NATIONAL REGENERATION OF SHORTLEAF PINE

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ABSTRACT

Natural regeneration with clearcutting, shelterwood, seed tree, and selection systems is a viable method for establishing and managing shortleaf pine stands. An adequate seed source, a suitable seedbed, control of competing vegetation, follow-up cultural treatments, and protection of reproduction are the primary prerequisites for establishing and maintaining natural stands.

INTRODUCTION

Shortleaf pine (*Pinus echinata* Mill) is an important commercial species on millions of acres of forest lands and occupies a wide variety of sites from southeastern New York and New Jersey into eastern Texas and eastern Oklahoma. In the West Gulf region (Arkansas, Oklahoma, Texas and Louisiana) shortleaf pine ranks second only to loblolly pine (*P. taeda* L.) in commercial importance (Murphy 1982). Where shortleaf is found as a primary species or mixed with loblolly pine, it is estimated that about one-third to one-half of the existing stands will be regenerated naturally. Langdon (1981) indicates that 75 percent or more of the loblolly pine stands will be established by natural regeneration.

The major need for pine regeneration is on private nonindustrial ownerships, which include 75 million acres, or 72 percent, of commercial forest land in the midsouth (Birdsey et al. 1981). Natural regeneration may be the best alternative for maintaining pines on the vast acreages of private forest land, since it has the lowest establishment and capitalized costs of any regeneration method available (Baker 1982; Vesikallio 1981). For example, stands in the Southern Coastal Plains can be naturally regenerated for about $50 per acre--$5 per acre for a preharvest prescribed burn and $45 per acre for postharvest herbicide treatment. In comparison, artificial regeneration costs on the same sites would range

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from $100 to $200, depending on the specific treatments selected.[1]

SILVICULTURAL SYSTEMS FOR NATURAL REGENERATION

Forest managers using natural regeneration can choose to manage either even-aged or uneven-aged stands (Baker 1982; Lawson and Kitchens 1983; Williston and Balmer 1974). Single-tree or group selection, or a combination of the two methods, may be used in uneven-aged management. However, single-tree selection is more difficult to implement and maintain (Farrar 1981) in mixed pine-hardwood stands, which are common throughout the natural range of shortleaf pine. Where regeneration is badly needed, a combination of single-tree and group selection may be required. Uneven-aged management may work well on small private nonindustrial ownerships or other holdings where it fulfills special management objectives (Baker 1982; Baker and Murphy 1982; Gibbs 1975; Williston 1978; Williston and Balmer 1974).

In even-aged management, clearcutting, shelterwood, and seed-tree systems are alternatives for natural regeneration. The clearcutting method is used to regenerate small patches, blocks, strips, or ribbons if there is a seed source available from adjacent stands. These areas should not be over 300 to 400 feet wide with the long axis oriented perpendicular to the direction of prevailing winds (Baker 1982). The clearcutting method can also be used to regenerate larger areas where seedlings are in place or where a good seed crop is expected. When seeds are in place, clearcutting is done after seed-fall, but prior to germination, whereas when seedlings are in place, cutting is done in late summer after the seedlings are established (Baker 1982; Haymond 1983).

In the shelterwood system, the mature stand is removed in two or more cuts. Regeneration takes place under a partial forest canopy, which is completely removed when the stand contains about 1,000 seedlings per acre and 60 percent of the milacres are stocked. The overwood is usually removed 3 to 5 years after the regeneration cut. Growth rates of residual stems also increase because of thinning and may show a greater increase if additional understory control is provided (Bower and Ferguson 1968; Yocom 1971). Thinning and hardwood control will also enhance crown development for increased cone production.

With the shelterwood system, reducing the pine stocking to as low as 20 to 30 square feet of basal area per acre may be desirable (Baker 1982). Phares and Rogers (1962) found

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that more seeds were produced at 50 square feet of basal area than at higher levels and suggested that maximum seed production per acre might occur at even lower levels of stocking. Besides resulting in greater seed production, the lower stocking levels greatly reduce competition for seedlings. In south Arkansas, however, Grano (1970) found that densities of 60 to 70 square feet of basal area per acre produced the most seeds in loblolly-shortleaf pine stands.

The seed-tree system, probably the most widely used in natural regeneration of shortleaf pine, involves removal of all the overstory except 6 to 20 well-spaced, vigorous trees per acre. In mixed loblolly-shortleaf pine stands, 12 to 20 trees per acre should be left where shortleaf comprises a majority of the stand (Baker 1982; Williston and Balmer 1974). As with the shelterwood system, seed trees should be removed when there are about 1,000 well-distributed seedlings per acre (Walker and Wiant 1966).

Some managers prefer to leave a minimum of 12 seed trees for added protection against loss of seed trees and to make the final harvest more profitable. Widely scattered seed trees are not as resistant to windthrow as the more dense residual stands of the shelterwood system. In shallow, rocky soils where taproots do not develop, windthrow hazard is increased. Seed trees may be attacked by engraver (Ips spp) and other beetles if slash is not removed from around the tree bases before burning. Lightning also kills some trees, and losses to lightning may be critical where few seed trees are left.

Loss of seeds after they reach the forest floor is high but variable. On the average, only about 1 percent of the sound seed dispersed in the Ouachita Mountains produce seedlings (Yocom and Lawson 1977). In selection stands, where tree density is normally higher, 200 to 400 viable seeds may be required to produce each seedling (Grano 1970). Birds, animals, and insects may eat the seeds. Some seeds fall where they do not get enough moisture to germinate, and seedlings from seeds that do germinate may die before their roots reach mineral soil. High mortality may also result from droughty periods after seedling establishment.

SEED PRODUCTION

Annual seed production by shortleaf pine trees varies greatly, ranging from near zero to more than a million seeds per acre in moderately stocked stands. In one study (Yocom and Lawson 1977), an average of 10 seed trees per acre produced 3-year totals of from 308,000 to 916,000 sound seeds per acre. In mixed loblolly-shortleaf pine stands with basal areas of 12 to 92 square feet per acre, Grano (1970) found that 4-year viable seed yields ranged from 400,000 to 800,000 per acre.

Many factors contribute to the success or failure of seed crops during the 2 years required for maturity. In early stages of seed development, temperature and evaporation may limit successful fertilization of female strobili (Lamb et al. 1973). From the beginning of strobili development through cone maturity, losses due to insect predation are high. Other organisms and weather conditions cause losses, and many seeds abort from unknown factors.

Predicting seed crops very far in advance is difficult. Probably the best predictor is the presence of maturing cones during the growing season before cone maturity. This indicator is not infallible, however, since seed quality can vary greatly. For example, limited data from seed collected in traps in the Ouachita Mountains in the fall of 1975 indicated that 22 percent of the seeds were defective. Half of one shortleaf pine bumper seed crop in the Piedmont was defective (Haney 1957). Another study in south Arkansas showed that the proportion of seeds germinating was 24, 38, 65, and 29 percent during 4 consecutive years (Grano 1970).

Several silvicultural practices can enhance good seed crops. First, trees left as seed trees should be selected on the basis of vigor, size (particularly crown size), and past cone production. Generally, pine seed trees should be at least 12 inches in d.b.h. This minimum diameter provides trees that are old enough to produce large cone crops and large enough to provide good distribution of the seed. Shortleaf pines usually do not produce an abundance of seeds before they are 20 years old, although there are examples of seed production on trees much younger than 20 years (USDA 1965). A seed-tree cut will usually harvest young trees that are unsuitable for seed trees. Leaving very old (100 years or older), slow-growing trees should also be avoided, but if trees are vigorous, there is probably no upper-size limitation. Also, trees that have only a few old cones should not be selected for seed trees.

Second, because reduction of competition increases both the number of cones and the number of sound seed per cone, most harvest cuts and subsequent understory vegetation control will increase seed production. One study showed that releasing seed trees from surrounding competition doubled the cone production from a prerelease average of 498 cones to 1,069 cones following release. Release also increased the average number of seeds per cone from 35 to 38. Percentages of sound seed were 81 and 85 for unreleased and released trees, respectively. Partial girdling also increases cone production (Bower and Smith 1961). Phares and Rogers (1962) found that thinning and hardwood removal also significantly increased shortleaf pine seed production.

SITE PREPARATION

Adequate site preparation for natural regeneration of shortleaf pine must provide two basic requirements: (1) a seedbed without heavy litter accumulation so that radicles of germinating seeds can reach mineral soil, and (2) control of competing vegetation.

Seedbed Preparation

Often the disturbance caused by harvesting the overstory will remove enough litter to adequately prepare the seedbed. Litter usually decomposes rapidly when stands are opened during timber removal and hardwood control operations (Smith 1960). Most litter will be gone after being exposed for one summer, particularly on south and southwest aspects. On some sites, however, litter accumulation is a problem. When litter is redistributed during harvesting and mechanical site preparation, mineral soil is also exposed. In the Ouachita Mountains, Yocom and Lawson (1977) found that an average of 35 percent of the surface area was disturbed by logging. Whole-tree logging soon after seedfall has also been found effective in preparing the seedbed for regenerating pine stands (McMinn 1985).

Prescribed burning also removes litter and logging debris effectively. Yocom and Lawson (1977) found that burning and logging enhanced seedbed conditions and increased tree percents (ratio of established seedlings to sound seed produced x 100) as follows:

Burning treatment	Logging Disturbance	
	Undisturbed	Disturbed
	Tree Percents	
Unburned	0.42	0.98
Burned	0.98	1.29
	Percent Milacre Stocking	
Unburned	53.5	74.5
Burned	82.7	87.8

Both burning and logging disturbance resulted in similar tree percents and percent of milacres stocked. Thus, either burning or disturbance may satisfy seedbed requirements. Burning, however, generally provides seedbed conditions that are more uniform than those provided by logging disturbance alone. Multiple prescribed burns in seed-tree or shelterwood stands several years before final harvest have resulted in effective seedbed preparation (Crow and Shilling 1980).

Timing of seedfall in relation to seedbed preparation is also important. If spring or summer cone counts indicate low seed production, seedbed preparation should be delayed until the next year. Otherwise, establishment and growth of herbaceous vegetation before the next seedfall may negate the benefits of seedbed preparation.

Competition Control

On most sites, competition for water and light becomes critical to newly established seedings. Competition control should be implemented before seedfall or before growth starts the next spring. Burning, if it is part of the final site preparation, must be done before the seedfall that is expected to provide regeneration. In uneven-aged stands, hardwood control must be provided on a periodic basis to coincide with 5- to 7-year cutting cycles (Cain and Yaussy 1984).

On typical pine sites, many hardwoods are present and must be controlled to allow adequate natural regeneration. Single-stem injection, foliar spray, or soil application of herbicides will effectively reduce hardwood competition (Loyd et al. 1978), especially when many very small hardwoods are present. Mechanical methods, such as hand cutting and shearing, also temporarily reduce hardwood competition but may cause problems with sprouting. Maple (1965), however, found that a brush cutter provided higher tree percents and stocking levels than chemical treatment or burning. A good prescribed burning program begun several years before the harvest/regeneration cut has been found to be effective in reducing hardwood competition for newly established seedlings (Crow and Shilling 1980).

On south-facing slopes, achieving total hardwood control may not be necessary. In the Ouachita Mountains, Yocom and Lawson (1977) found that single and repeated hardwood control treatments on north aspects resulted in tree percents of 0.91 and 1.03, respectively. On south-facing slopes, however, these two values were 0.97 and 0.76. Southern slopes are drier than northern slopes, and some residual hardwood stems may help pine regeneration for the first few years by shading and protecting the seedlings from drying winds.

If adequate regeneration is not achieved within 3 years, additional site preparation may be needed. Our experience in the Ouachitas indicates that we can achieve adequate regeneration in 3 years when hardwoods are controlled with chemicals followed by burning on some sites. On better sites, hardwood regrowth will likely be so rapid that seedlings will have little opportunity to survive and grow, even if they are established soon after site preparation. Because most herbicide sprays may harm pine seedlings, sprays generally should not be used during the first year or two after establishment (Lawson 1960). Some of the newer herbicides, such as hexazinone, do not harm 1- to 2-year-old seedlings when applied at the recommended rates.

STOCKING CONTROL

Getting the correct number of seeds and seedlings distributed over the area being regenerated for even-aged management is often difficult. The number of seed trees left for regeneration gives some control over stocking. Results of one study (Yocom 1968) in the Ouachita Mountains showed that most of the shortleaf seeds fell within 2.5 chains from the seed source. Half the seeds fell within 1 chain of a forest wall (stand of mature trees adjacent to a clearcut or seed tree area), and 85 percent fell within 2.5 chains of it. In one year, 16,600 to 31,500 seeds per acre fell in traps 2.5 chains from the wall. At 1.5 chains from the wall, the number of seeds approached 42,700, or about a pound per acre. Neither prevailing nor shifting winds made a significant difference in seed catch, although they have in other studies (Little 1940; Siggins 1933). The maximum distance over which a tree will distribute seed is about 2-1/2 times the tree height. Thus, about 6 to 10 well-spaced seed trees per acre should distribute enough seeds to cover the area, with a little extra for insurance. However, some managers prefer more seed trees per acre or a shelterwood overstory to provide a greater seed source and a protective canopy (Haymond 1983). An overstory is always present in uneven-aged stands.

One of the big problems with natural regeneration is getting too many seedlings. This usually happens when there is a combination of a good seed crop, an adequate amount and distribution of rainfall, and a suitable seedbed. But overstocking may also occur because mature seed trees are left too long. In uneven-aged management, overstocking is generally not considered a problem (Farrar 1981).

Seedling counts should be made after each growing season to avoid leaving seed trees too long. Ideally, the seedling count should be made in late summer or early fall in time to remove the seed trees if adequate numbers of seedlings are present. Where herbaceous and other vegetation is dense, however, making an accurate inventory may be nearly impossible in late summer, so the inventory should be postponed until just before vegetative growth begins in later winter or early spring. The disadvantage of a spring count is that the number of seedlings that will be established at the end of the next growing season is unknown. If a good seed crop was present the previous fall and the regeneration area is approaching full stocking, you may want to go ahead and remove the seed trees.

If there is overstocking, reduce the number of seedlings to a suitable level as soon as feasible. If post markets are available, however, delaying thinning until most trees are merchantable may be desirable. The best thinning methods for upland sites have not been determined. Hand thinning or strip cutting with brush cutters (Cain 1983) and drum choppers have been used. Up to about post size, shortleaf pines severed above ground will sprout and are likely to remain as competitors for water and nutrients. As the seedlings develop into saplings, prescribed burning may be used to precommercially thin shortleaf pine stands, although there are risks of the fire becoming too hot (Crow and Shilling 1980; Nickles et al. 1981). Herbicides can also be used to thin young pine stands (Nickles et al. 1981), but may not always be successful (Cain 1983).

Natural regeneration may create overstocking problems next to forest walls on areas that have been (or will be) planted or direct seeded. Invading natural seedlings can cause a serious problem in plantations where genetically improved seedlings have been planted. Distinguishing natural from planted seedlings may be difficult at early ages. Natural seedlings may be present before harvesting and site preparation and will readily sprout back with vigorous growth if damaged by fire or equipment. I have observed newly germinated seedlings in the middle of large areas that were harvested, sheared, windrowed, and burned the previous summer. The presence of these seedlings suggests that shortleaf pine seeds may germinate later than the first year after seedfall, but this phenomenon has not been documented in the literature.

On many sites throughout the shortleaf pine range, natural regeneration is a viable management alternative and may be the only practical alternative on steep, rocky sites. On much of the vast acreage of private nonindustrial forest lands, natural regeneration may be the most desirable method of establishing pine stands because of economic and other considerations (Baker 1982; Haymond 1983; Williston 1978).

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