. Use lower rates when weeds are emerging and higher rates when weeds are established.

Post-emergent Grass Control

Select (Select 2EC™, clethodim, 26.4 percent). Select provides post-emergent control of grasses in non-crop, non-producing and fallow land. Apply when grasses are actively growing. Rates up to 16 ounces per acre can be used on fallow land and lower rates at 8 ounces per acre can be used to control

grass, with a directed spray for non-bearing hardwood trees (hardwood plantation).

Poast (Poast™, sethoxydim 18.0 percent). The herbicide provides post-emergent control of grasses in CRP (Conservation Reserve Program) plantings, non-crop deciduous trees, nonfood crop areas and fallow land including uncultivated agriculture areas and general outdoor sites. Poast™ is not specifically labeled for use in hardwood tree plantings. Test the herbicide on hardwood species to determine sensitivity.

Herbicide Application – Overtop and Directed Application

Herbicides can be applied by spraying directly over the top of planted hardwood seedlings (overtop spray) or by directing the spray to specific areas of the soil or weeds while avoiding planted trees and/or tree planting slits (directed spray).

Overtop Application

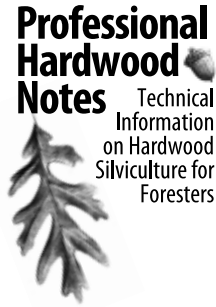
In tree plantings, herbicides can be sprayed directly over the top of seedlings when the herbicide has little or no effect on trees. The most common example is when a grass herbicide is sprayed directly over the top of seedlings to control grasses around them or when a pre-emergent herbicide (having no post-emergent activity) is applied to the soil around planted trees (see the herbicide label for specific timing and use guidelines). In a rescue treatment, a broad-spectrum, post-emergent herbicide can be sprayed over the top of tree seedlings IF competing vegetation has totally and thoroughly covered the leaves of the seedlings. In this application, care must be taken to minimize penetration of the herbicide to the tree foliage. Penetration is minimized (not eliminated) by carefully controlling application rates, using low pressures and relatively large droplet sizes. Droplet size is governed by nozzle pressures and nozzle type. Handheld (backpack or ATV sprayers) can be used to administer treatments to small areas.

Directed Application

Directed sprays are used with the application of a broad-spectrum, post-emergent herbicide when tree seedlings are in close proximity to target weeds or where there is a possibility of pre-emergent herbicide movement in planting slits. The spray must be directed onto the foliage of the weed species while minimizing the amount of herbicide contacting the trees or the soil to avoid the planting slit. Directed

spraying can be accomplished using handheld sprayers or by the use of a carefully adjusted boom sprayer. Boom spraying using a tractor or ATV can apply herbicides under tree foliage by dropping nozzles close to the ground (either by lowering the boom or using nozzle drops) and using off-center (OC) or underbanding (UB) nozzles. The pattern of these nozzles directs spray under relatively low-hanging tree foliage. Boom spraying can also be used to apply herbicides to the side of planting rows in rescue treatments when the competing weeds fully cover the seedlings and mowing has provided access in the rows. Directed spraying can also be administered by hand. Spray wands or handguns are used in conjunction with backpack or ATV sprayers. These types of application allow the spraying of only one or two rows at a time. Carefully control application rates, minimize pressures and maximize drop size to limit side penetration.





Professional Forestry Note
Cooperative Extension Service Publication Series
http://www.sref.info/publications/online_pubs

Sponsored by

University of Tennessee
University of Kentucky
Southern Forestry Extension
Tennessee Department of Agriculture, Division of Forestry
USDA Forest Service Stewardship Funds

A Regional Peer-Reviewed Technology Extension Publication

Published as University of Kentucky's Cooperative Extension publication FOR-107

Published as Southern Regional Extension Forestry publication SREF-FM-014

Partial funding of this publication provided by Tennessee Department of Agriculture, Division of Forestry

09-0192

R12-4910-079-019-09

PB1783-9M-06/09

Programs in agriculture and natural resources, 4-H youth development, family and consumer sciences, and resource development.
University of Tennessee Institute of Agriculture, U.S. Department of Agriculture and county governments cooperating.
UT Extension provides equal opportunities in programs and employment.