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In southwest Alabama, unburned seedlings under overstories ranging up to 90 square feet of basal area per acre survived as well as those with no tree competition. After 7 years, milacre stocking averaged 99 percent and survival 72 percent. Growth, but not survival, improved with distance from parent trees. Seedlings under tree crowns had less brown spot than those in the open.

Longleaf pine (*Pinus palustris* Mill.) is generally considered an intolerant species whose seedlings are unable to withstand prolonged competition from overstory trees. In good seed years, abundant reproduction often becomes established under well-stocked stands, but with the passage of time it seems to melt away. Chapman once said (*3*)1/ that "... not a single longleaf seedling has ever survived under the shade of either hardwoods, pine, or brush of any kind." Others have also reported poor survival and slow growth of longleaf seedlings under an overstory (*2*, 4, 8). However, Smith (6) in Mississippi found that seedling survival was unaffected by 9 years of seed-tree competition. The many reports of the poor competitive performance of longleaf led to the conclusion that release of newly established seedlings should not be delayed.

The difficulty with early release is that usable seedling stands become established infrequently--perhaps in less than 1 year out of 5. As it is impractical to confine removal cuts to these occasions, some delay is inevitable. The question is whether seedlings can survive some overstory competition. If so, how much and for how long?

This paper reports two studies of parent-tree competition on sites in southwest Alabama. The first measured seedling development at various distances from seed trees or forest walls. The other observed their development under a wide range of overstory densities. Each study is described separately.

1/ Italic numbers in parentheses refer to Literature Cited, p. 5.

SEED TREES AND FOREST WALLS

Methods

Starting in 1949, seedlings from the 1947 crop were observed on 40 transects originating at solitary seed trees and 40 extending from forest walls. The sample included seedlings that had become established on average and poor sites on the Escambia Experimental Forest and on a fresh burn and a 1-year rough on average sites of the Conecuh National Forest. Sites classified as average had sandy loam or heavier subsoil within 2 feet of the surface. The poor sites were deep sands lacking any soil heavier than a loamy sandwithin 30 inches of the surface.

Each transect consisted of a row of 8 square, milacre subplots that began 3.3 feet from the base of a marked pine. Forest-wall transects had two additional subplots in line with the main transect but inside the wall. Three longleaf seedlings in each subplot were marked and their survival, root-collar diameter, and brown-spot infection periodically recorded. After the third year, diameter measurements were made of only the largest seedling on each subplot.

The overstory trees were second-growth longleaf pine, from 35 to 45 years of age. Half of all seed-tree and forest-wall transects originated at trees classed as small (8 to 10 inches in diameter at breast height) and half at large trees (11 to 14 inches d.b.h.).

Results

By age 7 years, when survival was measured for the last time, 38 percent of the marked seedlings on exterior transects were still alive (table 1). Those established on a fresh burn survived much better than the rest. Prescribed burns made when the seedlings were 3 and 6 years old killed 17 percent of them, hogs destroyed 12 percent, and minor causes 8 percent. Cause of the remaining mortality could not be identified, but the fires may have been at least partly responsible.

Fire losses on forest-wall transects were heaviest under the canopies of trees, where seedlings were small and the fires burned hot in the needle litter. Most of the mortality resulted from the first burn.

Fire mortality on seed-tree transects was about half that on forest-wall transects. Sixty-two percent of it followed the second fire, when the seedlings were 6 years old. The first burn damaged chiefly the seedlings under the crowns of seed trees, which were smaller and more susceptible than those in the open. Three years later, most seedlings near seed trees had become large enough to withstand fire, while those in the open had advanced to the stage of early height growth and therefore were highly vulnerable (fig. 1). Distance from parent trees had no influence on survival except by affecting susceptibility to fire.

Table 1. --*Survival of marked longleaf seedlings at 7 years of age*

Location	Fresh burn, average site, Conecuh	One-year rough			All
		Average site		Poor site, Escambia	
		Escambia	Conecuh 1/		
	Percent				
Seed trees	66	33	38	29	41
Forest walls	59	27	28	24	35
All	63	30	33	27	38

1/ Seedlings at age 5 years.

Figure 1.--*Six-year-old longleaf seedlings near a seed tree. The white tapes mark the transect.*

Growth comparisons were based on rootcollar diameters, the only dimension that can be readily measured on stemless grass-stage longleaf seedlings.

At 10 years of age, seedlings on seed-tree transects were considerably larger than those on forest-wall transects, though the differences were most pronounced on subplots nearest the parent trees. All seedlings increased in size with increased distance from the parent trees (fig. 2). Overall size relationships, including the average diameter of 1.2 inches, were the same on poor as on average sites. There were indications, however, that parent trees suppressed seedlings for a greater distance on poor than on average sites, and that on poor sites suppression by forest walls extended beyond the transect. Parent-tree size did not significantly affect seedling size over transects as a whole, but walls with large trees seemed to suppress seedlings over a greater distance than walls with small trees.

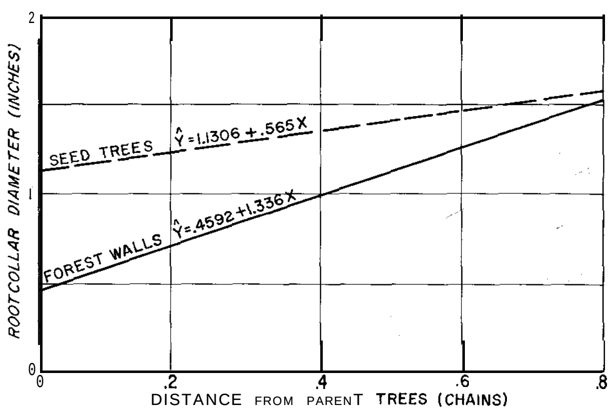

Figure 2. - - *How size of IO-year-old seedlings varied with distance from parent trees.*

Transects on the l-year rough on the Conecuh National Forest were abandoned when seedlings were 5 years old. At that time, seedlings established on the fresh burn averaged 0.85 inch in diameter, as compared to 0.52 inch for those started on the l-year rough. Similar results have been observed before (I). The fresh burn, made in late summer, may have killed more competing vegetation than the earlier winter burn, or perhaps mineral nutrients from the ashes of the summer fire were still available to the newly germinating seedlings. At all events, the seedlings on the fresh burn apparently acquired a growth advantage that persisted through at least 5 years.

Brown spot on marked seedlings was almost nonexistent at age 1. During the second year the disease spread rapidly--53 percent of the seedlings were infected--but the intensity remained very low. By the end of the third year 84 percent of all seedlings were diseased, and 21 percent of their foliage had been destroyed.

The proportion of seedlings infected was about the same for all site conditions, but the amount of needle tissue destroyed was significantly greater (0.01 level) on poor sites and l-year roughs than on good sites and fresh burns. Siggers (5) also observed heavier infection on poor sites. The disease was more severe on seed-tree transects than on forest-wall transects, though the difference was notable only on poor sites and l-year roughs.

Seedlings beneath tree crowns generally were lightly diseased, while those in the open had considerably more infection. The apparent sheltering effect of a group of trees in a forest wall was greater than that of a single tree. Wahlenberg (7) noted that large seedlings seem more susceptible to infection than small ones, but some factor in addition to seedling size appeared to exist in the present study. As figure 3 indicates, the amount of brown spot rose sharply just beyond the edge of the tree crowns, and then remained fairly constant. Seedling size, by contrast, increased regularly with distance along the transect.

Brown-spot infection was not measured after the third year.

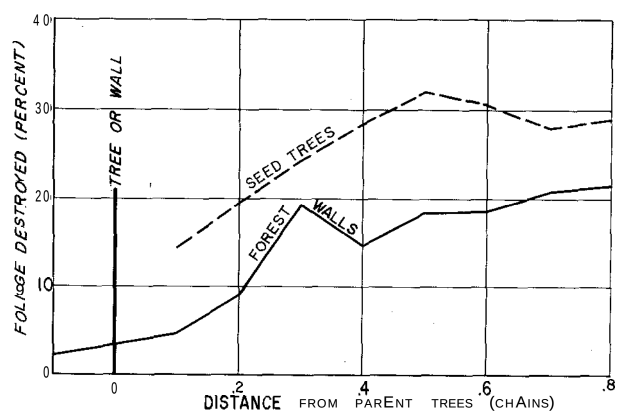

Figure 3. - - *Change in brown-spot infection of 3-year-old longleaf seedlings with distance from parent trees.*

OVERSTORY DENSITY AND SEEDLING DEVELOPMENT

Methods

The effect of overstory density on the survival and development of longleaf pine seedlings was measured by a study established on the Escambia Experimental Forest early in *1957.* Plots were installed in 40- to 60-year-old stands of second-growth longleaf, where abundant reproduction had resulted from a seedbed burn in January 1955 and a good seed crop in the following fall.

Ten 4-milacre plots sampled each of 7 different densities of overstory. Four densities were created in March 1957 by cutting back to 0 (clearcut), 9, 27, and 45 square feet of basal area per acre. Except for the clearcut area, each stand was 2.5 acres in size and had 52 to 65 square feet of basal area per acre before cutting. The trees left after cutting averaged 13 inches in d.b.h., or nearly 1 foot in basal area. Plots under 30, 60, and 90 square feet of basal area were established at locations that met specifications and thus required no cutting.

After logging was completed, three average, healthy, l-year-old seedlings per milacre were marked and all seedlings of other ages were removed. Milacre stocking of all 1955 seedlings and the mortaiity of marked ones were recorded quarterly through January 1960 and annually thereafter. Root-collar diameters of marked seedlings were measured annually beginning in September 1959, and brown-spot infection was recorded annually beginning in January 1960.

Seedlings under overstories have never been burned, but the clearcut plots were prescribe-burned in January 1960 for control of brown spot. The uncut plots have been grazed continuously by cattle; the other plots were fenced *to* exclude *cattle.*

Results and Discussion

In April 1957, the plots had an average of 12,400 one-year-old longleaf seedlings per acre. Milacre stocking was 100 percent. By January 1963, this number had decreased to 7,500, and milacre stocking averaged 99 percent.

At age 4, survival under uncut stands was high and uniform for all densities (table 2). Seedlings under the cut stands suffered some mortality, two-thirds of which occurred during the first spring and summer after reltase. Post-logging or release effects may have been responsible, but the cause was undetermined. Grazing intensified on the uncut plots after 1960, and caused much of the mortality since that date.

Overstory competition retarded seedling growth (fig. 4). On both cut and uncut plots, average diameter at the rootcollar decreased as overstory density increased. After 7 years seedlings on clearcut areas were more than twice as large as those in stands with 90 square feet of basal area per acre. The proportion of marked seedlings in height growth (at least 6 inches tall) was 26 percent for seedlings in the open and 4 percent for those under 9 square feet of overstory. Under heavier overstories, no seedlings had begun height growth by age 7.

Brown-spot infection was high in the clearcut areas and low under overstories. The incidence and severity of the disease decreased with increasing overstory density in both cut and uncut stands. In 1960 the proportion of foliage destroyed averaged 32 percent in clearcut areas, 10 percent under an overstory of 9 square feet, and 7 percent under 90 square feet. By January 1963 the proportions were *51, 21,* and 11 percent. The development of the disease was somehow inhibited by the presence of an overstory.

Table 2. --*Overstory density and* survival *of marked longleaf seedlings*

CUT STANDS

Basal area per acre (square feet)	Seedling survival	
	Age 4	Age 7
	-- Percent	*-*
0	*79*	*76*
9	*72*	*67*
27	*72*	*68*
45	*78*	*70*
UNCUT STANDS		
30	*92*	*65*
60	*92*	*78*
90	*92*	*80*

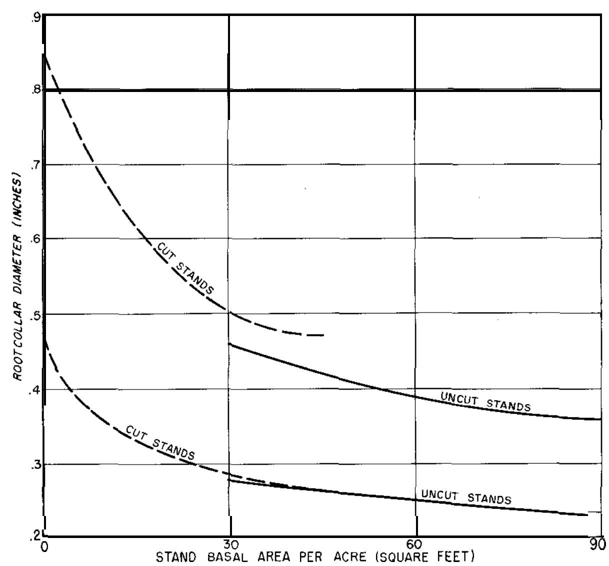

Figure 4. --*Seedling sizes* at ages 4 *and* 7 years, *in relation to overstory density.*

SUMMARY AND CONCLUSIONS

In the absence of fire, overstory density had no effect on seedling survival. Seedlings survived and remained healthy under overstories ranging up to 90 square feet of basal area per acre, under which survival of ?-year-old seedlings averaged 80 percent.

Fire mortality was related to parent-tree competition. Differential suppression by seed trees and forest walls resulted in seedlings varying in size. Prescribed fires then caught many seedlings either too small or too large to be resistant. Most fire losses occurred directly under parent trees, where maximum suppression was combined with maximum accumulation of needle fuel.

Though the retarding effect diminishes rapidly with distance, even light overstories suppress growth severely. Thus a relatively light overstory of 30 square feet of basal area per acre accounted for more than 70 percent of the size difference between open-grown seedlings and those beneath an overstory of 90 square feet.

Brown-spot infection of longleaf seedlings was high in open areas and low within forest stands. The presence of an overstory appeared to inhibit the development of the disease.

The results suggest that, in the absence of fire and on average or good sites, good longleaf seedling stands can be retained under relatively heavy parent overstories for at least 7 years. This finding can simplify some problems of natural regeneration. Seedlings established in one of the occasional good longleaf seed years can be stored under a full and productive pine overstory until scheduled harvest cuts take place. Overstory removal can then be based on the needs of management rather than a silvicultural requirement for prompt seedling release,

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