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LONGLEAF PINE REGENERATION AND MANAGEMENT: AN OVERSTORY OVERVIEW.

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ABSTRACT: Longleaf pine is the key tree in fire-dependent ecosystems long native to the southeastern United States. Once the most extensive forest ecosystem in North America dominated by a single species, it now occupies only a small fraction of its former range. Longleaf has the reputation of being a slow-growing species that is nearly impossible to regenerate and so unable to economically compete with other species. Yet, this is a high-quality timber tree providing a host of products. It also tolerates fire and is resistant to most of the serious insects and diseases that afflict other southern pines. Longleaf pine can be naturally regenerated at low cost and with a high probability of success if needed cultural treatments are properly timed and executed. Some evidence suggests that the species' reputation for slow growth may be more myth than reality. More than any other southern pine, the many distinctive attributes of longleaf make it uniquely adapted to a broad range of site conditions, management goals, and silvicultural methods.

INTRODUCTION

Longleaf pine (*Pinus palustris* Mill.) and its associated fire-dependent ecosystems once dominated perhaps as much as 92 million acres in the southeastern United states (Frost 1993). Due to a number of factors over the years, including land-clearing for agriculture, logging, exploitation for naval stores, forest type conversion, and forest fire suppression, longleaf pine now occupies only about three percent of its former range (Outcalt and Sheffield 1996). The decline has continued as second-growth longleaf has matured and is cut, usually to be replaced by loblolly or slash pine which are considered easier and more economical to establish and manage.

Longleaf pine has long been recognized as a highquality timber tree providing a number of valuable products. It is a highly versatile species with characteristics that allow use of a variety of silvicultural options. Both natural and artificial regeneration of longleaf pine are now practical management options. Natural regeneration is a low-cost alternative whenever sufficient seed trees are present (Boyer 1979). If not, then longleaf can be restored through planting. Risks of planting failure have been greatly reduced through use of container stock, especially on adverse sites (Barnett and others 1997, Barnett and McGilvray 1997). Longleaf's reputation as a slow grower may be more myth than reality. On many former longleaf sites, the growth of longleaf may equal or exceed that of loblolly or slash pine (Boyer 1997). This paper reviews the important attributes of longleaf pine and also the several options for management of this species and its associated fire-dependent communities.

THE LONCLEAF FOREST

The natural range of longleaf pine includes most of the Atlantic and Gulf Coastal Plains, from southeastern Virginia south through the northern two-thirds of Florida and west to eastern Texas. Longleafalso extended into the Piedmont Ridge and Valley, and Mountain Provinces of Alabama and northwest Georgia. The species occurred on a wide range of site conditions, from low, wet flatwoods near the coast to dry, stony mountain ridges at elevations up to 2,000 feet (Boyer 1990).

Longleaf pine is a long-lived tree, capable of reaching ages close to 500 years, although this is rarely attained due to the many natural hazards ranging from lightning strikes to tropical storms. Longleaf pine is a very intolerant pioneer species, but generally lacks the characteristics of such species. It is a poor seed producer. The seeding range is relatively short. Seedlings, once established, may remain in the stemless grass stage for years before beginning height growth. Despite these competitive drawbacks, longleafpine has maintained itself in place for thousands of years. To do so, the species had to become naturally established in sufficient numbers and, despite its slow early growth, manage to overcome many aggressive competitors.

The long-term competitive advantage/ of longleaf pine is primarily due to one factor, fire. Longleaf is adapted to, and dependent on, periodic fire for its continued survival in nature. The species can tolerate fires that its principal competitors cannot, and thus became the key tree in a series of fire-dependent ecosystems that once dominated so much of the southeastern United States.

In: Kush, John S., comp. proceedings of the Longleaf Pine Ecosystem Restoration Symposium, presented at the Society of Ecological Restoration 9th Annual International Conference • Ecological Restoration and Regional Strategies. 1997 November 12-15. Longleaf Alliance Report No. 3. Fort Lauderdale, FL. 14-19.

THE TREE

Longleaf pine has always been recognized as a high quality timber tree providing a wide range of products: logs, poles, piling, posts, peelers for plywood, and pulpwood. It almost always has a higher specific gravity than other southern piness and thus produces more dry weight per unit of volume. On average sites 30 to 80 percent of the trees will make poles, which are more valuable than sawlogs (Landers and others 1995).

Longleaf pine has many attributes that allow a variety of management options. In addition to its commercial quality and versatility. longleaf, once established, is a low risk species to manage. It is resistant to fire and the more serious diseases and insect pests that afflict other southern pines, including fusiform rust, annosus root rot. phytophthora, pitch canker, southern pine beetle, and tipmoth. The species develops a massive taproot that, in mature trees, may reach a depth of 8 to 12 feet or more, reducing the risk of windthrow (Boyer 1990).

NATURAL REGENERATION

Successful natural regeneration of longleaf pine will depend on one of the occasional good seed years. Longleaf cone crops are highly variable from year-to-year, and also from place-to-place (Boyer 1987). In most years. the cone crop will do little more than supply the many animals that feed on these large, nutritious seeds. In poor seed years not only are there fewer cones per tree but also fewer sound seeds per cone (Croker 1973). Given a receptive seedbed, 360 cones per acre are needed, on average, just to obtain the first seedling. A minimum of 750 cones per acre is usually needed to provide for acceptable regeneration. Given 25 residual seed trees per acre in a shelterwood stand, it takes an average of 30 cones per tree to reach this minimum. Cone crops of this size or larger arc uncommon throughout much of the longleaf region, and are erratic in their occurrence. The large "masting events", indicated by an average of 150 or more cones per mature tree, are extremely rare. Two have occurred in the central Gulf Coast longleaf belt in the last 50 years: 1947 and 1996. In most years, cone crops will average less than IO cones per mature seed tree. A typical example is cone production over a 30-year period at a west Florida site, one of several monitor.& regeneration areas throughout the longleaf region During this time six cone crops were potentially large enough for regeneration. These good cone crops were not very well distributed in time as there were none in the 15-year period from 1972 through 1986, but five occurred in the lo-year period from 1987 through 1996!

Following one of the occasional good seed crops, longleaf seedlings may be established in large numbers on the forest floor. In the open or under a light overstory, established longleaf seedlings may survive periodic surface fires. Under medium to dense pine over-stories. seedlings often cannot survive the combination of slower growth caused by competition and the hot fires fueled by abundant needle litter. Thus longleaf pine regeneration often survived in small gaps or under light overstories where less intense fires still limited hardwood encroachment but did not seriously harm established seedlings, Surviving seedlings were released by overstory mortality through continuing attrition from lightning, insects, disease, and occasional windthrow. Patchy stands originating in this way are common in second-growth forests. and were probably common in presettlement forests. Early logging sometimes simulated this process when stands were high-graded one or more times. Reducing the overstory in stages promoted establishment and survival of seedlings which were eventually released with the final logging or other catastrophic destruction of the old growth Although entirely unintentional, this process was responsible for most second-growth longleaf forests.

Natural regeneration is a practical low-cost alternative given an adequate number and distribution of seed-bearing trees. It should not be difficult under these conditions, since nature has managed to do so over the millenia. Some of the observed examples of successful regeneration in nature seemed to resemble a shelterwood method and Icd Croker (1956) to the hypothesis that this approach could be the most appropriate for longleaf pine. This has since proven to be the case. The shelterwood method of natural regeneration is highly flexible and can be adapted to a wide variety of site conditions and management objectives.

To insure success, the manager needs to see that all biological requirements for natural regeneration are met in a timely manner. These include:

1. An adequate seed supply.
2. Pre-establishment competition control.
3 A well-prepared seedbed.
4. Post-establishment competition control.

5. Control of brown-spot needle blight.

Except for seed supply, all these requirements can be met through timely use of prescribed fire.

Given a mature, managed stand of longleaf pine periodically thinned to medium densities, the regeneration process begins about five years before the planned harvest date. At that time, a seed cut creates a shelterwood stand with a residual density of 25 to 30 square feet of basal area per acre of welldistributed, highquality dominant trees, preferably those with a history of cone production. Cone production on a per-acre basis peaks at stand densities of 30 to 40 square feet, but the lower end is preferred because logging-related seedling mortality increases with increasing density of the overstory removed (Maple 1977). At a stand density of 30 square feet, logging related seedling mortality should remain below 50 percent. In addition to maximizing seed supply, this density produces enough needle litter to fuel the fires that can limit hardwood encroachment and also prepare an adequate seedbed when needed. During the wait for a good seed crop, highquality volume growth is added to residual trees. Although the seed cut may reduce stand density by half, volume growth is reduced only about one-third as the dominant trees take advantage of released growing space.

Within a regeneration area, advance warning of a coming good cone crop is obtained through annual checks of flowers and conelets on sample trees. Binocular counts are made in the springtime, when both flowers and conelets are most visible. Flower counts are relatively unreliable predictors of cone crop size, due to uncertain and often heavy flower losses. These counts do reliably predict cone crop failures, and also reveal any possibilities of a good cone crop. Counts of the green conelets are good predictors of cone crop size for the coming fall, although only a limited time remains to accomplish any needed competition control and seedbed preparation.

The regeneration goal is 6,000 or more seedlings per acre at least one year old before the parent overstory is removed. This number allows for logging losses of up to half the stand and still leaves enough survivors that the superior, fast-growing, brown-spot resistant fraction of the stand will provide 300 to 600 high quality trees per acre for the nest generation (Boyer 1979). This number of one-year-old seedlings is not inflexible and may be adjusted to meet local conditions. A smaller number of established seedlings may suffice, especially if logging mortality *can* be reduced through careful supervision.

Once a regeneration survey indicates adequate seedling stocking, the over-story can be removed Longleaf seedlings can survive for years under a parent overstory provided they are not burned before reaching a fire-resistant size. Thus overstory removal can be scheduled to meet management needs or market conditions. However, the over-story should be cut before many of the best seedlings begin height growth. Stemless grass-stage seedlings are less likely to suffer serious damage from logging, but when they do are more Likely to sprout. Burning should be delayed until at least two years after overstory removal. This allows time for logging slash and accumulated litter to decay and for suppressed seedlings to respond to release.

A number of successful tests and applications of the sheltenvood method described above indicate that longleaf pine stands can be regenerated naturally at low cost and with a high probability of success provided necessary cultural treatments are properly timed and executed.

MANAGEMENT

A principal management goal should be the use of silvicultural methods that can sustain longleaf pine ecosystems in perpetuity. They will incorporate natural regeneration and will likely simulate, in a systematic way, some of the events and processes that maintained longleaf ecosystems in nature. Management, however, can exercise positive control of the processes rather than merely responding to the impact of chance events.

Longleafpine forests can be maintained with any one or more of three basic management systems or their variants. The three systems are: 1) even-aged management, 2) two-aged stand management (the irregular sheltenvood), and 3) uneven-aged management Bach of these can simulate the processes that maintained longleaf pine in the past. While much is known about even-aged management of longleaf pine, relatively little is known about the long-term consequences of alternatives to traditional even-aged management or their adaptability to differing site conditions. Limited tests suggest that, at least on average sites, management of ho-aged stands (Boyer 1993) and selection management (Farrar and Boyer 199 1) are both viable alternatives for longleaf pine. Management systems, with some of the possible variants within each, are listed below.

Even-aged management. Even-aged stands are initiated by natural regeneration from one or several seed crops that occur within a short span of time. The parent overstory is removed only after an adequate seedling stand is established.

Variants include:

1. Rotation age.
2. Thinning regimes.

This method represents the catastrophic stand replacement event that often led to the even-aged stands found in nature. Cutting replaces the blowdown that often followed severe tropical storms. Ultimately, most coastal plain forests will experience such an event, certainly within the potential lifespan of a longleaf forest. Risks from tropical storms increase with rotation length and proximity to the coast. Management hopes to insure that the stand replacement event (overstory removal) occurs only after adequate regeneration is present This may or may not occur in nature, and possibly not even under management.

Two-aged stand management. A mature stand is reduced to a shelterwood density after which seedlings from one or more good seed crops are established All or part of the parent overstory is retained through all or part of the next rotation

Principal variants are:

1. Maintain two-aged stand through rotation. Dominant ingrowth fills canopy gaps; thinning *from* below removes intermediate/suppressed trees, plus some dominant/codominant trees as needed to maintain desired stand density. At the selected rotation age, the process is repeated. Area control is preserved.

Within above, variants include:

a) Density of residuals retained.
b) Length of time residuals retained.
c) Rotation length.
d) Thinning regimes.

2. Maintain the reverse-J diameter class distribution resulting from retention of overstory trees. This is a fast way to reach an uneven-aged stand structure. Selection management is imposed, leading ultimately to an uneven-aged condition which is maintained indefinitely.

Variants: Once the uneven-aged structure is established, variants will be the same as those listed with 3, below.

This method represents the situation in which a partial stand is left after a catastrophic event and regeneration is present on the forest *floor.* Most likely to occur where good seed crops are infrequent and regeneration from the first big crop preempts the site, maintaining essentially a two-aged stand

Uneven-aged management. Forest stands are comprised of three or more age classes. Conditions are established to promote periodic recruitment of regeneration in order to develop and retain a full range of age classes within the management unit. Once established, it can be maintained indefinitely in absence of a major catastrophic event.

Variants include:

1. Single tree selection.
2. Group selection Group sire and shape a variable.
3. Any one of several methods of regulation.

This method represents the condition that develops over time with normal attrition, mainly through lightning strikes, bugkills, fire, and limited blowdowns. This is combined with regularly recurring recruitment and retention of regeneration in newly created gaps.

A fourth alternative is no *management.* In this scenario, nature takes its course. This is a default approach that may or may not maintain the ecosystem, depending on the course of natural events. Periodic fire is assumed, without which the system will degrade over time.

Variants include:

1. No cutting.
2. Salvage cutting.
3. Salvage cutting plus incipient mortality.

The three management systems outlined above illustrate systematic ways to perpetuate longleaf pine forests, including their diverse associated fire-dependent communities, using processes that maintained these systems in nature. The adaptability of longleaf pine to so many management goals and methods should make it an attractive management option for many forest landowners in the longleafregion (Franklin 1997). Stewardship of diverse and productive longleaf pine forests, growing high-value products, will not only provide a good economic return to the landowner but can also preserve environmental values that have nearly vanished from the southern landscape.

SUMMARY

Longleaf pine is a long-lived but very intolerant pioneer species that grows best in the absence of competition. Longleaf lacks the principal characteristics of most pioneer species but instead is adapted to regimes of frequent surface fires that its principal competitors cannot tolerate.

Longleaf pine is adapted to a wide range of site conditions, from low, wet flatwoods near the coast to dry, rocky mountain ridges.

Once established, longleaf is a low risk tree to manage. In addition to its tolerance of fire, the species is resistant to many of the more serious insects and diseases that afflict the other southern pines.

Longleaf pine is a high quality timber tree, producing a range of valuable forest products from logs and poles to quality pinestraw.

Longleaf pine can be easily regenerated provided all necessary cultural measures are properly timed and executed.

Longleafs habits and requirements make it uniquely adapted to a wide variety of management goals and silvicultural methods. This, along with its many desirable attributes, should win this species, and its associated ecosystems, a permanent place in southern forests.

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