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Opportunities for Uneven-Aged Management in Second Growth Longleaf Pine Stands in Florida¹

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The Longleaf Pine Ecosystem

In pre-colonial times, longleaf pine (*Pinus palustris* Mill.) forests covered nearly 60 million acres of land in the southeastern United States, from southeast Virginia to central Florida, and west to the Gulf Region of Texas. Since European settlement, the longleaf pine resource has steadily declined. In 1935, 20 million acres were found throughout the South (a 70% reduction), while in 1994 only 3.3 million acres remained (a 95% reduction; 2, 6, 22, 35).

The decline in the longleaf pine resource can be attributed to several factors. First, extensive harvesting, particularly between 1900 and 1930, greatly reduced the area occupied by mature longleaf pine (10) and, hence, the availability of seed sources. Therefore, natural regeneration was both scarce and unpredictable. Second, a lack of understanding of the biological requirements of this species and seedling predation from feral hogs (35) led to the failure of many regeneration efforts. Finally, and perhaps most importantly, many sites were converted to other commercially valuable species (mainly loblolly pine (*Pinus taeda* L.) and slash pine (*Pinus elliottii* var. *elliottii* Engelm)) or to other land uses such as agriculture (22, 35).

As a result of this decline, much of today's interest in the restoration of Florida's native ecosystems has focused on longleaf pine. Of the 3.3 million acres of longleaf pine in the southeastern United States, about 29% of this total is found in the Panhandle region of Florida. Approximately 800,000 acres were naturally regenerated and about 100,000 acres were artificially regenerated. The naturally regenerated stands average 60 years in age, while the plantations are about 40 years old. This pattern in age class distributions and stand origin is similar for longleaf pine forests elsewhere in the Southeast. In Florida, the public sector owns nearly half of the longleaf pine resource. Non-industrial

private landowners own slightly less acreage, while forest industry owns approximately 150,000 acres (22, 26).

Today, longleaf pine forests are managed for a variety of desired benefits including aesthetics, habitat diversity, and quality timber production. The longleaf pine forest is one of the most diverse ecosystems in the world, outside of the tropics. The high-quality timber produced in longleaf pine forests generally has a higher stemwood specific gravity than timber from either loblolly pine or slash pine. The timber from mature longleaf pine trees is strong, rot-resistant, and knot-free (29, 30). Longleaf pine may be a suitable alternative to loblolly pine and slash pine on difficult sites, such as excessively well-drained sandhill soils that do not support acceptable growth rates for these other southern pine species. In addition, longleaf pine is generally considered to be less susceptible to southern fusiform rust and therefore a desirable species to plant on high rust hazard sites (31).

Non-industrial private landowners own almost 400,000 acres of longleaf pine in Florida, so their management strategies have a large impact on the status of the resource. For non-industrial private landowners whose main land management objective is something other than timber production (i.e., aesthetics, recreation, wildlife habitat, soil or watershed protection), alternative silvicultural systems provide an opportunity to create diversity at the landscape level. The objective of this bulletin is to describe an alternative to even-aged management for longleaf pine in Florida. The alternative approach uses a modified group selection system to create an uneven-aged stand structure, which will provide income from periodic timber harvests, while maintaining continuous tree cover. A discussion of traditional and alternative longleaf pine management practices follows, as well as a description of the process of converting an even-aged stand of mature longleaf pine to an uneven-aged stand.

Management Options for Longleaf Pine

Longleaf pine has traditionally been managed using even-aged silvicultural systems that rely on either natural or artificial regeneration. With this approach, single age class stands are managed over a fixed period of time (rotation) using intermediate cutting techniques (e.g., thinnings) to regulate stand density, control species composition and improve stand vigor and health. Examples of even-aged silvicultural systems used with longleaf pine include the clearcut and shelterwood systems. In the clearcut reproduction system, all mature crop trees are harvested simultaneously at the end of the rotation. The site is then regenerated using either natural or artificial regeneration. The shelterwood reproduction system uses two partial harvests to reduce the basal area of the stand to about 30 ft²/acre (the density which maximizes seed production of longleaf pine). Seed from the remaining mature trees is used to naturally restock the site. Once regeneration is established, the parent overstory trees are removed. Both the clearcut and the shelterwood systems have been shown to be effective even-aged systems for regenerating and managing longleaf pine (11, 12, 13).

The even-aged approach to management offers a variety of advantages. For

example, even-aged management is easy to apply and intermediate cuttings and other cultural practices (i.e. herbicide application, fertilization) can be applied uniformly across the entire stand (1). Even-aged systems produce trees that are fairly uniform in size, which simplifies harvesting operations. There are, however, some disadvantages to even-aged management. The uniform stand offers fewer aesthetic, recreational and wildlife benefits and may not produce significant income for 15 to 20 years (1).

On public lands, there is an increasing interest in developing uneven-aged stands of longleaf pine. In Florida, the U.S. Forest Service is converting over 250,000 acres of even-aged longleaf pine and mixed longleaf pine-slash pine stands to an uneven-aged structure, using a modified group selection system. While even-aged management systems create stands with one age class of trees, and a diameter distribution that follows a smooth bell-shaped curve, uneven-aged management systems create stands that contain at least three distinct age classes. The diameter distribution of an uneven-aged stand follows a reverse J-shape ([Figure 1](#)).

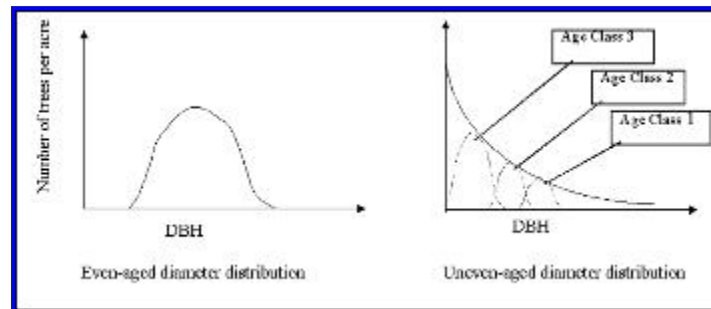


Figure 1. Comparison of even-aged and uneven-aged diameter distributions (17, 32). DBH is the diameter of the trees at breast height. Age class one contains the oldest trees; age class three contains the youngest trees.

The canopy profile of an even-aged stand is fairly uniform, but the profile of an uneven-aged stand is varied, with trees representing the spectrum from tall canopy dominants to seedlings and saplings ([Figure 2](#)).

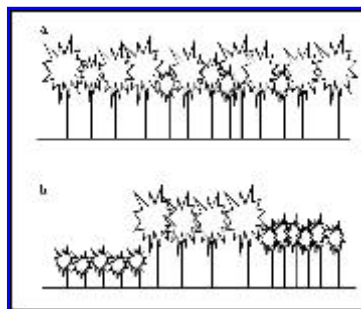


Figure 2. Stand profiles showing (a) even-aged stand structure and (b) balanced uneven-aged stand structure. The even-aged stand has one age class (i.e. the trees are approximately the same age). The uneven-aged stand, which in this example was developed using the group selection system, has three distinct age classes.

If the stand is a balanced uneven-aged stand, the ground area occupied by each age class is approximately equal.

Uneven-aged stands are created using the selection system. In the selection system, trees representing a range in size are harvested at fixed intervals (called the cutting cycle, which ranges from 10 to 25 years). Regeneration (either natural or artificial) occurs in the harvested openings. This management approach allows periodic harvests, while maintaining a continuous forest cover. Smaller, lower quality trees are also removed to improve the overall quality of the stand.

There are two main variations of the selection system. The first, referred to as the single tree selection system, involves removal of individual trees across the stand, creating small openings in which primarily shade tolerant species can naturally regenerate ([Figure 3](#)).

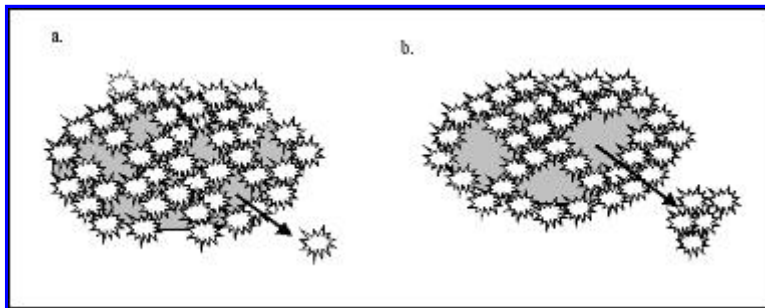


Figure 3. An aerial view provides a stand level comparison of opening size and arrangement after harvest, and the trees removed during harvest using (a) the single-tree selection system and (b) the group selection system.

However, regeneration of shade intolerant species may be difficult to achieve in these small openings because of insufficient sunlight and inadequate disturbance of the seedbed that exposes mineral soil for seed germination.

The second type of selection system is referred to as group selection. In this system, groups of trees are removed in patches (ranging from 0.2 acres to 5 acres in size) throughout the stand ([Figure 3](#)), allowing for potential regeneration of the more shade intolerant species such as longleaf pine (provided seedbed requirements are met; 8, 23, 24, 25). Canopy openings can be regenerated using either natural or artificial means. These harvested groups mimic canopy gaps created by natural biotic and abiotic events (e.g. insects, windthrow, lightning). Generally, the group selection method has lower logging costs than the single-tree selection management system.

There are numerous advantages to uneven-aged management (using both the single-tree and group selection systems). Stands with a variety of age classes are less likely to suffer catastrophic damage from insect outbreaks, disease, or low intensity fire because, usually, only one age class of trees is susceptible to any one damaging agent. For example, longleaf pine seedlings are susceptible to brown spot needle blight, but saplings and mature trees are not. A brown spot needle blight outbreak in an uneven-aged stand may result in high seedling

mortality, but trees in the other age classes will not be damaged. Another advantage of uneven-aged management is that periodic income can be obtained from high-valued products at relatively short intervals, over time. Also, due to the continuous presence of large trees, the selection system creates stands with high aesthetic values and diverse wildlife habitat (1, 18), while providing excellent site protection. However, both single-tree and group selection systems may involve higher logging costs than even-aged systems, and are sometimes difficult to apply (1). Also, there is potential for substantial losses due to damage to the residual stand during harvesting operations.

Because longleaf pine is intolerant of both shade and competition from mature overstory trees, openings created in the single tree selection system are not usually large enough for adequate natural regeneration to become established. Seedlings in small openings (<1/3-acre) compete directly with adjacent mature trees for limited site resources (i.e., water, mineral nutrients; 18). Fine root competition from mature residual trees on good quality sites may extend 50 feet into openings, and may be even higher on poor sites (7). Any established longleaf pine regeneration in these small openings would have slow growth rates (19), and may suffer higher mortality from periodic prescribed burning (20) than young trees in larger openings. In spite of these difficulties, however, the single-tree selection system has been used successfully in some open-canopied longleaf pine forests.

Group selection silviculture may create an uneven-aged stand similar in structure to old-growth stands of longleaf pine, which are comprised of small, even-aged patches of trees. The diameter distribution of an old-growth longleaf pine forest is somewhat reverse J-shaped, with trees ranging from 3 to 500 years old (28).

Longleaf Pine Ecology

The first step in developing a viable group selection management system for longleaf pine involves a review and understanding of the ecology of the species. Specifically, the management strategy must match the habitat, reproduction, germination and growth requirements of the species. [Table 1](#) summarizes the biological factors that are important for regenerating and managing longleaf pine.

These biological requirements can be met using a modified group selection system. With this modified system, a reverse J-shaped diameter distribution is created and maintained by creating at least three distinct age classes within the stand using area regulation. The following example describes the process of converting an even-aged longleaf pine stand into a balanced uneven-aged stand structure using a modified group selection system.

Conversion of Longleaf Pine Stands from Even-Aged to Uneven-Aged

A hypothetical stand with the following characteristics will be used to illustrate

the modified group selection system.

Stand Description

- 45 acres
- 60-year-old naturally regenerated longleaf pine (currently on site)
- Site index 70 (base age 50 years)
- Previously unthinned
- 230 trees per acre, 114ft²/acre basal area (33)
- Current standing volume = 16 thousand board feet (MBF - Scribner)/acre (33)
- Product objective: Pole and Sawtimber production (14)

Assumptions

1. Mature longleaf pine that surround regenerated openings do not have adverse affects on growth and survival of seedlings within the openings.
2. Trees over 45 years old exhibit a minimal growth response to thinning.
3. Damage to the residual stand (i.e., scarring and soil compaction) from harvests and thinning operations will be minimal.
4. Planting of longleaf pine seedlings will be used to regenerate the created gap openings.

Reproduction Cuts

Group selection openings will be harvested on a 15-year cutting cycle ([Figure 4](#)). Using a 45-year rotation, this amounts to harvesting fifteen acres per cutting cycle.



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Figure 4. A recently harvested group selection opening in a second-growth stand of longleaf pine in the Apalachicola National Forest.

The fifteen acres will be allocated among five 3-acre gaps within the stand ([Figure 5](#)).

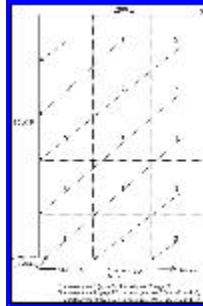


Figure 5. Schematic of a hypothetical 60-year old second growth even-aged longleaf pine forest, managed under a modified group selection system (based on recommendations in 23). Note: The gaps do not need to be rectangular.

Circular or irregular shapes will work as well. Not to scale.

Since the age of the current, naturally regenerated stand is 60 years old (the average age of longleaf pine stands in Florida), the ages of the trees harvested in the first three cutting cycles will be 60, 75, and 90 years old, respectively. Once the stand is fully regulated, the difference between the oldest and the youngest trees in the artificially regenerated gaps will be 45 years. The artificially regenerated trees planted in the created gaps will be harvested at age 45. The rotation age for the naturally regenerated and the artificially regenerated trees differs because naturally regenerated stands require longer rotations to produce volumes of sawtimber comparable to that of planted stands (14). For example, at age 60, a naturally regenerated stand would be expected to yield 16 thousand board feet of timber (MBF)/acre (Scribner), while at age 45, a planted stand would yield about 22 MBF/acre (Scribner) (33).

A 15-year cutting cycle allows for adequate growth between harvests, to ensure operable volumes, and it falls within the recommended range of cutting cycles for this species. Sawtimber revenues occurring at 15-year intervals may be preferable to pulpwood revenues occurring at 20-25 year intervals. The large (3-acre) gaps that are created with this management system should reduce detrimental edge effects that may impact seedling survival and growth within the openings (19, 27). Skid trails should be oriented in the direction of the planted rows and be as wide and straight as possible to facilitate future harvesting and thinning operations, and to minimize damage to trees in the residual stand. The size and the location of the gaps, and the positioning of the skid trails parallel to the planted rows, simplify both marking and timber harvesting operations.

Regeneration

Site disturbance resulting from harvesting should sufficiently scarify the soil for planting. If there is excessive woody vegetation in the openings, a

prescribed surface fire may be used to reduce competing vegetation. Some additional site preparation (i.e., herbicide application) may also be required prior to planting in areas with heavy understory competition or oak (*Quercus* spp.) encroachment (9, 21).

Although longleaf pine can be regenerated by both natural and artificial means, artificial regeneration by planting is recommended for this modified group selection system because of the sporadic nature of longleaf pine seed crops, the bare mineral soil requirement for natural germination, and the heavy seed predation pressures commonly found with this species (Table 1). These three factors make natural regeneration of longleaf pine somewhat unreliable. Artificial regeneration also helps to ensure prompt and uniform seedling establishment (35). Spacing and density can be manipulated to meet specifications for desired products. When relying upon natural regeneration for longleaf pine, canopy openings are limited to about 0.7 acres to ensure adequate seedfall throughout the created gap (effective seed dispersal distance of longleaf pine is about 100 ft). However, there is no biological limit to the size of openings when artificial regeneration is used.

Another advantage of artificial regeneration is that it provides an opportunity to use genetically improved seedlings. Improved longleaf pine seed is being developed, which has higher survival rates and earlier emergence from the grass stage than unimproved seed sources (30).

Artificial regeneration of longleaf pine can result from direct seeding, or planting of bare-root or containerized seedlings. Containerized seedlings are more expensive, but usually have higher survival rates due to decreased transplant shock, which results in a greater ability for the seedlings to compete with understory vegetation. In general, containerized longleaf seedlings are easier to plant, have an extended planting season, and they initiate height growth earlier than direct seeded or bare-root seedlings (3, 4, 5). The high survival and rapid growth rates of containerized seedlings result in better yields, which in turn offsets the higher initial planting costs associated with their use. Containerized longleaf pine seedlings (minimum root collar diameter 0.4 in.) (3) can be planted (either by hand or machine) at a density ranging from about 500 to 725 trees per acre (e.g. 9 x 9 to 6 x 10 ft spacing). Staggered spacing can be used to create a more natural appearance (Figure 6).

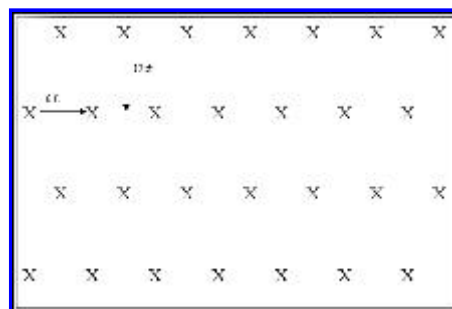


Figure 6. Schematic of a staggered 6 x 10 ft spacing, where X represents individual seedlings (not to scale).

Although containerized seedlings can be planted throughout the year, survival is best when they are planted under moderate weather conditions. The traditional planting season for longleaf pine in Florida occurs from November through February, although there has also been successful planting of containerized longleaf pine seedling in late summer. Additional information on planting Southern pines is available in a number of other extension publications (12, 15, 16).

Intermediate Operations

To provide more operable volumes and revenues, thinnings should be timed to coincide with group selection harvests. A low thinning (which removes smaller or poorly formed trees) beginning at about age 30 years is recommended for the remainder of the stand (residual basal area should be about 80 ft²/acre; 14).

Prescribed surface fires can be used on a three-year burning cycle to minimize fuel loads and to control understory and woody vegetation (17). Regular competition control is necessary to encourage growth and survival of longleaf pine seedlings. A three-year burn cycle is currently being used successfully on the National Forests in Florida to maintain longleaf pine-wiregrass (*Aristida stricta* Michx.) ecosystems (34). Although longleaf pine is fairly resistant to fire damage, the seedlings are susceptible to injury during the initial stages of height growth. Therefore, fire should be postponed during this stage and not resumed until seedlings are over 3 feet in height. To minimize damage to longleaf pine seedlings, cool prescribed burns should occur during the winter months. When the trees are taller than 10 to 15 feet, low intensity burns could be prescribed in other seasons, assuming that fuel loads are low to moderate.

Disadvantages

There are many advantages associated with using a modified group selection system with longleaf pine. There are, however, a few potential problems with the system. The main disadvantage is that it has not been rigorously field-tested. Potential decreases in yields due to increased competition between the overstory and understory trees, as well as decreased volume production from periodic prescribed burning, may make this method less productive than even-aged management systems. Therefore, landowners primarily interested in commodity production may find this management approach less appealing than even-aged systems (23).

Conclusion

The group selection silvicultural system represents an uneven-aged management strategy useful for longleaf pine. Although traditional even-aged management systems will continue to be used with this species, the group selection system offers many additional potential advantages, including periodic income from high-quality timber, continuous presence of large trees on site, diverse wildlife habitat, soil and watershed protection, and high aesthetic and recreation values. The stands created using this system are based

on sound biological principles and they can be used to develop diversity in forest structure at the landscape level, and restore a native ecosystem that once dominated much of the southeastern United States.

Non-industrial private landowners interested in managing their forestland using the modified group-selection approach are encouraged to consult with a professional forester. The forester can facilitate implementation of these guidelines by evaluating the site, estimating current timber volumes, drafting a timber sale contract, and assisting with regeneration efforts. They will also be able to evaluate landowner opportunities for federal cost share assistance programs for non-industrial forest landowners. Additional information on forest management, including incentives programs can be found on the University of Florida Forestry Information web page at:

<http://www.sfrc.ufl.edu/Extension/ffws/home.htm> Additional definitions of terms used in this paper can be found at:

<http://www.sfrc.ufl.edu/Extension/ssfor11.htm>

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Tables

Table 1. Biological characteristics of longleaf pine important in developing a management plan. (Adapted from 2, 6, 7, 11, 13, 35).

Climate	Temperature: 60 - 70°F hot summers/mild winters
	Rainfall: 43 - 69" annually
Soils	Sandy, acidic, low organic matter - Ultisols, Entisols, Spodosols
	Wet, poorly-drained sites to dry, rocky mountain ridges
Seed Production	Heavy seed crops (50 to 60 seeds/cone) every 5 to 7 years
Cone Production	Maximized in stands with 30ft ² /acre basal area
	Dominant and codominant trees with diameters at breast height > 10"
Seedfall	Late October through early November
Seeds	4200 clean seeds/lb, winged
Dispersal	Wind, maximum distance 120'
Seedbed Requirement	Bare mineral soil, low competition. Prescribed fire within one year of planting/seedfall
Germination	One week after reaching bare mineral soil
Growth	Stemless grass stage lasting 2 to many years; intolerant of competition and shade; growth comparable to slash pine and loblolly pine on cultivated and fertilized sites
Pests	Brown-spot needle blight, seed predators, grazing animals, and feral hogs
Fire	Resistant, except during early height growth

Footnotes

1. This document is CIR 1404, one of a series of the School of Forest Resources and Conservation, Florida Cooperative Extension Service,

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