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NATURAL REGENERATION OF LOBLOLLY PINE

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Abstract.--This paper highlights some of the ecological and silvical characteristics of loblolly pine that provide the basis for recommended natural regeneration methods for various portions of the broad range of loblolly pine.

Additional Keywords: Natural regeneration methods, ecological and silvical characteristics, prescribed burning, hardwood competition, preharvest seed tree release, seed production, seed dissemination, seed- seedlings-in-place.

Loblolly pine *(Pinus taeda* L.*)* is the "bread and butter" tree for a large and expanding forest industry. It occurs from Maryland to Texas and is a major species on about one-fourth of the forest land in the South. About three quarters of a million acres of loblolly pine are harvested each year. If productivity of this timber type is to be maintained, prompt establishment of a new forest after the harvest cut is a necessity and a key silvicultural activity.

Fortunately, a great deal is known about the tree--its silvical characteristics, it silviculture and management, and its wood properties and utilization. Literally, thousands of articles have been written about the species, including two books--one published as long ago as 1915 (Ashe 1915) and another in 1960 (Wahlenberg 1960). Unfortunately, full use is not always made of what is known about the tree, and many stands (for one reason or another) are not adequately reproduced. Although planting plays an important regeneration role on forest industry lands, 75 percent or more of the loblolly pine stands will probably be regenerated by natural means.

In this paper, I will, first, highlight some of the ecological and silvical characteristics of loblolly, then show how some of the regeneration systems fit these characteristics, and finally introduce you to a new regeneration concept.

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ECOLOGICAL CHARACTERISTICS

Loblolly pine occurs in the early and intermediate stages of plant succession as succession progresses from bare soil to an edaphic or physiographic climax. A key factor in how a species fits into a given stage of succession is how it competes with its neighbors, and especially how it competes with its neighbors in an understory.

Loblolly pine usually loses the competitive struggle in an undisturbed understory because it is less tolerant than most of its hardwood associates. In the absence of fire or other control measures, these hardwoods increase in size as the loblolly pine overstory ages. Finally, as mortality takes its toll, the pine overstory breaks up and the hardwood climax components eventually assume dominance of the site (Wahlenberg 1960).

Succession toward the hardwood climax is also hastened if, when the pine is harvested, the hardwoods are left to occupy the site. Such cutting practices prevent the establishment and reduce the growth of loblolly pine probably more than any other known practice. Loblolly pine is an excellent competitor, however, and if given anywhere near an equal chance, will compete successfully with many, if not most, of its hardwood associates.

SILVICAL CHARACTERISTICS

Success in natural regeneration depends on an adequate seed supply, a receptive seedbed, ample moisture during the germination and establishment period, and freedom from competition for space for the seedling to grow. If one or more of these variables are inadequate or limiting, a regeneration failure is a likely result.

Seed Production

An adequate seed supply is the first requisite in the natural reproduction of loblolly pine. Loblolly is a prolific and a rather consistent seed producer in the coastal plains of the Carolinas.

On the lower coastal plain of South Carolina, 27 years of seedfall records on the Santee Experimental Forest revealed several bumper crops (more than 1 million sound seed per acre) and only one year of seed failure (Fig. 1). Similarly, on the lower coastal plain of North Carolina, 8 years of records by Wenger and Trousdell (1957) on the Bigwoods Experimental Forest showed adequate to excellent seed crops and no seed failures (Fig. 2).

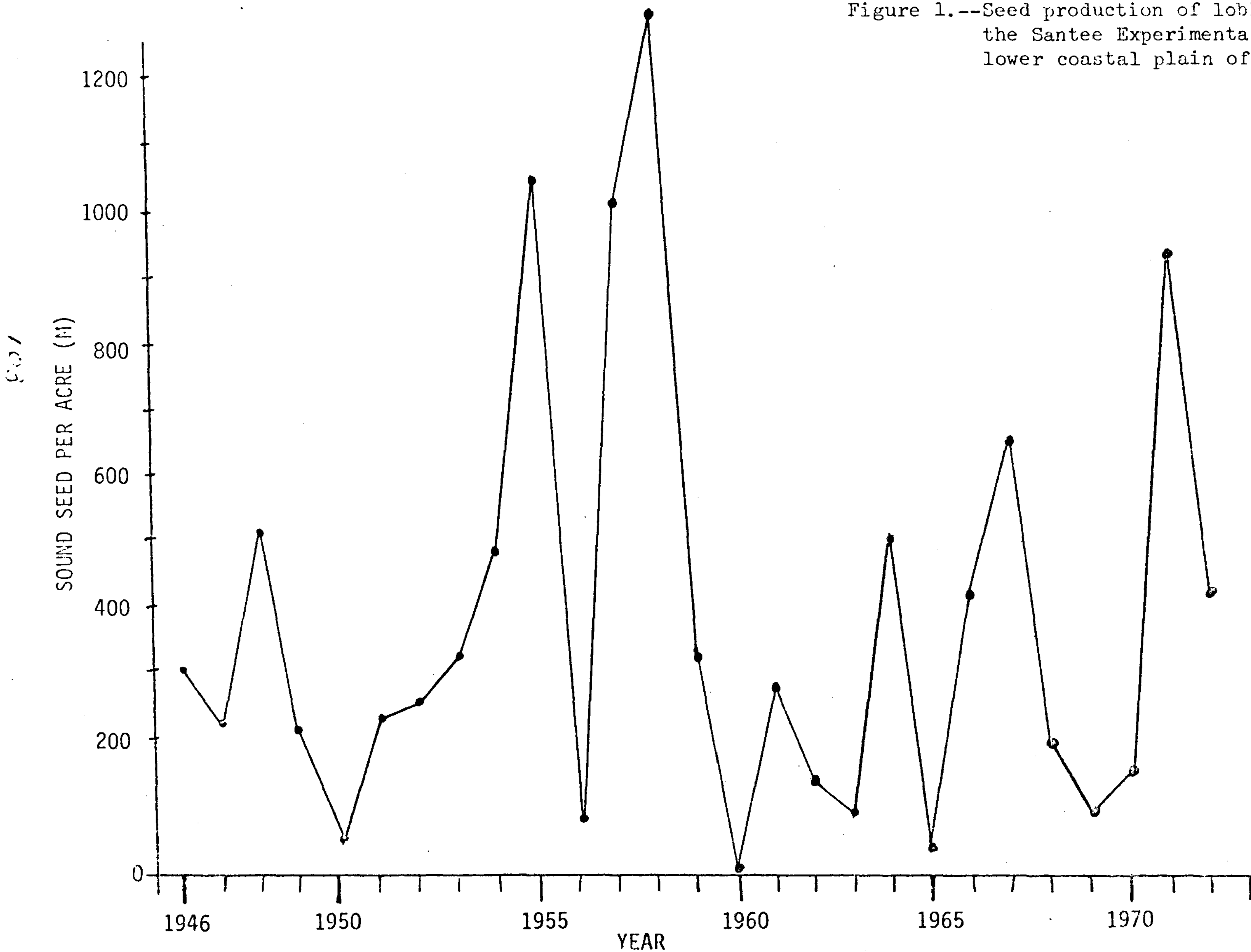

Figure 1.--Seed production of loblolly pine on the Santee Experimental Forest in the lower coastal plain of South Carolina.

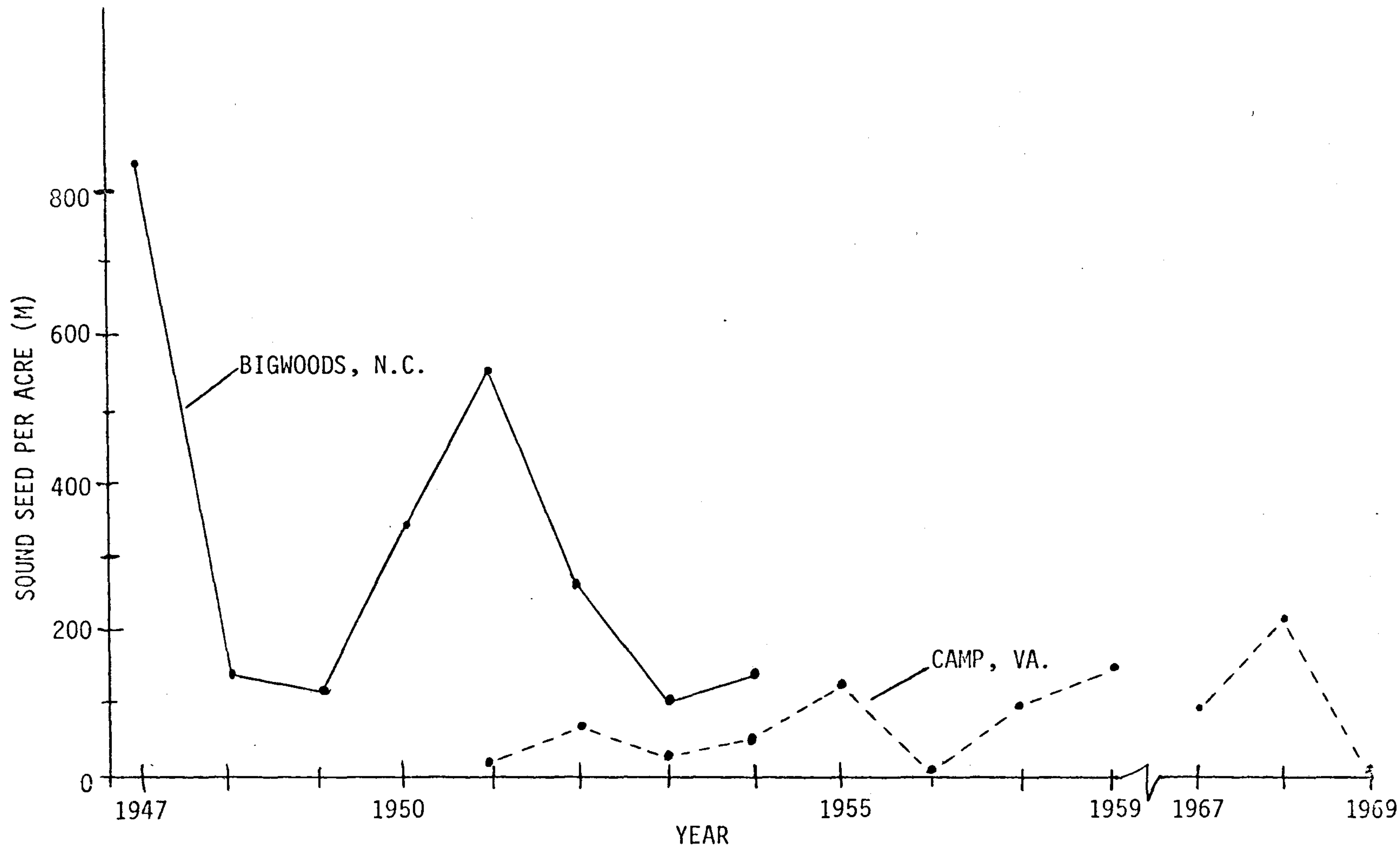

Figure 2.--Seed production of loblolly pine on the Bigwoods Experimental Forest in the lower coastal plain of North Carolina (after Wenger and Trousdell 1957) and the Camp Experimental Forest in the middle coastal plain of Virginia (after Stewart 1965).

Compared to those records from the lower coastal plain, seed production on the Camp Experimental Forest[2] on the middle coastal plain of Virginia was neither as consistent nor as prolific. During 11 years of keeping records, Stewart (1965) found that two of those years (18 percent of the years) had seed failures, two had poor seed crops, and seven had quite adequate numbers of seed produced (Fig. 2).

Loblolly seed production in the Piedmont is not as abundant nor as reliable as in the coastal plain (Brender 1973, Wakeley 1947). In the Georgia Piedmont, Brender and McNab (1972) found the frequency of seed crop failure to be 36 percent, which is double that reported by Stewart for the middle coastal plain. Brender and McNab's study also shows that a shelterwood cutting in which large numbers of trees are left for seed reduces the number of seed crop failures and increases the levels of seed production (Fig. 3).

Variation in Seed Crops

Yearly variations in seed crops are related to several factors, some of which are not fully understood (Wenger and Trousdell 1957). Freezing weather at time of flowering often injures or kills the flowers. Drought at other critical periods of the reproductive cycle may reduce seed production. For example, May-July rainfall has been found to be positively related to the setting of flower-bud primordia (Wenger 1957). If a drought occurs during this period, subsequent cone and seed crops will be reduced. Finally, insects may also damage or destroy cones and seeds at various stages of development.

Preharvest Release of Seed Trees

Cone production of loblolly pine seed trees is markedly stimulated (Fig. 4) by releasing them from competitors (Wenger 1954). In order to have adequate amounts of seed the first year after the harvest cut, the seed trees must be released in the winter or early spring three growing seasons before the seed is needed. If seed trees are released later than May 1, cone and seed crop stimulation will be delayed 1 year (Stewart 1965). If seed trees are not released prior to the harvest cut, stimulated seed production will be delayed either 2 or 3 years depending on the time of year that the harvest cut is made.

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[2] The Bigwoods and Camp Experimental Forests are owned by Union-Camp Corp., Franklin Division, Franklin, Virginia whose cooperation with the Southeastern Forest Experiment Station, Forest Service in making land available and conducting various forestry operations required in the experimental work is gratefully appreciated.

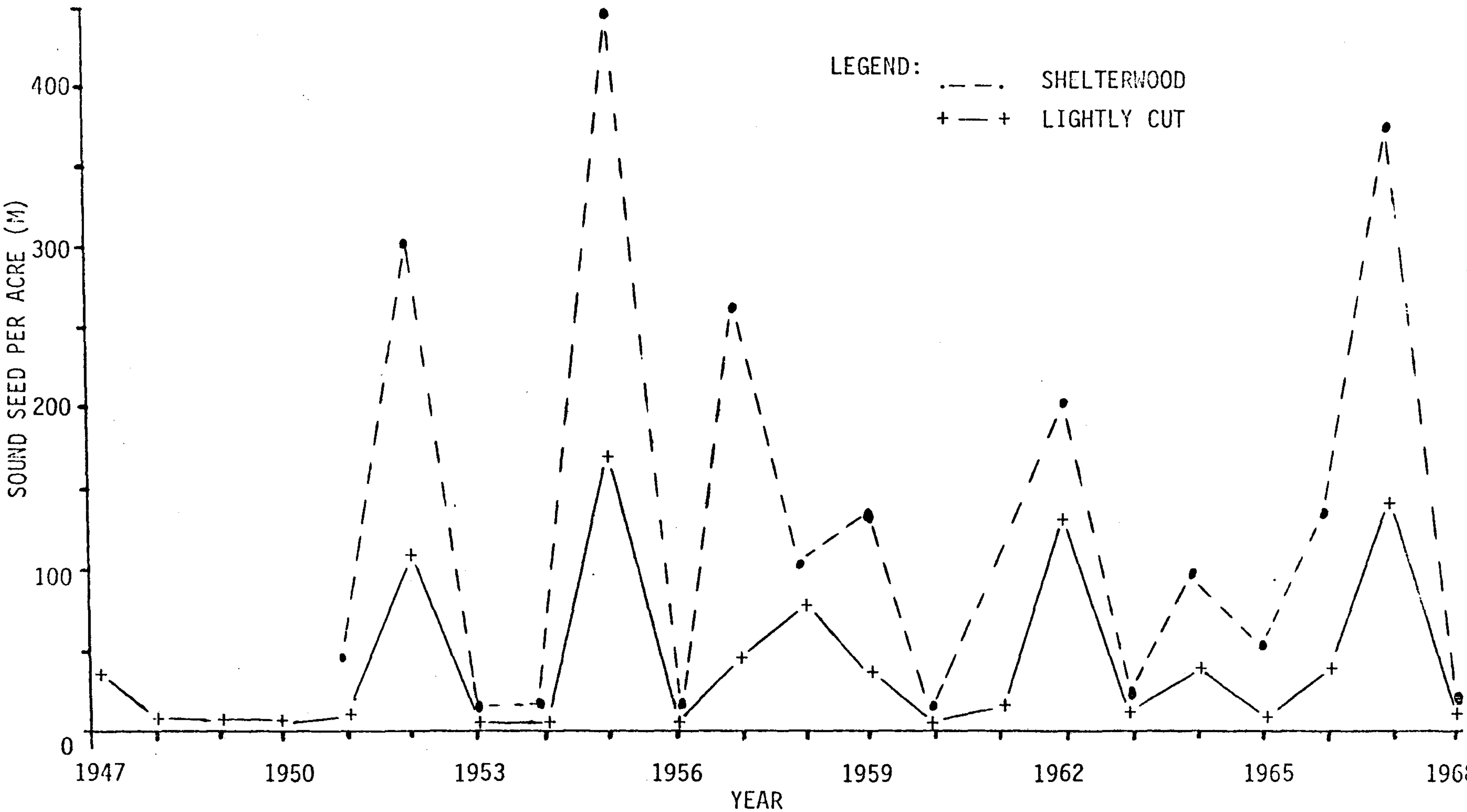

Figure 3.--Seed production of loblolly pine on Hitchitti Experimental Forest in the Piedmont of Georgia (after Brender and McNab 1972).

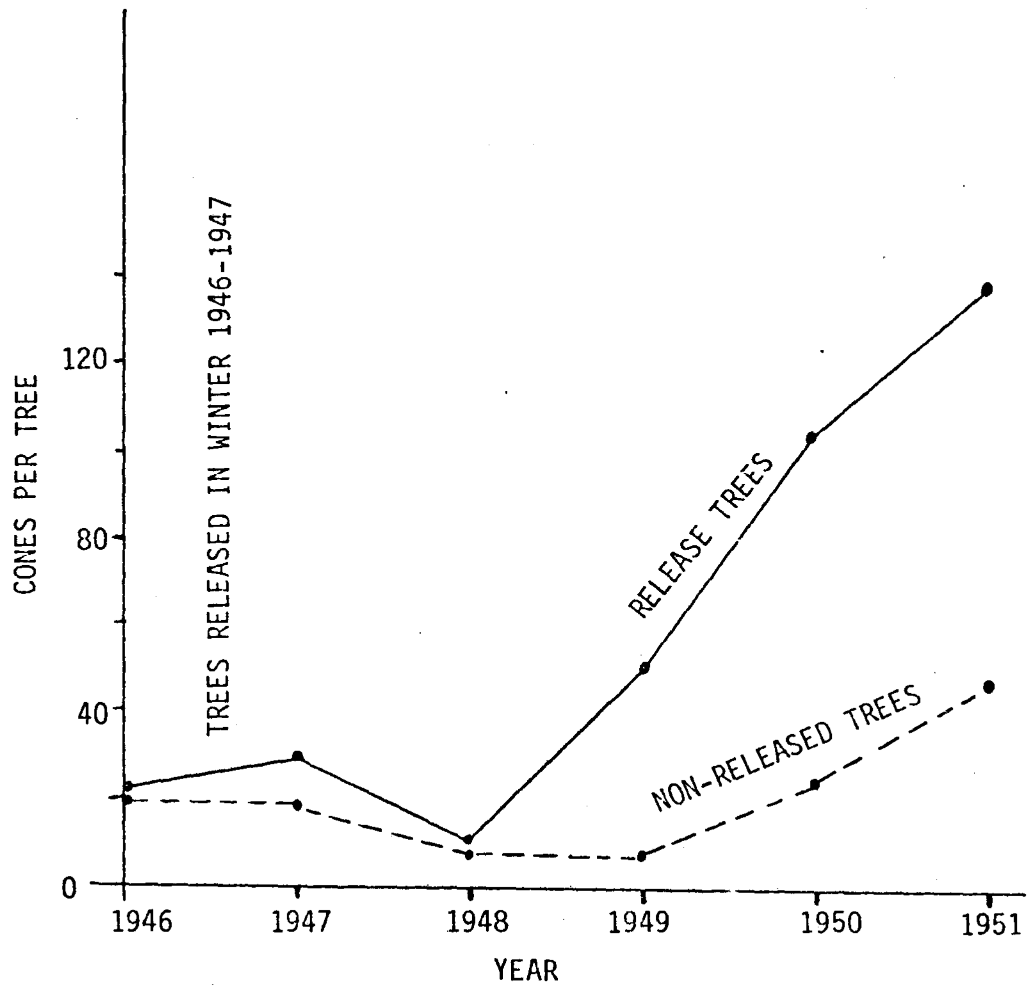

Figure 4.--Effects of preharvest release on cone production of loblolly pine (after Wenger 1954).

Seed Dissemination

Loblolly pine seedfall on the Santee Experimental Forest starts in early October and peaks in November (Fig. 5). By mid-November about 50 percent of the seed crop is on the ground, and by mid-December about 85 percent has fallen (Lotti 1961). Seed dissemination occurs in about the same pattern in the coastal plain of North Carolina (Wenger and Trousdell 1957).

Seed Germination

Loblolly pine seed germination starts in early April when temperatures become favorable. Under a full overstory, germination is often delayed several weeks or more. Thus, the seed lays dormant on the forest floor from 4 to 8 months and is subject to many forms of depredation. Rodents and birds eat an appreciable amount of seed during this period. Rodent populations, although small in uncut stands, build up rapidly after clearcutting and remain high for several years (Trousdell 1954).

Germination of seed and initial seedling establishment of loblolly pine are greatly enhanced by having a disturbed or mineral soil seedbed (Pomeroy 1949). Conversely, litter on the forest floor impedes germination and seedling establishment. Consequently, an increasing quantity of seed is required (table 1) to produce one seedling as one goes from a disturbed (mineral soil) seedbed, to a burned seedbed, and to an undisturbed seedbed. Seed requirements also increase with age of seedbed (Wenger and Trousdell 1957). Heavier textured soils afford a better seedbed (requiring less seed per established seedling) than lighter textured soils (Trousdell and Wenger 1963).

Table 1.--Number of sound seed required to establish one loblolly pine seedling by condition and age of seedbed (after Wenger and Trousdell 1957).

Condition of Seedbed	Age of Seedbed		
	1 Year	2 Years	3 Years
	--- No. Sound Seeds Per Seedling ---		
Disturbed	9	36	126
Burned	15	47	134
Undisturbed	46	--	427

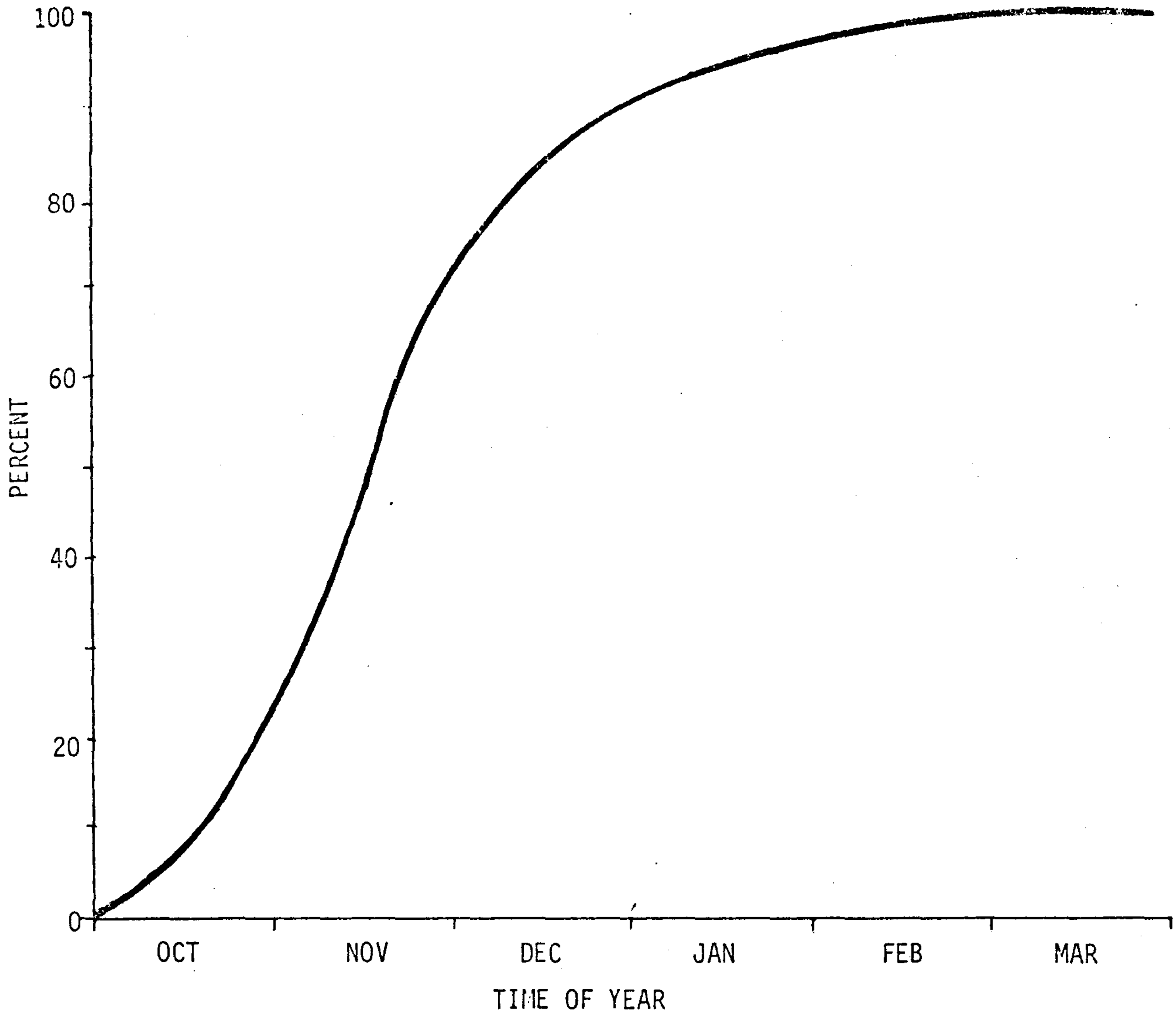

Figure 5.--Time of seed dissemination by loblolly pine (after Lotti 1961).

Soil Moisture

Soil moisture is a most important factor in the survival of newly germinated seedlings. Trousdell and Wenger (1963) found in a Bigwoods study that April through June rainfall in an interaction with amount of sound seed per acre accounted for 51 percent of variation in first year seedling establishment. Another study conducted in South Carolina and Virginia showed that the seed:seedling ratio decreased as the amount of rainfall between March 15 and May 1 increased (Fig. 6). Past weather records can be used to estimate rainfall probabilities. For example, in a 26-year period on the Santee Experimental Forest, rainfall in the March 15-May 1 period exceeded 3½ inches 75 percent of the time. There was only one year when rainfall in this period was less than 2½ inches.

Hardwood Competition

Even though there is an adequate supply of seed, a receptive seedbed, and ample soil moisture for seed germination and initial seedling establishment and growth, seedlings must have space in which to grow. Competition from large residual hardwoods can greatly reduce pine seedling stocking and subsequent seedling growth (Trousdell and Wenger 1963). These large, residual hardwoods left after a harvest cut should be controlled by chemical or mechanical means. Prescribed winter fires used periodically (every 5 to 7 years) during the rotation are excellent for controlling smaller hardwoods and for keeping the hardwood competition small (Lotti, et al. 1960). Large hardwood competition has a tremendous impact on loblolly pine seedling growth. Long-term studies have shown that controlling the large hardwoods at the time of regeneration doubled loblolly pine growth by age 20 (Langdon and Trousdell 1975), and controlling small hardwoods increased the loblolly pine growth by an additional 20 percent.

REGENERATION METHODS

The ecological and silvical characteristics of loblolly pine lend themselves to managing and reproducing the tree under several even-aged methods.

Seed Tree Method

In the coastal plain where seed crops are heavy and noted for their consistency, and where seed failures are rare, the seed tree method, with seed trees left standing singly or in strips has been used successfully to regenerate loblolly pine. From the knowledge that has been developed on cone and seed productivity, one can compute the minimum number of seed trees of a given size needed to reproduce a stand by types of seedbeds. Ordinarily, seedbeds will be most ideal for seed germination the first year after the harvest cutting. Each year thereafter their receptiveness will steadily decrease.

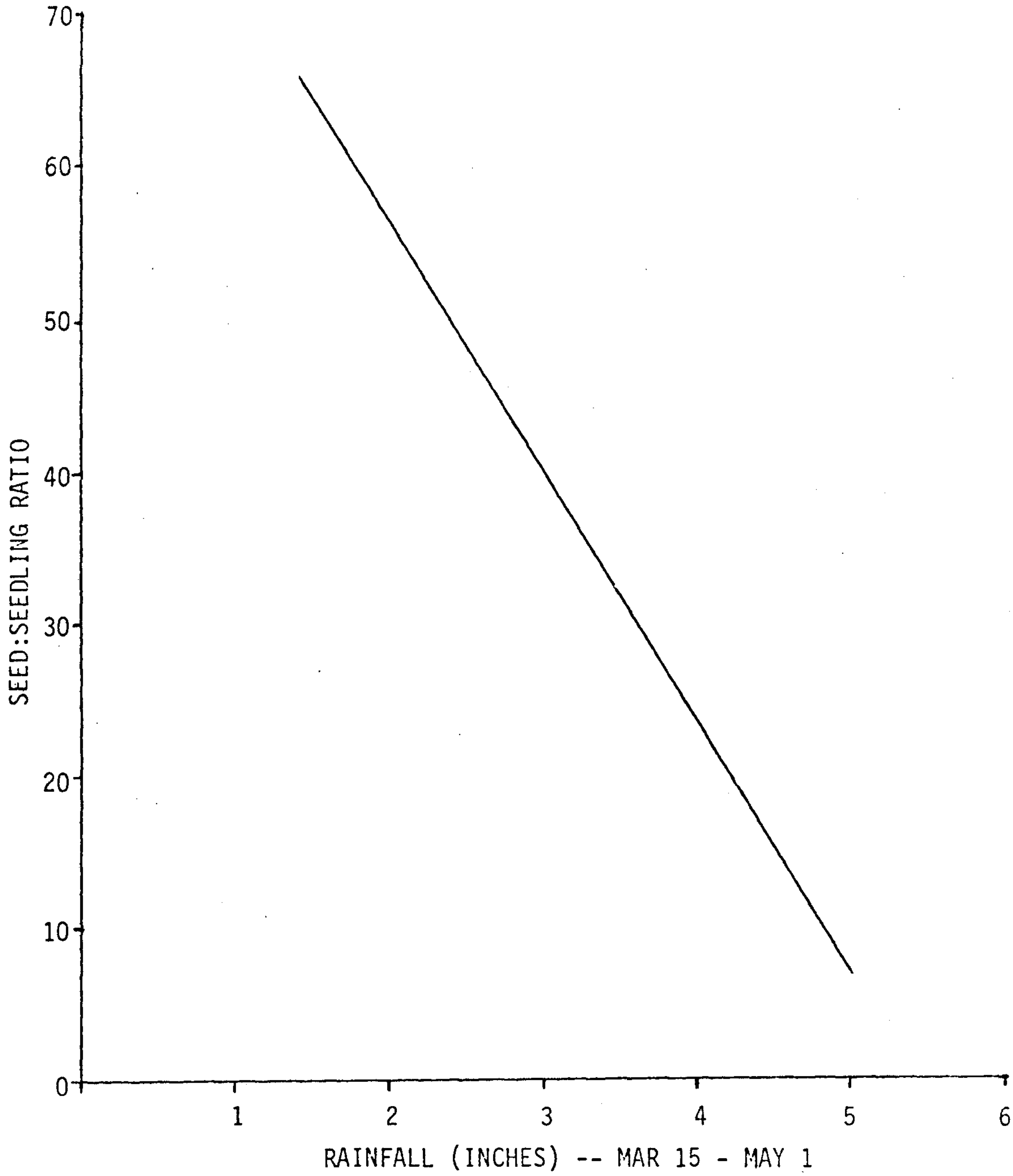

Figure 6.--Relationship between seed:seedling ratio and rainfall between March 15 and May 1.

In order to match an adequate amount of seed with the most receptive seedbed, seed trees should be released two growing seasons prior to the harvest cut. This preharvest release will increase the chances that the seed trees will produce enough seed the first year after the harvest to reproduce the stand. If loblolly pine seed trees are not released, then they will not likely produce enough seed until two years after the harvest cut. This delay increases the chances of a regeneration failure because receptiveness of seedbeds decreases and competition from hardwoods increases after logging and other seedbed and site preparation work (Wenger and Trousdell 1957).

Shelterwood Method

In the Piedmont or other areas where seed crops may not be as dependable as in the coastal plain, the shelterwood method of regeneration offers an attractive alternative to the seed tree method (Brender 1973). This method is recommended, not so much because shelter is needed for loblolly pine seedlings, but rather because more trees are left as a seed source under this method, which results in a more dependable seed supply. There may, however, be instances on droughty sites that shelter may be needed to reduce seedling transpiration and increase seedling survival. A heavy shelterwood may also have a place on very poorly drained sites in lower coastal plains where rising water levels after the harvest cut may impede seedling establishment and early seedling growth (Langdon and Trousdell 1978). If thinnings or other improvement cuts have not been carried out in the stand, then the preparatory or stand conditioning cuts used in this method can also provide for seed tree release.

Prescribed burning should also play a key role in this method in preparing seedbeds and controlling hardwoods. If prescribed burning is done periodically through the rotation, then toward the end of the rotation the advance reproduction that comes in after a good seed crop can be "stored" for a few years under a wide range of overstories (Brender 1973). In such cases, the seed cuttings and removal cuttings used in this regeneration method can be accomplished simultaneously and would be recognized by most observers as a clearcutting. Indeed, that is what it really is; distinctions among regeneration methods may often be blurred.

Clearcutting Method

The clearcutting method is more often associated with artificial than with natural regeneration because the "clearcut-site prepare-plant" system is so commonly used by the forest industry to reproduce loblolly pine. However, clearcutting with natural regeneration using seed from the trees harvested is also a viable alternative. This method, called "seed- or seedlings-in-place", was first conceived by Lotti (1961) after he observed in the coastal plain how prolific a seed producer loblolly pine was, how effective prescribed fire was in controlling small hardwoods and in preparing seedbeds, and how consistently seedling establishment was obtained. The question, then was: Why not regenerate a stand using this knowledge?

The concept (Fig. 7) involves using chemical or mechanical means to control large, unmerchantable hardwoods and prescribed fire to control small hardwoods and to prepare the seedbed. All of these measures are done prior to the harvest cut. The stand to be harvested is the seed source. After sufficient seed has fallen (30 to 50 thousand), the stand may be clearcut. If the stand is clearcut before seed germination in April, the method is called "seed-in-place". If the stand is clearcut after seed germination, it is called "seedlings-in-place", which is, in effect, the "advance" reproduction mentioned previously under the shelterwood discussion.

The concept has been tested in two different years in South Carolina and three different years in Virginia in a study involving 90 plots. Stands were logged in January-February for seed-in-place and in May-June and August-September for the seedlings-in-place treatments. The seed-in-place treatment resulted in more seedlings with better distribution than did either of the two seedlings-in-place treatments (table 2). Differences by treatment in stocking and number of seedlings were largely the result of logging damage. About two thirds of the seedlings initially established were destroyed by the logging. But in spite of this loss, an adequate number of seedlings were surviving at age 3 with a good distribution to assure a well-stocked stand in later years. This clearcutting method has proved to be an effective means of regenerating loblolly pine.

Table 2.--Number, size, and distribution of loblolly pine seedlings at 3 years using the seed- and seedlings-in-place method of regeneration.

Method	Date logged	Seedlings per acre	Stocking[a]	Height tallest[b]
		(no.)	(%)	(ft.)
Seed-in-place	Jan-Feb	10,500	91	3.7
Seedlings-in-place	May-Jun	1,800	49	3.0
Seedlings-in-place	Aug-Sep	1,500	51	2.5

[a] Percent of milacres having free-to-grow seedlings.

[b] Average height of tallest seedling measured on a milacre.

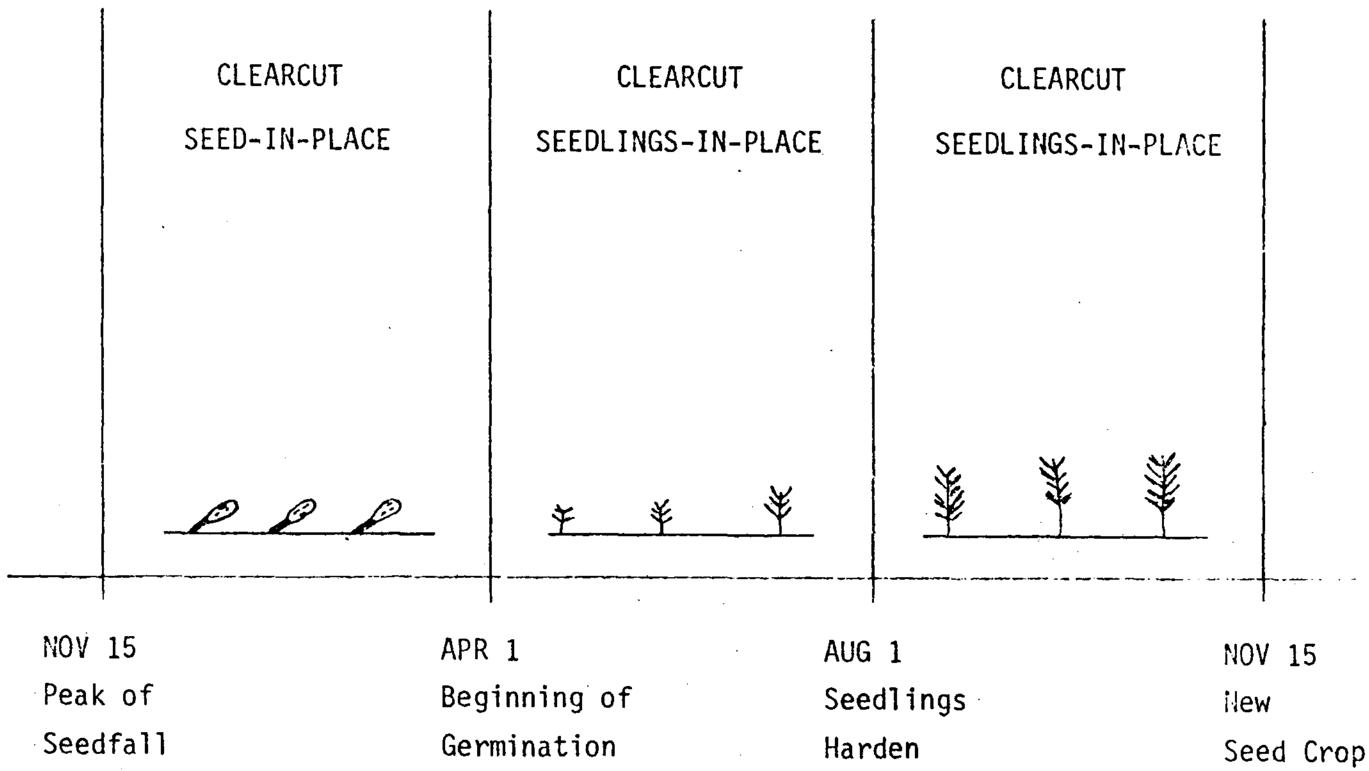

Figure 7.--The seed- seedling-in-place regeneration method by clearcutting.

SUMMARY

The known ecological and silvical characteristics of loblolly pine provide the basis for recommending several even-aged methods of natural regeneration. The seed tree method has been used successfully, but preharvest release of seed trees is highly recommended to help assure sufficient seed to establish seedlings the first year after the harvest cut. The shelterwood method is recommended for the Piedmont and other areas where seed production tends to be erratic, in the lower coastal plain on very wet sites where rising water table levels after a harvest may impede seedling establishment and early growth, or on droughty sites where high overstory shelter may increase seedling survival. The seed- seedlings-in-place variations of the clearcutting method are recommended especially for the Atlantic coastal plain region where seed production is prolific and rather consistent, and where prescribed burning or other measures have been used to prepare seedbeds and control the hardwood competition.

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