5 Regenerating Hardwoods In Mississippi

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Introduction

The southern hardwood forest has long been managed for a variety of products, ranging from chips for pulp and paper to veneer for high-quality furniture.

Hardwoods are now being used in new technologies, such as bio-energy, phytoremediation (removal of heavy metals and other toxins from the soil), and carbon credits (the selling of carbon stored in the soil and vegetation to offset additions of carbon entering the atmosphere).

Several governmental programs, such as the Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), and the Wetlands Reserve Program (WRP) have also promoted or assisted in the planting of hardwoods throughout the South.

Much of Mississippi's forestland was once owned by large industrial organizations. Today, new landowners are more interested in using their land in a combination of ways, such as recreation, wildlife, and aesthetics. These changes could quite possibly result in reduced harvests and longer rotations where hardwoods are allowed to grow to higher valued products.

It is important to understand that hardwoods, unlike conifers, are very "site demanding." This means that a greater understanding is needed of soil and site conditions before a landowner makes a decision on regeneration. Relatively few commercially valuable hardwood species grow well on very wet or very dry sites. Willows, water tupelo, and cypress are found on sites that are inundated by water most of the year, if not year round. On the other hand, there are extremely droughty upland sites that support blackjack and post oak. In both cases, these two extreme types of sites are difficult to regenerate to highly desirable hardwood species. As a result, the economic returns from these sites will be minimal.

A number of sites between these two extremes, however, will support good hardwood growth of commercially valuable species. A complete understanding of the soil and site condition of these types of sites will allow you to pick the best species to manage on that site. Unlike today's pine in

the southeastern United States, the great majority of hardwood stands are naturally regenerated. The reason for this is that pine, especially loblolly pine, will grow well on a large number of sites and soils throughout the southeast. In addition, the market for pine is much better because pine can be used for chips, structural lumber, veneer, plywood, oriented strand board (OSB), and poles.

A great deal of research has been done on the cost of establishing and growing pine. This research has resulted in an artificial regeneration system that is much more financially viable than similar regeneration systems for hardwoods. This pine system has been aided by research in genetics, silviculture, competition control, physiology, harvesting, and biometrics.

On the other hand, hardwoods have not been researched as much; therefore, natural regeneration of desirable hardwoods is much more cost effective than artificial regeneration. This is the main reason that natural regeneration is a viable option for a hardwood regeneration system. In most cases, this type of system is more difficult and must be approached in a different manner than that of an artificial regeneration system.

Site Selection

Since hardwoods are more site-sensitive than pine, it is critical to match the species to the site. A rule-of-thumb that has been used for a long time was to examine the species make-up of the existing stand and to use that as a guide to determine which species might perform best. However, a great majority of hardwood stands have been high graded. High-graded stands have had all the best stems removed consistently over time, leaving low quality and undesirable stems behind.

A better method would be to use the Baker-Broadfoot Method developed by the USFS Southern Hardwood Laboratory at Stoneville, Mississippi, in 1977. This method can be found in a publication titled "A Practical Field Method of Site Evaluation for Commercially Important Southern Hardwoods," and is available from the U.S. Forest Service, Southern Forest Experiment Station. This method uses the physical condition of the soil, moisture availability during the growing season, nutrient availability, and soil aeration. If followed correctly, this method will provide information on 14 hardwood species, of which 5 are oak species.

To evaluate a site fully for hardwood potential, you must have an understanding of a wide variety of hardwood species, their flood and shade tolerances, their growth habits, ideal soil conditions, and the topographical positions where these species are frequently found. An optimal hardwood site will have deep silty-loam to sandy-loam soil that is fertile with good moisture availability, good soil aeration, neutral to slightly acidic pH, and free of soil pans or other barriers that would restrict root growth. This type of site would produce excellent growth of a variety of hardwood species. However, in most situations, you will not find this type of site but rather sites similar to those shown in Table 1.

County soil surveys will also provide you with valuable information that can be used in the proper site selection. These publications are available from your county Natural Resources Conservation Service (NRCS) office. The key is to examine the site closely by using a soil borer or auger. You should also evaluate the site under various environmental conditions, such as after heavy rains or during different seasons of the year. The importance of selecting or matching the correct hardwood species to a specific site cannot be overstated.

Natural Regeneration

Natural regeneration of desirable hardwood species is not fast, not simple, and is usually one of the greater challenges in hardwood management. It is important to remember that hardwood species can (and will) regenerate naturally. For that reason, many landowners have done little or no actual management. The basic assumption was that "hardwoods had been there before, and they will be there again." That assumption is true, but the regeneration that came back naturally was typically from undesirable species. This partially explains why the high-grading mentioned earlier has resulted in millions of acres of hardwood forests that are covered with hardwoods that are not valuable commercially.

To be successful, the land manager must identify the desirable species best suited for the site and then try to create the conditions that will encourage the establishment and growth of seedlings of those species. To be sure of success with most desirable species, this must be done before the existing stand is removed. Seedlings that are at least 2 feet tall are called advanced regeneration. Advanced regeneration is necessary for successful natural regeneration for most of the desirable hardwood species….especially oaks.

Table 1. Physiographic site position, site characteristics, soil characteristics and possible species commonly found on bottomland and upland sites in Mississippi.

Floodplain			
Front	Good surface and internal drainage	Loam to sandy loam soils - pH will limit species	Cottonwood, sycamore, sweet gum, pecan, water oak, and green ash
Ridge	Moderate surface and internal drainage	Not as fertile as fronts because of age	Sweet gum, willow oak, water oak, green ash, pin oak, and cherrybark oak
Flats	Poor internal and surface drainage	Higher clay content	Nuttall and overcup oak, green ash, sugarberry, water hickory, and persimmon
Slough	Poor drainage, easily inundated	High clay content	Black willow, overcup oak, and water hickory
Stream Terrace	Very good hardwood site but generally very narrow	Good nutrient and moisture availability	Yellow poplar, northern and southern red oaks, black cherry, sweet pecan, black walnut
Upland (Generalized)			
North Slopes	Good site for hardwoods, with slower organic matter decomposition allowing for deeper soil surface layers	High amount of organic matter, better moisture availability	Northern red oak, southern red oak, yellow poplar, black cherry
South Slopes	Droughty site, pan may greatly affect growth, usually poor hardwood site, chert or gravel may be near the surface	Little organic matter, poor moisture availability	White oak, post oak, hickory
Broad Ridges	Usually better than South-facing slopes but depth to pan may determine hardwood potential	Fertility and moisture availability determined by the depth of loess over parent material	Southern red oak, hickory, sweetgum, blackgum, white oak
Coves	Grows some of the best hardwoods, usually deep soils	Excellent moisture availability, fertility above average	Yellow poplar, sugar maple, American beech, white oak, northern red oak, and black cherry
Terrace	Characterized as old floodplains of ancient or current streams, may have fragipans that restrict growth	Fertility varies but lower than floodplain soils as well as typically lower moisture availability	Sweet gum, cherrybark oak, Shumard oak, sweet pecan, black walnut, southern red oak, water oak, and willow oak

Factors To Consider

When naturally regenerating your hardwood forest, the primary factors to consider are species availability (seed sources), seed crop, soil nutrients, available moisture, and light. Soil nutrients and moisture are rarely a problem on good hardwood sites in Mississippi. However, the other factors should be examined.

Seed Source: For best results, the desirable species not only have to be present, but also need to be well distributed across the site. A few desirable species, such as yellow poplar, green ash, and cottonwood are all light-seeded species. Their seeds can be carried a long distance by wind. However, most desirable species, such as the oaks, have heavy seeds that will not travel far from the parent tree. If a species could grow well on a site but is not present, you will have to use artificial regeneration if you want to grow that species.

Seed Crop: All desirable species do not produce a "bumper crop" of seeds every year. For that reason, it is necessary to monitor the seed crop and time the natural regeneration activities in conjunction with a good seed crop. Keep these points in mind:

- Light-seeded species have good seed crops more consistently than heavy-seeded species.
- White oak acorns form and mature in one year.
- Red oak acorns require 2 years to form and mature.

Generally, this means you can depend on the light-seeded species most years. You have to check the white oaks every year, and you can plan a year ahead with red oak species.

Light: Light is the key in regenerating most desirable hardwood species. Generally, these desired species (such as oaks) do not grow well in the shade. However, full sunlight is not necessary. Most oaks actually grow better in partial (33-50%) sunlight as seedlings. However, once established, they generally grow better in full sunlight. It is important for you as a landowner to know the seedling light requirements of the various species.

Regeneration from Sprouts: The previous discussion has focused on seeds and seedlings. This section focuses on sprouts from roots or stumps. We know that hardwoods can and will sprout. The problem is that most of the sprouting that follows harvesting in mature hardwood stands is not desirable. Some species seem to sprout regardless of size or age. A good example of this is the sweetgum tree. Unfortunately, most of the desirable hardwood species do not produce viable sprouts as they age and become larger. If they did, all we would ever have to do is cut large trees, and they would be replaced by one or more sprouts. If sprouts from desirable hardwood species appear following a harvest, they are a welcome addition to the new stand.

Depending on the species, natural regeneration includes the following steps:

- Stand Assessment
- Pre-Harvest Preparation
- Partial Over-Story Removal
- Final Over-Story Removal

Stand Assessment: This procedure is used to determine the presence and distribution of desirable species on the site. It is the essential first step before making decisions about any pre-harvest work and the timing of any operations. If you don't have the sufficient numbers of desirable species on the site, the site will likely need to be artificially regenerated.

Pre-Harvest Preparation: If the stand assessment reveals an abundance of advanced regeneration of desirable species, no pre-harvest preparation may be necessary. Unfortunately, desirable advanced regeneration is rarely present. In addition, mature hardwood stands are usually occupied by stems of undesirable species. These trees may range in height from 8 - 50 feet and in diameter from one-inch or more. They are very effective at intercepting any sunlight that makes its way through the canopy before it reaches the forest floor. This is the reason you may find many small oak seedlings (less than 6 inches tall) from time to time in a hardwood stand, but very few of these seedlings will have enough sunlight to grow to be advanced regeneration or saplings. This is a good example of a situation where the desirable species are present, a good seed crop occurred, moisture and nutrients were adequate, but light was the limiting factor.

If the understory or midstory contains these undesirable stems, they must be controlled before harvest. Again, it is best to do this when a good seed crop is expected so the desirable seeds can take advantage of the conditions. The best way to control the undesirable understory/midstory is to inject the trees with an herbicide solution. The injected trees will die, which will allow light to reach the forest floor and will also decrease the demand for water and nutrients, which the desired seedlings can use.

Injection is best for many reasons: it is selective, meaning that you can leave desirable stems; it costs less than most mechanical options; it controls sprouting, which often happens following mechanical work or fire; it will not damage the desirable trees when done properly; it requires no specialized equipment, can be done by anyone; and it is very effective. If there are stems in the overstory that have no commercial or wildlife value, they should also be injected. A number of chemicals can be used for stem injection. For more information, please refer to Mississippi State University Extension Service Publication 343, *Mississippi Weed Control Guidelines*.

Partial Overstory Removal: The harvesting of overstory trees should be tailored to the species being regenerated. If the desired species are all light-seeded and very intolerant of shade (yellow poplar, sweet gum, cottonwood), you should remove most of the overstory. Seed will disseminate by wind across the area, and the resulting seedlings need all the sunlight they can get.

However, if oaks are preferred, the seedlings will do best in 30-50 percent full sunlight. It is possible that the preharvest injection will allow enough light to reach the forest floor if wind, disease, or past harvests have left sufficient gaps in the overstory canopy. However, if these gaps are not present, or are not sufficient, you should harvest a portion of the overstory. Research demonstrates that harvests that leave 50 square feet of basal area per acre evenly distributed across the site provide optimum conditions for oak regeneration. Basal area is the surface area of a tree measured at 4.5 feet above the ground (diameter at breast height or DBH). The surface area of the tree at DBH is projected onto the ground. This projected area is the basal area for that tree. With enough measurements, basal area can be accurately estimated on a per acre basis.

A professional consulting forester can assist with marking trees that should either be removed or left to achieve the desired species mix and density. A partial removal is also an opportunity to remove any undesirable stems from the overstory. You should time the partial removal to coincide with a good seed crop to ensure that the seeds can germinate and become established while conditions are best. This illustrates how the process can be challenging. Once the decision to regenerate the stand is made and the assessment completed, the timing of operations becomes critical. Seed crops must be monitored and the injection and/or partial removal must be completed in a timely manner for best results.

Final Overstory Removal: It normally takes a few years for desirable regeneration to be classified as "advanced" or "established." For the rapidly growing species such as cottonwood or yellow poplar, this could be only 1 or 2 years. Most oaks and other desirable hardwoods may require 3-5 years. Of course, freezing temperatures, flooding, or other unforeseen events can damage or destroy the seed crop or the smaller seedlings. If this happens, the residual overstory offers an opportunity to capture the conditions created if it is not too long before another good seed crop.

When the desired regeneration is established, the overstory can be removed in one or more harvests, depending on the landowner's objectives. Some owners dislike the appearance of a total clearcut and may prefer to retain scattered overstory trees across the site. Retaining overstory trees indefinitely is acceptable, but the owner must recognize that the residual overstory trees will interfere with the development of the new stand. In addition, these residual trees are often more valuable because of their size and species. These "leave" trees will continue to grow, of course, but they are more susceptible to damaging agents, such as insects, wind, and disease. Leaving the trees behind can result in lost monetary value to the landowner. Overstory removal will damage some of the regeneration present, but unless the root system is pulled out of the ground, the seedlings should recover.

Enhancement Plantings

In some cases, the landowner may want to use natural regeneration, but if the desirable species is not plentiful enough in the overstory to serve as a seed source, or a more diverse species mixture is desired, then enhancement plantings are needed.

In most cases, seedlings being used for enhancement plantings should be larger and possess large root systems. These seedlings will have to be planted with a shovel. Transplanting 100 to 200 trees per acre of this type and quality of seedling will add the needed aspect to your stand. However, care and planting of these types of seedlings are just as important as with any planting operation.

Artificial Hardwood Regeneration

Seedling Quality

A number of variables are important in the production of a quality hardwood seedling. Among these variables are the genetic quality of the seed, nursery and soil characteristics, nursery fertilization and water regimes, seed-

bed density, weed control, shoot and root modification, and insect and disease control. If these variables are correctly addressed, the resulting seedlings will be well suited for survival and growth, even under unfavorable field conditions.

An ideal bare-root hardwood seedling has the following characteristics:

- Between ⅜-inch and ½-inch root collar diameter
- 5 to 8 major lateral roots
- Tap root of about 8 inches
- Shoot with numerous branches

These key characteristics provide the seedling with the best chances of survival and growth, even under stressful establishment conditions. Unfortunately, this ideal hardwood seedling is rarely found in many commercial nurseries. As a landowner, resource manager, or forester, you should recognize this problem and take the appropriate steps to get high-quality hardwood seedlings.

The first step to take is to locate a nursery that has a history of producing quality hardwood seedlings. Talk with others who have purchased seedlings from that specific nursery. If possible, visit the nursery during the growing season and determine the seed-bed density and weed control. Inquire about the geographic and genetic origin of the seed before you purchase it. Never move seedlings of northern geographic sources to southern planting sites. The seedlings need to be graded to ensure that they have the desired characteristics. Grading is the process of sorting the seedlings, removing those that are too small, poorly formed, too small of a root system, etc. This grading should be done before planting, thus eliminating sub-par seedlings and resulting in a higher probability of survival and increased growth rates.

Do not allow root systems to dry during any grading process. It is best to grade the seedlings in a closed building where water is accessible so that the roots can be periodically moistened during the grading process and before bagging. Close planting bags as tightly as possible without injuring the shoots of the seedlings, and then place them in a cooler at 35 °F until planting. Hardwood seedlings can be held for several months in cold storage, but you should periodically inspect the bags and root systems to ensure that no problems have arisen. It is best, however, to plant the seedlings as soon as possible following delivery.

Eastern Cottonwood or Hybrid Poplars. If eastern cottonwood or hybrid poplars are being used, much of the previously stated information is applicable. However, the planting stock with these species will most likely be unrooted cuttings. The size of the cutting will vary. Cottonwood is usually longer in diameter and length as compared to hybrid poplars. A typical cottonwood cutting will be between 14 and 24 inches long with a diameter ranging from ½-inch to 1-inch. In comparison, hybrid poplar cuttings will be about 9 to 12 inches in length with diameters ranging between ⅜-inch to ½-inch.

Cuttings should also be graded before planting so that damaged and poorly formed cuttings are eliminated. Once grading is completed, the cuttings are soaked from 12 to 24 hours to ensure that the maximum moisture levels of the cuttings are attained before storage. They can then be bagged and stored in various ways, but optimally, the cuttings should be placed in thick plastic bags and stored at 28 °F until they are planted.

Below-freezing storage allows much longer storage duration and improves survival. If the cuttings are stored under more typical conditions (such as 35 °F) storage time should not exceed 4 months.

Genetic Quality

Outside of eastern cottonwood, there are few truly genetically superior hardwood seedlings or cuttings currently being produced. Generally, hardwood seed are collected from a variety of geographic areas by various means, including trees from urban areas. Throughout the South, state and private nurseries are growing millions of hardwood seedlings annually, with the vast majority of these seedlings having no genetic superiority and in many cases little or no information of origin. Therefore, the majority of hardwood seedlings are unimproved. While the governmental programs (CRP, CREP, and WRP) previously mentioned have accounted for a great majority of hardwood planting, these programs have focused on water quality, soil erosion, and wildlife habitat, and they have had few instructions on seedling quality.

Information suggests that the use of seed from sources north of the planting site not only results in less growth but could even lead to disease problems and mortality as the stand matures. Hardwood species such as cottonwood and sycamore are exceptionally vulnerable to diseases from northern sources. Therefore, it is always best when purchasing hardwood seedlings to make sure the seedlings are at least from a southern seed source.

As genetic improvement programs for hardwoods progress, improved seedlings may be available in the future. Be sure to ask the nursery if they have any genetically improved seedlings available.

Site Preparation

Hardwood plantations have historically focused primarily on rapidly growing species such as eastern cottonwood, American sycamore, sweet gum, and green ash. Because these species have high demands for light, water, and nutrients, most plantations were established on fertile floodplain or bottomland soils. Successful plantations combine excellent site preparation with intensive herbaceous competition control on the proper sites during the early stages of establishment. Without proper site preparation, intensive mechanical competition control will be greatly hindered, if not impossible. Unlike pine, very few chemicals can be used over-the-top of hardwoods during the growing season. An important point to remember is that there are a number of ways to ensure an excellent stand of hardwoods through artificial regeneration. The amount of money spent can vary greatly and will depend on the amount of mechanical and cultural treatments involved. Growth and survival of rapid-growth hardwoods, such as cottonwood, sycamore, and sweet gum, will improve greatly from intensive mechanical and chemical treatments. However, in most cases these treatments are too costly for private landowners. Other hardwoods, such as oaks, do not demand the extreme measures used for fast-growth hardwoods, and these treatments can be modified, which will reduce costs while producing a quality hardwood stand.

Landowners must carefully consider the cost of site preparation for hardwood plantations. The primary reason is the length of time required for hardwood management. Rotations of 50-60 years (and compound interest) force landowners to be cautious with site-preparation and planting expenses if the operation is to be cost effective.

Most of the land currently being planted is in retired agricultural fields. A relatively small number of natural hardwood stands are being replanted since most of these stands are naturally regenerated. Site-preparation methods that are cost effective for each type of site are discussed in the following sections.

Agricultural Field Sites – You should subsoil all old fields. Decades of mechanical and/or animal traffic result in a restrictive layer in the soil that will reduce planting quality and seedling growth. In most cases, the vast majority of the vegetation on the site will be herbaceous species (grasses or broadleaf weeds). These do not require any chemical site preparation. However, extensive coverage by aggressive vines, such as pepper vines, trumpet creeper, or red vine, will require treatment before planting. The appropriate herbicide treatment will vary with the vines involved. Extensive coverage by aggressive and invasive woody species such as tallow tree will also require chemical site preparation.

Subsoil treatments should be done on either 10-foot or 12-foot centers (based on the desired number of seedlings per acre). The site should be dry and should be timed well in advance of planting so that rain will settle the soil in the trench. September or October before planting is usually the best time. The subsoil trenches will improve planting quality and promote seedling growth and establishment. In summary, subsoil every field. Do not disk or bed because these treatments will not provide any marked control of competing vegetative weeds.

In most cases, the vast majority of the vegetation on the site will be herbaceous species (grasses or broadleaf weeds). These typically require some chemical site preparation to ensure survival of your planted hardwoods. The appropriate herbicide treatment will vary with the herbaceous species, present and the hardwood species being planted. Be sure to apply the appropriate herbicides at the right time for your site conditions.

Natural Stand Sites – Use natural regeneration in these areas if at all possible because site preparation and planting are expensive. If desirable species are not present, many stands should be converted to pine stands. You can under-plant desired species, but the same conditions are required that must be met for natural regeneration (available light, right species on the right site, control of competing herbaceous and tree species).

Establishment

Once you have chosen the site and have matched the correct species to the site, have acquired high-quality seedlings, and have prepared the site to an optimal level during the correct time, the next step of establishment seems to be the simplest. However, when dealing with hardwoods, any of the steps, including the handling and planting of seedlings, are critical to making your hardwood planting efforts a success.

Store the seedlings properly to ensure that they will be in good condition at the time of transplant. Once the seedlings are removed from the cooler, transport them to

the site in a covered vehicle. At the site, keep the seedlings out of the sun and the wind. Once a bag has been opened, the seedling should be planted as quickly as possible. Keep all the seedlings in their planting bags until they are ready to be placed in the ground. Do not prune the root systems. Plant the seedlings well below the root collar. Seal the transplant hole as tightly as possible to promote survival and early growth.

Later in the planting season, it is best, if possible, to machine plant. This will eliminate air pockets and will provide increased contact between the seedlings' roots and the soil, even when the soil is dry. When planting late in the planting season, consider weather conditions, and plant just before rains.

Competition control is important for both natural and artificial regeneration efforts. Control of the midstory and understory is a critical component for all regeneration efforts. In artificial regeneration, chemical site preparation may be required, but it should be used only when asolutely necessary. Another important aspect of competition control is herbaceous weed control in planting areas of old fields. While chemical site preparation in old fields may or may not be necessary, herbaceous weed control (HWC) during the first growing season after planting is critical. It is absolutely essential for cottonwood or sycamore plantings. In years of average rainfall, survival of oak seedlings will be increased by 20 percent. During dry years, survival will increase by 40 percent. Mowing and disking between rows will help keep vegetation down, but it should be done several times during the year, making it very costly. Best control will be achieved if herbicides are applied over the top of the seedlings before bud break and before the weeds break dormancy (pre-emergent). The herbicides used depend on the hardwood species as well as the weed species present.

Direct Seeding

Another method of regenerating hardwood stands, especially the heavier seeded species such as oaks, is to collect the seed and sow them directly. Collect the seed fresh, soak them in water for about 2 hours, float the seed to determine if they are viable, and store them at 35 °F in a sealed plastic bag until they are planted. Plant the seed at a depth of about 2 inches. Plant a large number of seed (700 to 1,000/acre) to ensure a good survival rate. This method has been used primarily on agricultural fields where the primary competition is grass. More information on collecting acorns for regeneration can be found in MSU Extension Service Publication 2421.

High-Graded Stands

High-graded hardwood stands have resulted from an absence of markets for poor quality hardwoods and from decades of removing the biggest and best trees, leaving the rest behind. Viable pulpwood and other markets for small, otherwise commercially undesirable species help to relieve this problem.

Site quality is critical to the possible improvement of degraded stands. Where site quality is poor and not capable of supporting growth of valuable hardwood species, it is best to harvest and plant pines or to accept a pine-hardwood mixed stand. However, if site quality is good but the stand is in a degraded state, you can make treatments to improve the quality of the stand, thus reflecting the potential of the site. You have four options in deciding what to do with degraded hardwood stands:

- Naturally regenerate the stand if there are sufficient high quality desirable trees to serve as the seed trees.
- Artificially regenerate the stand.
- Rehabilitate the stand.
- Leave the stand alone.

There is a simple evaluation of six criteria that will help you decide what should be done. These criteria are stand age, site quality, manageability of trees, number of cull trees, number of desired trees, and advanced regeneration.

Manageability of trees refers to the species, stem form, and the ability of the tree to respond to silvicultural treatments. The target is 30 to 50 square feet of basal area per acre or about 40 to 50 small saw-log sized trees per acre. The silvicultural treatments that will help rehabilitate degraded stands include the following:

- site-preparation techniques of clearcuts
- deferment cuts to favor regeneration of desired species
- control of undesirable species in the mid- and understory
- crop-tree release of the acceptable growing stock
- adjustment of harvest openings to take advantage of regeneration and site quality.

If regeneration is the decided course, the regeneration methods already discussed can be used, along with the appropriate site-preparation and vegetation-control

activities. The use of chemicals to control more shade-tolerant species will be necessary so that the more desired species will have sufficient growing space.

Conclusion

Hardwoods can be regenerated naturally or through the use of seed, seedlings, and cuttings. Natural regeneration is the most economical, and in many cases, the best way to provide sustainable hardwood stands. However, there are times when plantations can be used effectively.

Natural regeneration is effective when adequate advanced regeneration of the desirable species is present at the rates needed to regenerate the site. Artificial regeneration can also be very effective, but there are a number of factors that must be met. These include proper site selection, matching the species to the site, site preparation, and seedling quality. Although these previously stated factors are critical, other factors such as proper handling and planting of seedlings, as well as competition control are also critical to the success of a hardwood plantation.

Other options for establishing hardwood stands are direct seeding and enhancement planting. Direct seeding of a variety of oaks has been successful on a number of sites, especially agricultural fields that have been placed in one of the governmental conservation programs. Many of these direct seeding efforts, however, have failed. Enhancement plantings can also be used on these conservation programs, especially on the Wetlands Reserve Program or Wildlife Habitat Improvement Program land where wildlife is critical to the success of the planting.

Enhancement plantings can also be used in natural systems where the desired species is absent, increased genetic quality is wanted, or a greater diversity of species is needed. Typically, planting seedlings is more dependable than direct seeding and is used more extensively across Mississippi.

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