RESTORING LONGLEAF PINE FORESTS IN SOUTH CAROLINA

A Guide for Landowners

Photo by Randy Tate

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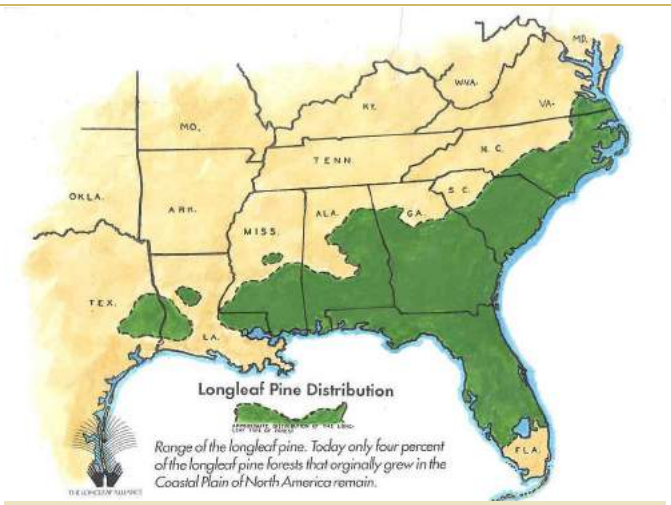
Robert M. Franklin
SoLoACE Longleaf Partnership

VALUE & HISTORY



Range of longleaf pine

Old growth longleaf pine

Longleaf Pine (*Pinus palustris*) once dominated landscapes across South Carolina and the Southern US. Ranging inland from the coast as much as 200 miles, you could find longleaf from southeastern Virginia down to south Florida and westward into east Texas. While primarily a Coastal Plain species, longleaf pine ranged up into the lower Piedmont in Alabama, the Carolinas & Georgia and into the mountains in northeast Alabama and northwest Georgia.

Early explorers marveled at the open, park-like nature of longleaf forests. William Bartram, the naturalist who traveled through the south in the 1770s, described one extensive stretch of longleaf woodlands as, "A level, open, airy pine forest, the stately trees scatteringly planted by nature, arising straight and erect from the green carpet, embellished with various grasses and flowering plants."

The park-like characteristic of many longleaf forests, which were more appropriately called woodlands, set them apart from the dense, closed canopy forests of New England or the Pacific Northwest. The dramatic difference was due to fire. The south is the lightning capital of North America. There are more thunderstorm days and lightning strikes than in any other part of North America. These lightning strikes caused wildfires. Over eons of time, longleaf pine and the grassy understory developed under a regime of periodic fire. It's estimated that fires naturally moved through longleaf forests every 2-6 years. Native Americans and early settlers also supplemented fire frequency through early fire management. Frequent fires eventually allowed less fire resistant hardwoods to survive only in the wetter areas that would burn less frequently, i.e. hardwood stream bottoms and swamps.

Blazing Star

Frequent fire, over long periods of time, crafted a rather unique ecosystem of plants and animals that required fire in order to complete their life cycle. For example:

Up to 50 plant species per square meter and 140 species per 1,000 square meters are found in healthy, fire-maintained longleaf forests. More than 300 plant species are native to longleaf pine ecosystems.

Gopher tortoise laying eggs.
Photo by Randy Tate

170 species of reptiles and amphibians are found in longleaf ecosystems. More bird species are found in longleaf ecosystems than adjacent hardwood forests; although greater total numbers of birds are found in hardwood forests.

36 mammal species are characteristic of longleaf forests and more than 2/3 forage primarily on the ground, as do about 1/3 of the birds.

At small scales, healthy longleaf forest diversity rivals that of tropical rainforests.

When Europeans first arrived in the southeast, longleaf occupied as much as 90 million acres of land, dominating on an estimated 60-74 million acres. At the time of the establishment of Charleston in 1670, it's estimated that longleaf pine forests occupied as much as 8.0 million acres of what became South Carolina. This was the largest area of forest in North America dominated by a single tree species. The settlement of the southland with the resultant land clearing for agriculture, development of towns and cities, turpentine operations and timber harvesting without thought of regenerating the forest lead to the longleaf ecosystem's decline. This decline started slowly with the settlement of the south and increased with the advent of steam driven, railroad logging during the late 1800s. By the mid-1980s, much of the longleaf range had been cut over and replanted with faster growing loblolly and slash pines which better suited the needs of the pulp and paper industry that developed in the region during the 1930s. By 1985, the acreage of longleaf pine had declined to less than 2.9 million acres range wide. South Carolina paralleled this decline, with acreage dropping to around 280,000 acres. Today, thanks to efforts of a large group of conservation interests, longleaf has increased to more than 4.4 million acres range wide and 480,000 acres in South Carolina.

Early logging with oxen.

AMERICA'S LONGLEAF

In 2007, a multi-agency/organization group developed a Range-Wide Conservation Plan for Longleaf Pine. This effort, spearheaded by the Longleaf Partnership Council is called America's Longleaf Restoration Initiative. The range-wide conservation plan has a goal of increasing longleaf pine forests to 8 million acres by 2024 and improving the condition of existing longleaf pine forests. The group is already seeing success, as the recent increase in acreage range wide is attributed to restoration efforts throughout the range, including the three project areas in South Carolina.

ECONOMICS (LONGLEAF VS. LOBLOLLY)

Longleaf pine fell out of favor with foresters and landowners because it had a reputation of being expensive, difficult to plant, and slow growing. Faster starting slash and loblolly pines were easier to plant, faster growing and better suited to the short rotations needed by the pulp and paper industry. Make no mistake, time IS money with forestry investments. The long time periods needed to recoup the investment, coupled with the upfront costs of site preparation and planting put slower growing longleaf pine at a disadvantage, compared with its faster growing cousins. However, advances in planting research have resulted in techniques that now achieve excellent survival and faster growth out of newly planted longleaf. As the tree's grass stage has been shortened, longleaf pine height growth is approaching that of other southern pines.

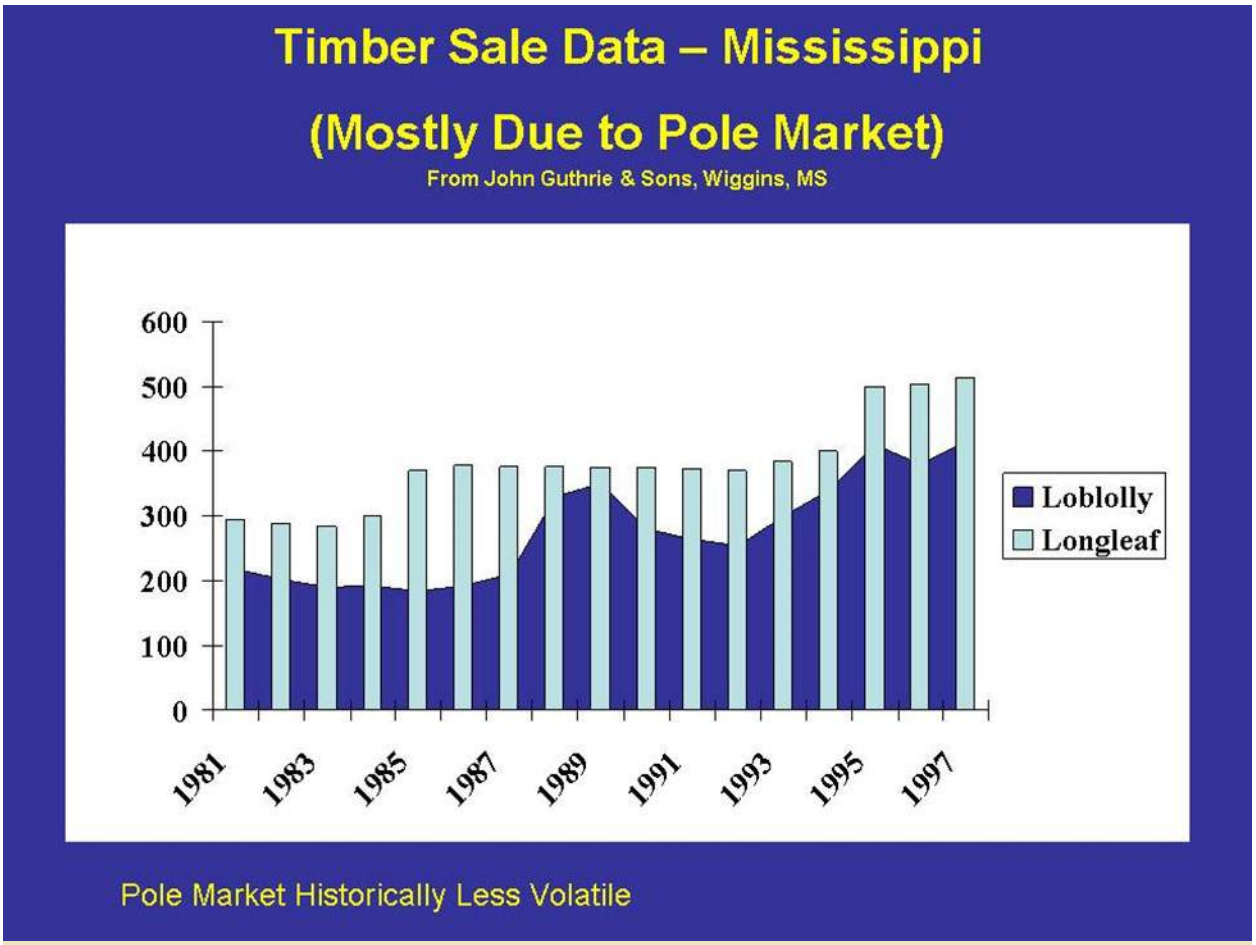
Another option to help recoup upfront costs is to participate in one of the cost-share programs for planting longleaf pine. There are several cost-share programs available from various federal, state, and conservation organizations. The advantage of these programs is that if you qualify, they can help reduce your upfront cost by reimbursing you for a portion of your site preparation, seedling purchase and planting costs. Check with the sponsoring agency/organization as qualification standards may vary.

Cost Share Opportunities

Program	Agency/Organization	Contact
CRP	USDA Farm Service Agency	Local County Office
EQIP	USDA Natural Resources Conservation Service	Local County Office
FRP & SPB	South Carolina Forestry Commission	Local County or Regional Office
Partners	USDI Fish & Wildlife Service	Joe_cockrell@fws.gov 843-300-0425
Sandhills	Sandhills Longleaf Pine Conservation Partnership	jlisenby@chesterfieldswcd.com 843-623-2187
SLCC	Sewee Longleaf Conservation Partnership	steveg@scwf.org 843-795-9005
SoLoACE	SoLoACE Longleaf Partnersship	bobby@longleafalliance.org 843-893-7775

The biggest advantage that longleaf has over other southern pines is the production of quality forest products, especially solid wood products. While longleaf will still take a little longer to reach pulpwood size than loblolly or slash pine, the sawtimber and pole stage is where longleaf will outshine other southern pines. Experience suggests that, depending on site quality, maximum production of utility poles occurs at stand ages between 40 and 60 years on most sites. Longleaf produces poles in greater numbers than other pine species. It is not unusual in longleaf sawtimber stands for half of all the stems to meet the exacting specifications for utility poles. In comparison, less than 15% of loblolly and slash pine trees would meet these specs.

Higher proportions of poles equals a great value paid to landowners at harvest time. Over the past 59 years, stumpage (value of the standing timber paid to landowners) paid for poles exceeds that of sawtimber by about 40%. In addition, pole prices are less volatile than other forest products such as pulpwood & lumber. This adds stability to the investment. The figure below shows a comparison of loblolly and longleaf timber sales over a 17 year period from timber sales in south Mississippi by John Guthrie & Sons forestry consulting firm. In good markets and bad, sales that were predominately longleaf fetched better prices than sales of loblolly, reflecting the value of poles and quality sawtimber that longleaf produces.



Timber Sale Data – Longleaf Pine vs. Loblolly Pine

Pine straw is another quality product that can be harvested from longleaf stands at an early age and help pay down the initial capital investment in site preparation and planting. Longleaf pine straw is the most highly desired of all pine straw for landscape mulching. Planted stands on old agricultural fields can often be raked as early as ages 8-10 with annual straw incomes of between $50--$300/acre up until the first thinning.

Longleaf pine straw bale. Photo by Carol Denhof.

Healthy, fire-maintained longleaf forests are desirable habitat for a host of upland and big game species; white-tailed deer, eastern wild turkey and bobwhite quail are the most popular. If a landowner is interested, there are many sportsmen who are willing to pay top dollar for recreational hunting leases in quality longleaf game habitat. Annual leases of $10-$20/acre are not unheard of for quality habitat in the Lowcountry.

Healthy fire-maintained longleaf pine forests are desirable habitat for a host of game species, including wild turkeys. Photo courtesy of Salem Saloom.

In addition, risk of catastrophic forest loss is significantly lower for longleaf. Longleaf pine is the most fire-resistant of all the Southern pines, is more resistant to wind storms and hurricanes, and is generally more resistant to disease and insect infestations.

RISKS

Longleaf pine is relatively insect and disease resistant. The southern pine beetle can attack healthy stands of longleaf if populations reach epidemic proportions, but as a rule, longleaf pine is more resistant to their attack than other pine species. As with the other southern pines, prevention is the best control method. Good timber management using periodic thinnings to remove weaker trees and give the remaining stems room to grow is the best way to reduce losses from this insect.

Pitch tubes are a sign of southern pine beetle infestation.

Ips engraver beetles can be a problem at times, but these insects typically attack trees under extreme stress such as trees hit by lightning. Black turpentine beetles also are attracted to stressed trees such as those damaged in logging or by a hot fire. Controlling logging damage is the best way to reduce problems with black turpentine beetles.

Brown-spot needle blight can be a problem with longleaf pine, but typically isn't where competition control is sufficient to allow seedlings to rapidly emerge from the grass stage. For seedlings slow to emerge from the grass stage, brown-spot can be very destructive. It appears to be more prevalent from south Georgia westward. This fungal disease attacks the needles of seedlings in the grass stage and will delay the initiation of height growth and may kill the infected seedlings.

In the western portion of longleaf's range, it is important to monitor plantings and natural regeneration for brown-spot needle blight. Before using prescribed fire, systematically survey the stand. If 20% or more of the cumulative needles on the best seedlings per acre are infected, a burn is needed. If the burn is delayed and 40% or more of the needle surface is infected, seedling mortality from the prescribed burn will often exceed survival.

Brownspot needle disease in longleaf pine seedling.

Pitch canker can be a problem in longleaf plantings on highly fertile sites.

Fusiform rust, annosus root rot, and pitch canker sometimes infect longleaf pine, but longleaf is still more resistant than the other southern pines.

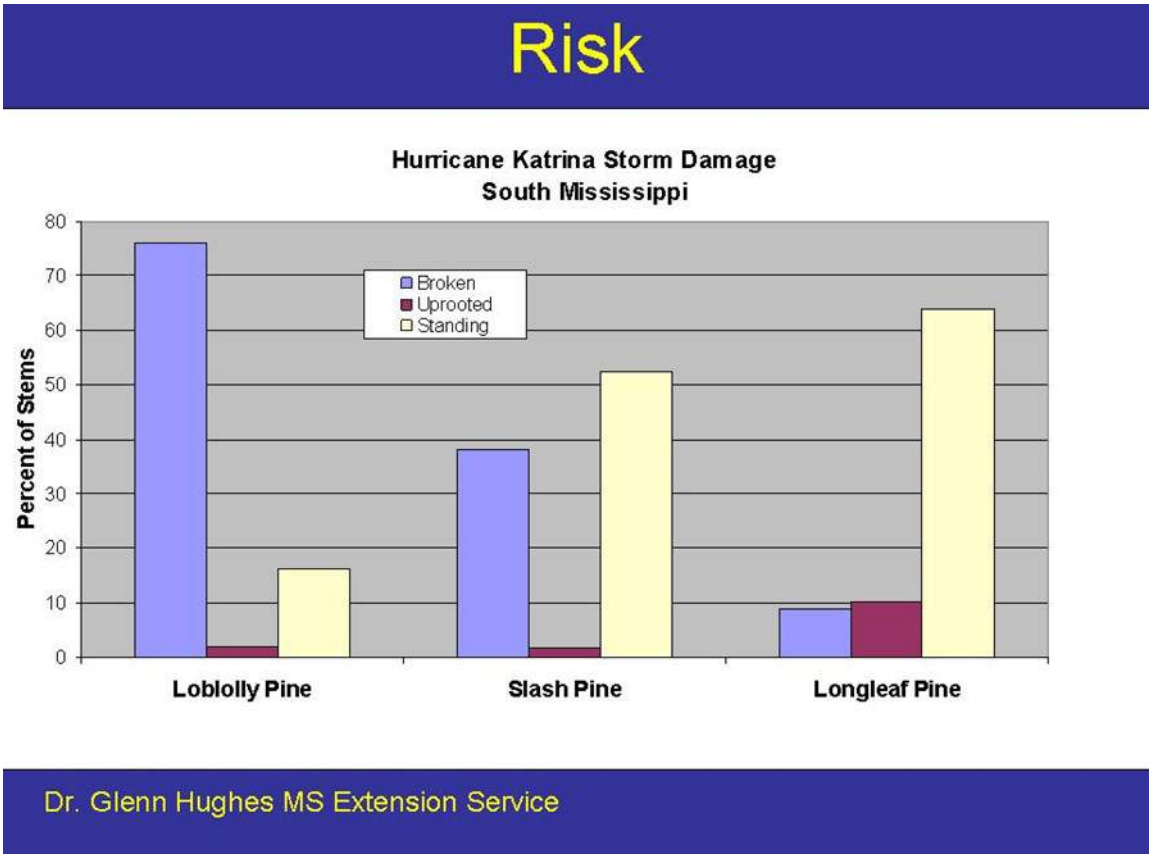
There is concern, however, that longleaf pine on high-fertility, old-field sites will have greater problems with insects and disease. Longleaf seedlings and trees are more susceptible to pitch canker on nutrient-rich sites, especially those adjacent to chicken houses, fertilized with chicken manure or with high rates of commercial fertilizer. Some minor insect species such as red-headed pine sawfly and pine colaspis beetles can cause damage and growth reduction to young longleaf, but seldom cause mortality or merit control measures. Both insects feed on needles and are attracted to the succulent, high-nutrient foliage of longleaf

grown under intensive management and high soil fertility.

Also important in the management of any pine species is the potential for damage as a result of wildfire and windstorm. Longleaf pine is the most fire-resistant of all the southern pines. The species developed over time in association with periodic, naturally-occurring, but mild surface fires. It is not, however "fire proof." From a risk management perspective, longleaf is a better choice for areas at increased risk for wildfire.

A prescribed burn in a sapling longleaf stand. Longleaf is the most fire tolerate of all the southern pines and can be burned as early as on year after planting.

Since most of the range of longleaf pine lies within one-hundred miles of the coast, there is increased risk of wind damage from hurricanes. The entire range of longleaf is subject to thunderstorms and tornados. But, compared to the other southern pines, longleaf is much more resistant to wind damage. Studies after Hurricanes Hugo in South Carolina (1989) and Katrina in Mississippi (2005) found longleaf to be more resistant to both windthrow (uprooting) and breakage than either loblolly or slash pine.



MANAGING LONGLEAF PINE: A PRIMER

If you have existing stands of longleaf pine, the species can be managed by natural regeneration in even-aged stands, where all the trees in a given stand are the same age, or in uneven-aged stands where you have three or more different age classes in the same area. In most situations, you are establishing longleaf by planting, either in cutover sites, previously in forests, or on former agricultural or pasture sites.

Planting

Containerized or Bare Root Seedlings?

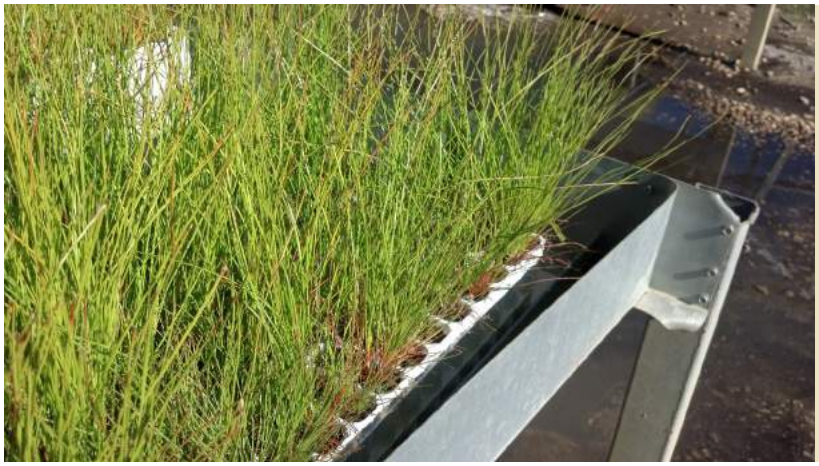
Landowners who wish to plant longleaf pine have two options -- planting bare-root seedlings or containerized seedlings.

Containerized Longleaf Pine Seedlings

Advantages	**Disadvantages**
Generally higher survival	Higher cost per seedling
Lower cost per surviving seedling	Less tolerant of deep planting
Easier to hand plant	Bulky, more difficult to handle & ship
Store better for longer than bare root	
Widely available	
Longer planting season	

Bareroot Longleaf Pine Seedlings

Advantages	**Disadvantages**
Lower cost per seedling	Frequent lower survival
Tolerates deep planting better than containerized	Do not store well for long periods of time
Some planters more familiar with	Harder to plant by hand or machine
Can be more available in some areas	Much shorter planting season



A flat of containerized longleaf seedlings Photo by Carol Denhof.

Planting

Planting Containerized Seedlings

Containerized seedlings now comprise more than 85% of longleaf pine seedling production and planting. Container grown seedlings can be used to extend the planting season and can be used to replant partial regeneration failures in the year in which they occur. In many studies and surveys, both fall-planted and late winter-planted, containerized longleaf have shown better survival and growth when compared to winter-planted, bareroot longleaf seedlings (85% vs. 65% survival rates).

When planting containerized longleaf seedlings, keep these factors in mind:

- Minimize competing vegetation for one year after planting. Good site preparation that includes some combination of mechanical, chemical or fire is required. It is much easier to control competition during site preparation than after the seedlings are planted. With good site preparation, you may not necessarily need an herbaceous release treatment during the first growing season.
- Plant good-quality seedlings. Just because the seedlings are containerized doesn't mean they are all good quality. Good quality seedlings have dark green needles, root-collar diameters of ¼ inch or larger, fibrous roots that are light brown in color with numerous white tips and show mycorrhizae (a beneficial root fungus) development.

  Two good tests of quality seedlings are:

  (1) plugs that remain intact after removal from containers and handling

  (2) plugs that remain firm when held horizontally

A good quality containerized longleaf seedling. Photo by Mark Hainds.

- Plant containerized seedlings early. In some parts of the South, container planting stock can be planted as early as September or October, if there is adequate soil moisture. In any case, containerized planting stock will do better if planted in November-December compared with plantings in January-March. As longleaf seedling roots grow through the winter, early planting allows for greater root development and an ability to better tolerate herbaceous competition during the following growing season. In Florida, use of containerized longleaf seedlings has allowed summer planting to take advantage of the rainy season. Summer plantings show promise in other areas throughout the longleaf range where summer rains provide adequate soil moisture, such as the South Carolina Sea Islands and adjacent coastal areas. However, survival of plantings if drought conditions prevail, is problematic..

- Depth of planting is critical. Containerized seedlings need to be planted shallow. In studies conducted by The Longleaf Alliance, containerized longleaf seedlings had better survival and early growth when planted with the tops of the plugs exposed. This helps accommodate soil movement on well-prepared sites. Some rules of thumb for various planting situations are:

  (1) Level Sites – Plant with top of plug slightly above the soil surface, about one-fourth to one -half inch.

  (2) Scalped Sites – The top of the plug should be 1 to 1.5 inches above the soil surface

  (3) Wet Sites – On wet sites use six-inch plugs and plant them with the top 2 to 3 inches ex-

From left to right: Proper planting depth for containerized longleaf seedlings on (a) level sites; (b) scalped sites; (c) wet sites. Photos by Mark Hainds.

  posed.

- Plant enough seedlings to give 300 to 600 seedlings per acre surviving after one year. Pick a planting spacing that best meets your objectives. Planting for wildlife objectives will usually mean planting at the low end of this range while pine straw objectives may require the high end or greater.

Planting Bareroot Seedlings

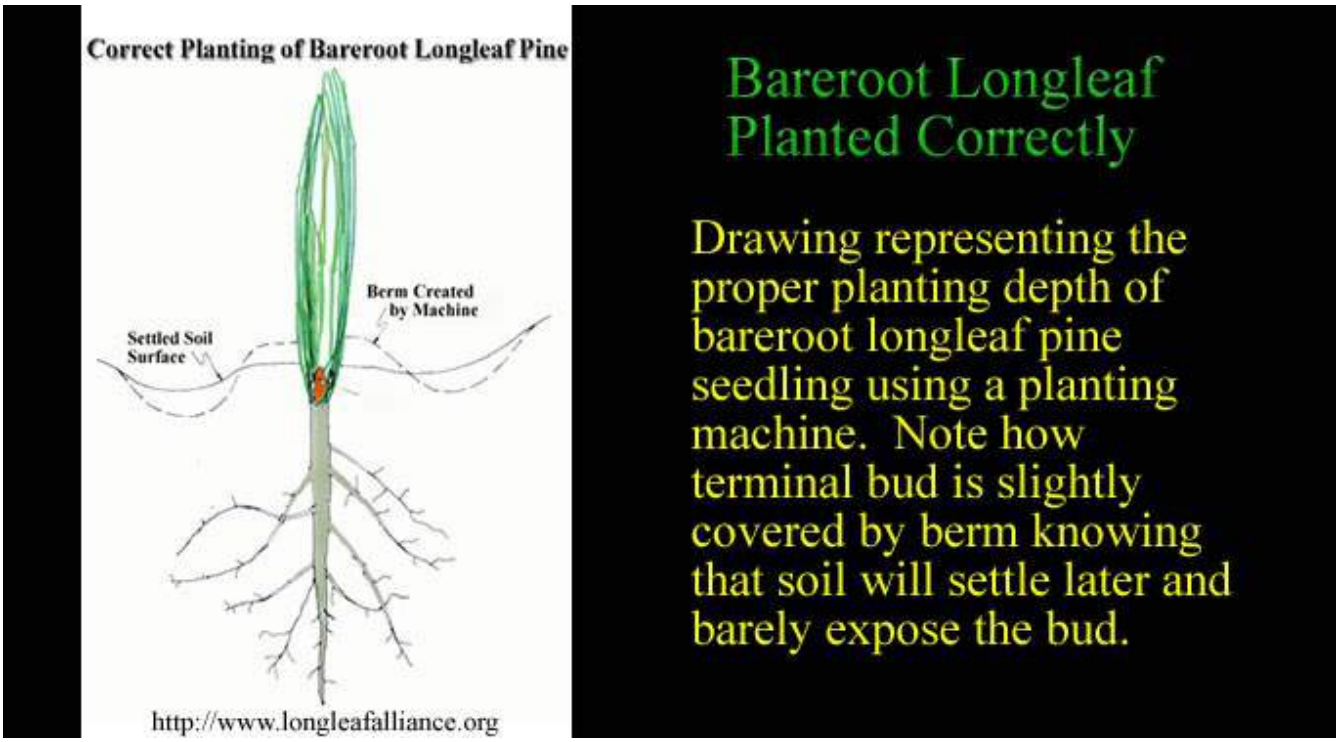
To initiate height growth longleaf seedlings must grow to a sufficient root collar diameter (RCD) as soon as possible. Longleaf pine seedlings are stemless and look very much like a carrot with a clump of pine needles on top. They remain in a grass stage condition until the RCD reaches one inch. While in the grass stage, the seedling is growing a huge root system several feet in length. When a one inch RCD is attained, the seedlings begin rapid height growth comparable to loblolly or slash pine. When planting longleaf pine seedlings, keep these points in mind:

- As with containerized seedlings, minimize competing vegetation near the seedling (at least a 3-foot radius) for the first year after planting. Good site preparation (SP) should include some combination of mechanical SP, chemical SP and/or fire. It is much easier to control competition during site preparation than after the seedlings are planted. With good site

preparation, you may not necessarily need to do an herbaceous release treatment during the first growing season.

- RCD of bareroot seedlings should be at least 0.4 inches or greater, and root systems should have a stout tap root six inches or longer with at least six, preferably more, well-developed, primary lateral roots, and a highly fibrous root system, healthy and reddish-brown in color.
- Keep root exposure to an absolute minimum between packaging at the nursery and planting.
- Plant seedlings within two days of pickup from the nursery. Do not put seedlings in cold storage. Keep seedlings out of direct sunlight and as cool as possible without freezing. Get the seedlings from the nursery and plant them as soon as possible.
- When transporting bundles of seedlings, do not stack the bundles. Seedling survival is improved the shorter the distance the seedlings are transported. Avoid exposing seedlings to rapid air movement when transporting.
- Plant seedlings so the terminal buds will be at ground level or slightly below the settled soil surface 2 to 3 months after planting.
- Bare-root longleaf seedlings may be planted between mid-December and April 1, as long as soil moisture and weather factors are favorable. Planting in the early part of this time frame (December through January) is better as this allows greater root growth compared to late planted seedlings. Additional root growth allows the seedlings to better tolerate spring

Well-stocked, healthy 2 year old longleaf pine planting. Photo by Robert Abernethy.



droughts. Avoid planting during periods of low soil moisture and dry weather. Also avoid planting during times of low temperature, low relative humidity, and high wind associated with the passage of a strong cold front.

- Control damaging influences such as livestock, brown spot disease, and competition as needed.
- Plant enough seedlings to give 300 to 600 seedlings per acre surviving after one year. Pick a planting spacing that best meets your objectives. Planting for wildlife objectives will usually mean planting at the low end of this range while pine straw objectives may require the high end or greater.

Planting Sites

Cutover Sites:

Longleaf pine is easier to establish on sites that have been in forests. Cutover sites are typically less fertile and have fewer problems with aggressive weeds, root diseases and root feeding grubs than most agricultural sites.

Planning ahead of time is essential when planting either cutover or agricultural sites with long-

Cutover site with newly planted containerized seedlings.

leaf. First, match the site preparation operation to the site. For most cutover tracts, a chemical site preparation using herbicides followed by fire is a good choice. Chemical site preparation typically does a better job controlling the woody brush competition found on cutover sites. The use of herbicides followed by fire typically causes less soil erosion and is less expensive than mechanical site prep. Less soil movement through erosion means more consistent and correct planting. Incorrect planting of seedlings is the most frequent cause of planting failures, so the decreased soil movement after chemical site preparation is a major advantage. Chemical site preparation usually keeps more of the native perennial herbaceous community intact. This is important to keep wildlife and diversity values high.

There are an array of herbicides available for site preparation with longleaf pine that can be used to control just about any kind of competing vegetation. Consult with a knowledgeable natural resources professional prior to making any herbicide site preparation decisions. Applications can be tailored to control target species and minimize impacts to desirable understory plants. Remember, it is much easier to control competing vegetation before you plant than afterwards.

Follow up six to eight weeks after herbicide application with a prescribed fire. The fire will consume much of the dead plant material killed by the herbicide and remaining woody debris. This will greatly improve access for the planting operation, resulting in more precise planting.

Plant good quality longleaf seedlings, either bare-root or containerized as early in the planting season as possible. Seedlings planted using the directions above will show excellent survival, even in drought years.

Planting

Agricultural Sites:

Scalping implement . Photo by Mark Hainds.

In recent years, several USDA Farm Bill cost/share programs have emphasized planting longleaf pine on agricultural sites. These fields with their high soil fertility and aggressive weed species can be a challenge to successfully plant. Again, planning is essential. Know what the weed component is on each site and take steps to control the weeds during site preparation. Weed control at this stage is easier than after the seedlings are planted.

The basic prescription for planting agricultural fields is; (1). Site prepare based on the weeds on the site; (2). Rip or subsoil the site prior to planting. This is needed on most agricultural sites to break through the hardpan that develops on sites that have been under long-term cultivation. Breaking this hardpan is essential to allow seedlings to develop deep roots that have better survival and are more resistant to wind-throw in later years; (3). Scalp the rows to be planted. Scalping is a mechanical process where the sod in fields and pastures is peeled back in a shallow furrow to prepare the area for planting. On rolling land, be sure to scalp on contour to avoid soil erosion problems. Do not scalp low spots or flatwoods sites that may hold water for extended periods of time. Do not plant directly over the subsoiled furrow, but offset at least 6 inches to one foot; (4). Plant bare-root or containerized seedlings in the scalped row as early in the planting season as practical; (5) Monitor the stand for post-planting herbaceous weed control as needed.

Subsoiling. Photo by Mark Hainds.

On most agricultural sites, longleaf seedlings may need some sort of herbaceous weed control the first growing season after planting. In many cases this is usually a one-time, first year application that may dramatically improve early survival and growth.

Consult with a knowledgeable natural resource profes-

sional to determine the best herbicide or mixture to use for herbaceous release. Labeled products and rates may change over time. In general, it is better to control competing vegetation ahead of time with good site preparation.

There is one exception to the above recommendation. If the soil pH is 6.0 or greater, don't use sulfometuron (Oust). The function of this chemical is greatly improved at higher soil pH, and this can result with increased longleaf seedling mortality. In addition, seedlings should exhibit good new fine root growth before Oust is applied. These new feeder roots are usually white in color and relatively fine. Excavating a few prior to applying an herbicide can avoid unnecessary chemical damage or mortality. Do not apply herbicides if the seedlings have less than 2 inches of new root growth.

When using soil active herbicides for post plant-release, always check for seedling root growth.

NATIVE GROUNDCOVER AND LONGLEAF PINE

Healthy, fire-maintained longleaf pine forests have a certain "look." It's been described as open and park-like. Early settlers described the forest as open and airy and remarked you could drive a horse-drawn wagon with ease through the forest. Open range grazing of livestock, especially cattle was a dominant use of the forest until the advent of fence laws in the 1920's and 1930's. Cattlemen were taking advantage of the numerous grasses and succulent forbs found in longleaf pine forests. In fact, there are more than 300 plant species native to the forest and at small scales, the plant diversity in longleaf pine forests rivals that of tropical rainforests! The diversity is in the understory and not in the tree canopy. Consequently, interests in restoring longleaf pine forests include restoring the native groundcover. If the site has been in pine forest, this may be as simple as thinning the trees and restoring periodic fire to the site. Getting sunlight on the ground and periodic fire, over a long enough time, the native plants should become dominant. The same can be said for cutover sites being converted to longleaf pine. However, restoration of native groundcover in former agricultural fields and pastures being planted to longleaf pine is more challenging. These sites may need planting of native plant seed. A decision will need to be made on the types of native grasses and forbs to be replanted, what kind of seed to use, land preparation, how much seed to put out or opting for use of containerized plants. Also challenging is finding local seed sources which are better adapted. Restoring native groundcover can get quite expensive. Research is ongoing and more local seed is being produced and made commercially available. For additional information on restoring native groundcover in longleaf forests see The Longleaf Alliance publication: *Keys to successfully restoring longleaf understory.*

In addition, the South Carolina Partners for the Restoration of Native Plant Communities is doing applied research on local populations of native plants in longleaf forests in an attempt to provide South Carolina seed sources at the commercial level. For more information, contact T.J. Savereno with the Clemson University Cooperative Extension Service at asavere@clemson.edu.

Seed Stage

- Seeds fall from cones from October to late November.
- Seeds need bare mineral soil to germinate.
- During this stage, the seedlings are very susceptible to fire, drought, etc.
- Takes roughly a year to reach the next life stage.
- DO NOT BURN WHEN IN THIS STAGE

Grass Stage

- Most well known stage of the Longleaf Pine.
- Pines don't generally grow upwards, but are putting down a large tap root.
- Terminal bud is protected by a thick layer of needles.
- Very high adaptation to fire during this stage.
- In the SE, grass stage usually lasts 1 – 7 years depending on the site and the level of competition.
- Burn during this life stage. (Usually every 2 – 3 years depending on site)

Bottlebrush Stage

- When the diameter of the root collar reaches about 1" the grass stage will begin to initiate height growth.
- Early spring, a single white growing tip (called a candle) will emerge upwards and may grow several feet in just a few months.
- No branches have begun to grow giving it the look of a 3 – 4 foot bottlebrush.
- By growing upwards rapidly, it is able to secure more sunlight and get the growing tip above fire.
- During this stage the trees are more vulnerable to fire due to thin bark. It might take a few years for the bark to thicken enough to withstand fire.
- The longleaf may remain in this stage for a few years.
- Consult a forester before burning. Burning rotations should be more spread out during this stage and done in the cool-season, before candling, and after bark has thickened.

Life Stages

Sapling Stage

- Trees will be approx. 6 – 10 ft tall.
- Lateral Branches begin to emerge, diameter increases & bark thickens.
- Vertical growth still occurs – 2 – 3 ft/year.
- As bark thickens, trees become much less susceptible to fire.
- Remains in this stage for a few years.
- Prescribed burn every 2 – 3 years in this stage.

Maturing Stage

- After sapling stage, tree continues to put on vertical & diameter growth.
- Roughly 30 years after vertical growth starts, trees begin to produce cones with fertile seeds.
- Lower branches are natural pruned off and the tree starts to resemble a telephone pole.
- Continue to burn every 2 to 3 years.

Mature Stage

- Longleaf pines are long-lived species. Anywhere from 150 – 400 years and in some cases older.
- Lightning is the most common cause of death in this stage.
- Continue to burn every 2 to 3 years.

Advantages and Disadvantages

For landowners with existing stands of longleaf, natural regeneration is an option to renew their longleaf forests. Advantages and disadvantages of natural regeneration include:

Advantages	Disadvantages
Low establishment costs	Longer rotations needed to equal volumes grown in plantations
Minimal disturbance to soil & understory	No control over spacing & initial stocking
Tree seed is native to site	Dependent on a seed crop that's periodic
Less insect & disease problems	Precommercial thinning may be needed
Minimal labor & equipment needed	Value of seed trees may be less due to low volumes remaining on tract
More aesthetically pleasing	Seed trees may be lost to lightning & wind-throw
Less potential for future wind-throw	Requires detailed planning & management to get stand in proper condition

The Shelterwood Method of Natural Regeneration

For those who wish to use natural regeneration, the shelterwood method has proven successful in regenerating longleaf pine. This method produces an even-aged stand and is low-cost and effective. However, success depends on four conditions: 1) adequate seed supply; 2) receptive seedbed; 3) minimum vegetative competition; and 4) ample soil moisture.

- Adequate Seed Supply: Start the development of potential seed trees about ten years before the planned harvest date. Begin by thinning the overstory to 60 to 70 square feet of basal area per acre. Keep the largest, best formed, and most fruitful trees in the residual stand (large crowns and history of cone production). Further reduce stand basal area to 25 to 30 square feet per acre (20 or so 16" DBH trees/acre) about five years before the final harvest. This is called a "seed cut." Monitor cone crops annually in the spring to predict an adequate seed crop. Schedule seedbed preparations such as disking or prescribed burning as needed. The seeds produced by 1,000 or more cones per acre should be adequate to establish a new crop of seedlings. This equates to an average of 34 green cones per tree when checked in the spring before seed fall the following autumn .
- Receptive Seedbed: A good percentage of mineral soil must be exposed for seeds to reach the seedbed, germinate, and become well established. A prescribed burn no more than one year before seed fall will usually create a receptive seedbed. A late summer or early fall burn just

prior to seed fall may provide a seedbed for two successive crops of seed, however, burning too late will expose seed to excessive predation. Burn early enough to leave time for litter to accumulate to shield the seeds. Mechanical treatments like disking that lightly scarify the soil surface may be used in lieu of burning. However, these treatments may cost more and damage the seed trees and the groundcover.

Newly germinated longleaf seedlings. Photo by Carol Denhof

- Minimum Vegetative Competition: The use of prescribed fire throughout the rotation will prevent excessive encroachment of woody plants in the midstory and understory. However, if competing woody vegetation is present, remove it, preferably before the seed-cut. This may be done by selling and removing merchantable trees, using spot treatment with approved herbicides, prescribed fire, mechanical treatments or combinations of two or more of these operations. Once an average of 3,000 to 6,000 longleaf seedlings greater than one year of age are present per acre, the remaining seed trees can be harvested. Generally, once 1,000 to 1,500 seedlings per acre have started height growth and are free from overhead competition, the new stand is considered established.
- Ample Soil Moisture: Removal of competing vegetation is about all that can be done to maximize available soil moisture during the stage from seed germination through the critical first year. The rest is left to chance. After the seed trees have been removed, the stand should be revisited periodically to monitor the presence of brown-spot disease, encroaching competition, and any livestock impacts. Undesirable levels of any one of these conditions should be controlled promptly.

Advantages of using the shelterwood method include; (1) Low cost and (2) The genetic material on site may be the best suited for the area. Disadvantages are the risk factor involved with leaving high-value seed trees on the site for several years as the next crop of seedlings becomes established. The risk factor is due to the trees being exposed to lightning strikes, wind-throw and increased mortality during this time period.

Multiple-Use Management

Longleaf pines can be managed to provide a desirable mix of wood products while providing excellent populations of game and nongame wildlife. A well-managed longleaf forest's open and park-like nature is aesthetically pleasing to many. The open vistas common in longleaf forests are desirable for many outdoor enthusiasts.

Quality longleaf pine lumber. Photo by Robert Abernethy.

Managing for Timber & Pine Straw Production

Longleaf pines can produce quality wood products when grown in a variety of densities. Longleaf pine timberland owners should especially consider growing and marketing poles and pilings. Historically, these products have provided landowners with stumpage prices that range from 30 to 50 percent or more over sawlog prices. Due to the tree's excellent form, longleaf pines can produce a higher percentage of pole and piling material than the other southern pines. Longleaf is the preferred species for poles. Poles and pilings can be produced from well-stocked, even-aged, and uneven-aged stands of longleaf.

On average sites, even-aged stands of longleaf pines can be managed for poles on a 40 to 60 year rotation. Timber thinnings should be frequent and light, concentrating on leaving the best pole candidates and a residual stand basal area averaging 60 to 90 square feet per acre. Pole and piling material is best grown in denser stands in order to reduce the taper of the tree trunks. Growing straight stems with minimal taper is the key to growing quality poles and pilings.

Longleaf pinestraw is the most desired for landscape mulch.

Another forest product which can be produced

concurrently with poles and pilings is pine straw. Highest pine straw yields consistently come from well-stocked longleaf pine stands with little or no understory and midstory development. Straw can be initially raked in longleaf plantations between ages 8 and 12 and afterwards every other year until ages 20-30. (Straw production peaks in planted stands at age 20, and at age 25 in natural stands). Exceptional stands could possibly be raked at younger ages.

Longleaf straw is in high demand as a landscaping material. Retail prices can average from around $3.00 to $7.50 per bale. Landowners typically receive an average of anywhere from $0.35 to $3.00 per bale. The variation in price is due to the method of sale. Most straw is sold either on a negotiated per bale basis or on a competitive sealed bid, lump sum by area raked. The amount of work landowners put into their pine straw businesses directly influences the price they receive. Landowners who rake very clean straw and deliver it to retail stores typically get better prices than those who lease their pine straw raking rights. Long-term pine straw leases usually receive more for the straw than short-term or annual leases.

Mechanized pinestraw raking demonstration. Photo by The Longleaf Alliance.

Straw bales can vary in size and weight. There really isn't a standard size. Most are the standard rectangular hay bale size. Even then, the weight of the bale can vary widely, depending on the type of baler (hand vs. hydraulic) used. In addition, many pine straw rakers are now using European/Japanese small hay balers that produce round bales. The point is that landowners should be aware of bale size and weight. Pine straw sale contract should have specifications on bale size and weight. While not done in many places, a possibly better way would be to sell straw by the number of pounds per acre.

Actual straw yields will depend on the age and stocking of the pine stand. Annual yields of up to

200 bales per acre are possible. One study in Georgia indicated that in natural stands of longleaf, commercial straw harvest averaged 87 bales and 1,633 pounds of straw per acre. Yields from plantations of longleaf pine should be greater.

Cleaning up stand debris is essential before raking straw. Photo by The Longleaf Alliance.

If pine straw production is an objective, it should be carefully planned. If care is not taken in monitoring both pine needle and soil nutrient levels when raking straw, it is possible to mine the forest's fertility. Fertility levels can be monitored by periodic soil testing and pine needle nutrient analysis. Nutrient loss can be offset by periodic fertilization based on test results. Take care to avoid over-fertilization. Longleaf pine does not respond to fertilization in the same manner as loblolly pine. Too much fertilizer will make the trees more susceptible to insect and disease problems (see risks section). Additionally, there are potential problems with overharvesting of pine straw that can result from changes in the soil structure, resulting in soil compaction, reduction in water infiltration and site degradation.

Keeping brush from encroaching into stands managed for straw is a challenge. Fully stocked stands will shade the understory and reduce brush encroachment. Periodic use of selective herbicides is common, but may be expensive. Mowing and prescribed fire can be used, especially before September. Since most of the needle-fall occurs between September and December, a cool prescribed burn before September followed by harvesting the fresh needles immediately after needle-fall could be the most economical way to control brush.

Also, there is concern that intensive straw management in natural stands of longleaf pine could severely impact the habitat of some rare and threatened plants and animals found only in longleaf pine woodlands and degrade associated wildlife values. Because of this, it is suggested that longleaf plantations be established on old field/marginal croplands with gentle slopes. Advantages to these sites include high residual fertility and little or no competing woody vegetation. In addition, the plantation can be laid out to facilitate mechanized straw raking. In stands with native groundcover, straw can be carefully raked. Some producers are using pitch forks to carefully remove straw around native groundcover. This can be time consuming, but the producers who use this method have productive operations.

Managing for Game & Timber

Most landowners with longleaf pine are interested in some combination of wildlife and timber management. Longleaf forests managed as even or uneven-aged stands on rotations ranging from 40 to 100 years or more offer excellent opportunities to accommodate both objectives.

Even Aged Management:

Stand Size: When managing longleaf forests in even-aged units for wildlife, stand size is critical. Forests should be composed of a variety of different aged stands. While it may not be practical to have a stand of timber for each year in the rotation, stands can be managed in age classes varying by 3, 5, 8 or 10 or more years. When using natural regeneration, age classes will be dependent on the frequency of seed crops. In some areas of the South, there may be as many as 20 years or more between seed crops adequate to naturally regenerate even-aged stands.

As an example of this style of management, 240 acres of planted longleaf forest grown on a 60-year rotation can be divided up into 12 age classes at 5 year intervals with each age class being approximately 20 acres. An array of other size and age combinations is possible. This is called "all-aged management in even-aged units" and is one of the simplest and best ways to accommodate wildlife values in timber management.

All-aged Management in Even-aged Units

240-acre Tract: An Example

Forest Age-class	Acres	Percent
Young growth	60 acres	25%
Intermediate growth	60 acres	25%
Mature growth	120 acres	50%

Timber stand size should be kept as small as practical, but not so small that timber harvests become uneconomical. This size limit will generally depend on the local timber market and har-

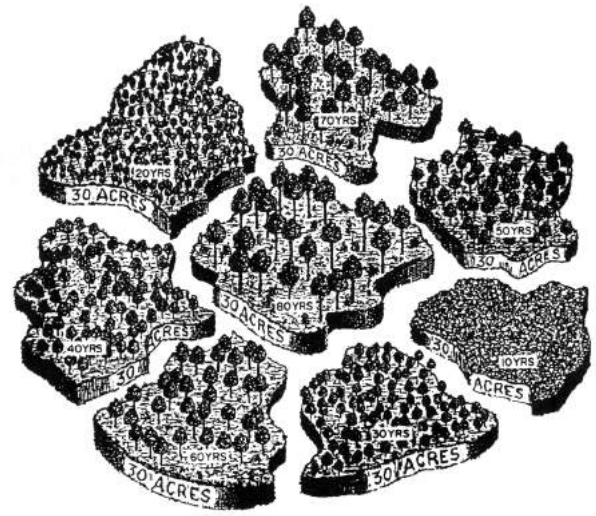


Illustration of how even-aged pine and hardwood stands can be arranged and age classes distributed to benefit wildlife without significant loss in timber growth and yield.

vesting systems that are being used in the area. Stands should be irregularly shaped in order to provide more edge for wildlife. Edges are transition zones where two different vegetation types meet. Edges can provide richer habitat for some wildlife species such as white-tailed deer, bobwhite quail, rabbits, and wild turkey than unbroken areas of one habitat type. Keeping streamside management zones (SMZ's) as wide as practical along streams (300 feet or more on each side, if possible) and leaving small pockets of mast-bearing oaks, persimmons, hickories, and other hardwoods in upland areas are other ways of improving edge.

Timber Thinnings: In longleaf forests with multiple objectives that include timber and wildlife, thinnings should be frequent, at least every 6 to 10 years. One rule of thumb for stands less than 100 years of age where sawtimber is a primary objective is to thin leaving a residual basal area equal to the site index (base age 50) plus the age, minus 40. As an example, a 35 year old stand with a site index of 80 would be thinned to leave a residual basal area of 75 (80+35-40) square feet per acre. Another rule of thumb when managing for sawtimber is to thin to a residual basal area equal to the 50 year site index of the stand.

When adding wildlife objectives, landowners have the option of further reducing basal areas. In general, thinnings for wildlife should occur every 6 to 10 years as is practical. Thinnings should favor the very best crop trees and leave residual basal areas in the range of 40 to 80 square feet per acre. This rule of thumb holds true for both even-aged and uneven-aged management. If

Examples of forests with varying basal area (BA) measurements: l-r, (a) 40BA; (b) 60BA; (c) 80BA; (d) 100BA. Photos by Ron Masters.

bobwhite quail management is an important objective, residual basal areas should be in the low end of this range. Deer and turkey will do well at the higher end of this scale.

Uneven-aged Management:

The whole purpose of small, even-aged timber stands with irregular boundaries and interspersed age classes is to accommodate various species of wildlife and to improve aesthetics. Large, unbroken, uniform stands of pines can be poor wildlife habitat for many species. Another way of accommodating multiple-resource values is by practicing uneven-aged management.

With uneven-aged management, forests are not segregated into even-aged stands of trees. Each unit of forest land will typically have many young, some middle-aged, and a scattering of mature and old trees growing together. Many landowners who do not like the appearance of a final harvest cut will like the concept of uneven-aged management.

Longleaf regeneration gap in an uneven-aged stand. Photo by Carol Denhof

Because of longleaf pine's excellent fire-tolerance, the tree is suited for this style of management. Areas with mixtures of older trees and seedlings can be burned with care if the landowner is willing to accept some seedling mortality.

In practicing uneven-aged management, managers must have some way of regulating timber harvest to growth while encouraging reproduction. There are several methods of doing this. At the simplest level, managers need to know the volume of timber present and the per acre growth rate. Timber harvest removes a certain percentage of the annual growth on a periodic cutting cycle. Individual trees or small groups of trees are typically removed during the periodic harvests. For example, a landowner may decide to harvest 75% of the annual growth on a 10-year cutting cycle. If that is the case, the landowner will have a greater volume in residual timber after harvest than at the start of the cycle.

Two methods often used when practicing uneven-aged management in longleaf pine forests are the Stoddard-Neel (S-N) method and the "basal area-maximum dbh-q" (BDq) method developed by the U.S. Forest Service.

Essentially, uneven-aged management of longleaf pine means harvesting timber with light thinnings and creating gaps for regeneration on a periodic cutting cycle. Trees selected for harvest are selected and marked on an individual or small group basis. Decisions on which trees to cut and which ones to leave require the land manager to look at each tree in the stand, its relative position, dominance, health, and rate of growth and compare it to the landowner's objectives, i.e. what he/she wants out of their forest.

Typically, around 20% of the stems are marked for harvest during each cutting cycle. Regeneration is encouraged in openings made by timber harvesting, and the burning schedule is adjusted to allow the young seedlings time to become fire resistant.

One unique characteristic of longleaf seedlings in openings larger than one-quarter to one-third of an acre is that mild surface fires tend to die out in these patches, allowing seedlings time to reach fire-resistant size. This is one reason you almost always see some scattered longleaf reproduction in annually burned longleaf woods managed for bobwhite quail. On the other hand, if the openings are too large, it is difficult to control competing hardwoods near the centers of the openings with fire, resulting in the establishment of clumps of oaks or other woody competitors.

When it appears that a bumper-crop of longleaf seed will be produced, a growing-season prescribed fire will prepare a good seedbed in longleaf woods accustomed to periodic fire. Next, interrupt the burning cycle in this area for two years or more, giving the seedlings time to become established.

Over the next several cutting cycles, longleaf regeneration is released so it can grow and become part of the continuous stand. By using light periodic harvests that concentrate on leaving the best trees and encourage longleaf regeneration, uneven-aged management can maintain a forest indefinitely.

Management in this manner produces a patchy longleaf forest with groves of older trees, interspersed with groups of younger saplings, middle-aged clumps and areas of reproduction. This produces a great deal of diversity on a small scale benefiting many species of wildlife.

It is worth noting that there are trade-offs when practicing uneven-aged management. First, uneven-aged management requires more attention to detail. If care is not taken in planning the harvest, this style of management can quickly "high-grade" the forest. High-grading is a term used to describe a timber harvest where only the best quality trees are harvested. Over time, the

average quality of the remaining trees is reduced. Second, studies have shown that where timber objectives are important, uneven-aged management will likely result in significantly lower volume growth than even-aged stands on the same site with the same residual basal area.

A third disadvantage with uneven-aged management is more frequent entries into the stand for timber harvesting. Logging impacts occur more often and are spread throughout the stand and could increase damage to the residual timber and/or cause reductions of site quality over time.

The major benefit of uneven-aged management for timber production is that when in place, the landowner will have the opportunity to harvest some higher-valued forest products such as poles and pilings every cutting cycle. With even-aged management, you may have to wait as much as 30 years or longer before you can begin to harvest the higher-valued products.

Fire in Natural Longleaf.

Some of the nongame species benefited by uneven-aged management and small-scale all-aged management in even-aged units include bluebirds, ground doves, native sparrows, towhees, woodpeckers, and numerous reptiles and amphibians.

PRESCRIBED FIRE

Periodic prescribed burning, the skillful application of fire under specific weather conditions to meet desired management goals, is essential for healthy longleaf forests and ecosystem restoration. Longleaf pine forests evolved in a climate that included frequent thunderstorms and associated lightning strikes that resulted in periodic fire. Native Americans perpetuated the practice of induced fire in these ecosystems. The plants and animals associated with longleaf forests need periodic fire to maintain habitat conditions in which they thrive. Today, prescribed fire is used in pine forests to mimic natural fire.

Managers use prescribed fire in southern pine forests, especially longleaf pine forests for:

- Reducing hazardous fuels, reducing the threat of wildfire
- Hardwood control, reducing the development of low value, off site hardwoods
- Site preparation, preparing land to be planted with pines
- Wildlife habitat improvement. Many of the wildlife species and plants in longleaf forests require fire for maintenance of their habitat requirements.
- Disease control, especially for brownspot needle blight which infests seedling longleaf and reduces early growth, increasing seedling mortality
- Improving aesthetics and accessibility. Fire creates open, park-like conditions in pine forests which are desirable for scenic beauty and improved access. The improved access may increase financial returns for hunting leases and timber sales.

Prescribed fire is our most economical tool for managing vegetation. Skilled, responsible use is essential for meeting management goals and allowing the continued use for fire in our forests. For additional information on prescribed fire, contact the South Carolina Forestry Commission at: www.state.sc.us/forest and the South Carolina Prescribed Fire Council at: www.clemson.edu/extension/pfc.

Converting a Loblolly Pine Plantation to Longleaf Without Clearcutting

Many landowners don't want to clearcut and start over with longleaf. They desire to keep a continuous forest. An option for those who wish to convert to longleaf and still keep their existing pine forest is to do it gradually, through underplanting openings within the existing loblolly or slash pine forest.

The steps are:

1) Start with an existing loblolly or slash pine stand.
2) Prescribe burn and/or use herbicides in the stand to control brush & develop an understory of native grasses & forbs.
3) When thinning the existing stand, create numerous small openings scattered throughout the stand. These openings can vary in size from ¼ to ½ acre.
4) Plant at a rate of 600-800 longleaf seedlings per acre in the openings. Higher planting densities are usually needed to compensate for increased mortality and slower development.
5) Begin burning the existing stand on a two year rotation to keep brush and wild pine seedlings from encroaching on the longleaf planting.
6) Repeat at each thinning.

Over time, you can use this method to gradually convert a loblolly or slash pine stand to an uneven aged longleaf stand. For additional details, see Clemson Extension Forestry Leaflet #31 Converting Planted Loblolly Pine (Or Slash Pine) to Longleaf Pine: An Opportunity.

Longleaf pine underplanted in slash pine stand. Photo by Carol Denhof.

Technical Assistance

For upland Coastal Plain and some lower Piedmont sites in South Carolina, longleaf pine is ideally suited for many of the objectives of private forest landowners. If you are interested in ecosystem restoration, wildlife, aesthetics and growing quality wood products, consider growing longleaf pine on your forestland.

Field exercise at one of The Longleaf Alliance's Longleaf 101 Academies. Photo by Ad Platt.

Many sources for technical assistance and cost sharing of establishment and management of longleaf ecosystems through sustainable forestry practices are available. For additional information, see sources of assistance in the flyer in the back of the publication.

Suggested Readings

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