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ESTABLISHMENT OF SWAMP TUPELO SEEDLINGS AFTER REGENERATION CUTS

Abstract. --Environmental factors influencing natural regeneration of swamp tupelo were examined in a study involving five harvest treatments replicated in 3 successive years. Initial seedling establishment was related to seed production, but other factors probably are more limiting in most years. Abundance of established seedlings differed significantly with harvest cuttings, probably because of temperature and shading effects. Year of cutting also led to significant differences in number of seedlings established, which probably resulted from effects of water table levels in the swamp. Because competition from other vegetation is abundant, the adequacy of regeneration established cannot be assessed at present.

Swamp tupelo (*Nyssa sylvatica* var. *biflora* (Walt.) Sarg.) is a major hardwood species on wetland sites in the Southeastern Coastal Plain. Although swamp tupelo has many important uses and covers thousands of acres, little is known of silvical requirements for regenerating the species. To help fill this gap in our fundamental and practical knowledge of wetland hardwoods, a study of environmental factors influencing natural regeneration of swamp tupelo was established in a headwater swamp (Bluebird) located in the lower coastal plain of South Carolina.[1] Our paper reports on seedling ‘establishment following five harvest treatments replicated in 3 successive years.

METHODS

Treatments

Five plots 7 chains square (4.9 acres) were laid out in each of three blocks in a nearly pure stand of even-aged, 90-year-old swamp tupelo.[2] The following harvest treatments were assigned randomly to plots in each block:

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[1] A cooperative study with the Francis Marion National Forest.

[2] For a detailed description of the site and stand, see: DeBell, D. S., and Hook, D. D. Seeding habits of swamp tupelo. Southeast. Forest Exp. Stn., U.S. D.A. Forest Serv. Res. Pap. SE-47, 8 pp. 1969.

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(1) control (no cutting, approximately 250 trees per acre)
(2) 90 trees left per acre
(3) 30 trees left per acre
(4) 15 trees left per acre
(5) clearcut (no trees left)

Block I was harvested in 1965-1966, Block II in 1966-1967, and Block III in 1967-1968, each in the dormant season (December through March). During the growing season prior to each harvest, all plots of each block were mist-blown with 2,4,5-T to kill a heavy understory. An additional effect of this treatment was killing advanced reproduction of swamp tupelo. Larger undesirable trees were poisoned by injector treatments with the chemical. Following logging, swamp tupelo stumps were sprayed with a 1: 30 solution of 2,4,5-T esters and diesel oil to prevent sprouting.

Measurements

All data were collected at randomly selected points in a central measurement plot 3 chains square (0.9 acre) within each harvest treatment plot. Measurements consisted of:

(1) Seed production estimates obtained from five O.l-milacre seed traps.

(2) Seedling establishment sampled in 10 circular milacre plots; two were located adjacent to each seed trap to relate seed production to seedling establishment. Furthermore, each quadrant (NE, SE, SW, and NW) of milacre plots was categorized by predominant type of logging disturbance: major skid trail, minor skidding, light slash (less than 3 inches in diameter), heavy slash (more than 3 inches in diameter), and undisturbed.

(3) Water table levels determined at two observation wells in each measurement plot .

Seed production data were collected from September to December prior to harvesting in each block. Water table and seedling establishment data were obtained during and at the end of the first growing season for Block II (1967) and Block III (1968). A complete seedling failure in the 1966 growing season necessitated use of data collected during and after the second growing season for Block I (196'7).

RESULTS

Seed-Establishment Relationships

Seedling establishment on milacre plots was related by linear regression to seed catch in adjacent seed traps. The following equation accounted for only 18 percent of the variation (highly significant) in seedling establishment:

$$Y = 8.9533 + 0.06212 X$$

where Y = seedlings per milacre, and

X = seed trap yield of the previous fall.

Data concerning seed production of the original stand immediately prior to harvest cutting were also tested by analysis of variance for differences associated with block, harvest treatment, and the block-harvest treatment interaction. Highly significant differences in seed production were associated with these factors.

Effects of Block and Harvest Treatment

Because seedling establishment was related to seed production and the latter varied significantly with block and harvest treatment, covariance analysis was used to evaluate differences in seedling establishment associated with block and harvest treatment. After removal of seed production effects, blocks were significantly different in seedling establishment at the l-percent level; harvest treatments, at the 5-percent level. Block and harvest treatment means were adjusted for seed production effects and compared by Duncan's New Multiple Range Test (table 1).

Table 1. --First-year seedling establishment by block and harvest treatment in Bluebird Swamp, coastal plain of South Carolina

	Blocks			Harvest treatments				
	I	II	III	30 trees left/acre	Control	90 trees left/acre	Clearcut	15 trees left/acre
	Number of seedlings per acre							
Raw mean	14,520	11,620	720	12,000	13,930	9,070	5,370	4,400
Adjusted mean[1]	12,810	11,860	2,190	12,460	12,330	9,180	5,530	5,270

[1]Means adjusted for seed production effects. Values not underscored by the same line are significantly different at the 5-percent level (Duncan's New Multiple Range Test).

Water Table Differences

Blocks were cut in successive years; therefore, it is "year effect" that is being evaluated. Weather conditions and resulting water table levels varied considerably in the first growing seasons after harvesting of Blocks I (1966), II (1967), and III (1968). Biweekly water table readings from 10 observation wells were averaged and plotted for each block to check for possible relationships with seedling establishment (fig. 1). Water table levels in 1966 were more than 0.3 foot above the soil surface from late January to early October. A survey in Block I revealed that no seedlings had survived the first growing season after the harvest cut. Thus, seedling establishment data presented for

Block I were collected after two growing seasons; accordingly, water table levels for 1967 also are presented for Block I. Water levels dur-, ing 1967 were below the soil surface in Blocks I and II from mid-April to early June. Our data also indicate that 1968 was a year of extremes. Spring was dry, with water table levels ranging from 1 to 1.5 feet below the soil surface; from mid-June through July water levels averaged 0.7 foot above the soil surface. This was followed by steady drying of the soil through late October.

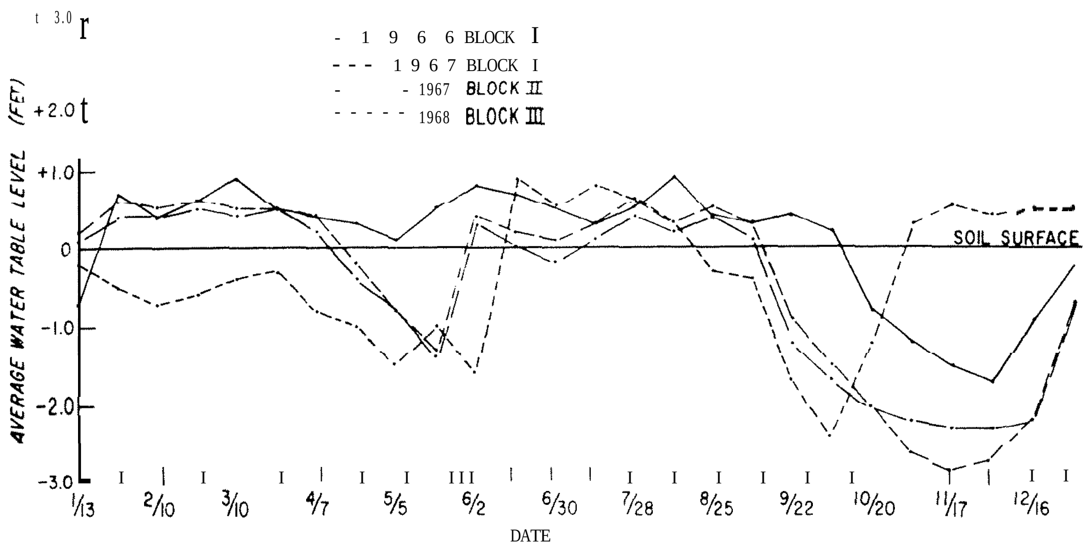

Figure l.--Water table levels in Bluebird Swamp during establishment of swamp tupelo seedlings after five harvest treatments.

Effects of Logging Disturbance

Seedling establishment data were also summarized by logging disturbance class with blocks as replicates and tested by analysis of variance procedures. Although the means for disturbance classes were quite different (see tabulation), the F-test was not significant because of insufficient replication.

Logging disturbance class	Mean number of seedlings /acre
Major skid trail	6,560
Minor skidding	30,120
Light slash	18,680
Heavy slash	30,000
Undisturbed	25,520
Average	22,180

DISCUSSION

Seed production differences had highly significant effects on seedling establishment, but accounted for only 18 percent of the variation. Apparently other environmental factors were more limiting to seedling establishment. This seems reasonable- -previous work[3] indicated that in most years swamp tupelo is a prolific seed producer (4-year average = 400,000 seed per acre) and that seed are rather uniformly distributed over the area.

Even when adequate seed are available for regeneration, the success of germination and early growth is extremely dependent upon water levels. DeBell and Naylor[4] have found that swamp tupelo seed will not germinate when the water table is at or above the soil surface, regardless of temperature or aeration status of the water. After germination, tupelo seedlings must grow rapidly if their apex and leaves are to remain above the water; otherwise, prolonged complete submergence during active growth is likely to kill them. This unfortunate consequence was aptly demonstrated in 1966. Spring water levels were high, but some germination did occur on high spots in late April. Water levels were extremely high in May and no seedlings survived.

Another deleterious effect of high water level occurred in 1966. Most seed in the swamp were submerged from January through early October and therefore could not germinate. However, many seed germinated in November and early December after the water table receded below the soil surface. The resulting seedlings did not "harden-off" and were killed by winter cold.

When swamp tupelo seedlings are well established, water levels slightly above the soil surface but below the seedlings' leaves are probably beneficial to growth. in the 3 years investigated, established reproduction was most abundant in 1967 on Block II (also Block I). In that year, spring germination and early height growth occurred from mid-April to early June when water levels were below the soil surface. Summer water levels slightly above the soil surface were probably conducive to growth by (1) maintaining favorable water balances in the seedlings, and (2) reducing competition. In other work[5] we found that growth of mature swamp tupelo is reduced when water levels drop below the soil surface and soil dries. Furthermore, general observations in Bluebird Swamp indicate that many weed species which compete with swamp tupelo seedlings do not become established when water levels are high. It seems likely that the lower number of seedlings established in 1968 (Block III) partly resulted from a combination of extreme dryness and competition from weeds.

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[3] Ibid.

[4] DeBell. D. S., and Naylor, A. W. Some factors affecting germination of swamp tupelo seeds. (In preparation for publication.)

[5] DeBell, D. S., Hook, D. D., and Langdon, 0. G. Diameter growth of swamp tupelo: Seasonal pattern and relation to water-table level. (In preparation for publication.)

Since logging was done in the dormant season after seedfall was complete, harvest treatment effects do not involve seed supply. Any minor statistical differences in plots due to seed production were removed by covariance analysis. Nevertheless, there were significant differences in seedling establishment; the control plots and those with 30 and 90 trees left averaged more than twice as many seedlings as clearcut plots and those with 15 trees left. Apparently, environmental conditions under an overstory containing 3 0 to 250 trees per acre are favorable for germination and early growth of swamp tupelo. Shading and temperature effects probably are the most important differences. General observations on other swamp tupelo sites indicate that advanced reproduction is common in undisturbed stands.

Though significant differences by logging disturbance class could not be established by our analysis, the means for major skid trails, minor skidding, and heavy slash were large departures from the overall average. Because of many general observations in the field, we believe that differences may be real in these cases and deserve comment. We have observed that very few seedlings become established in major skid trails. Those which germinated soon turned yellow and died, probably because of high temperatures occurring on the dark soil surface. Furthermore, major skid trails became thick slurries about 3 feet deep immediately after logging, and were prone to harden and crack upon drying. Such extremes would be detrimental to seedling establishment. Conversely, the slight disturbance associated with minor skidding was apparently beneficial to germination and seedling establishment. We also believe that heavy slash creates favorable conditions. Seedlings established in clearcuts and plots with 15 trees left appear to be congregated in piles of slash and on the shady side of logs and stumps. Shade and lower temperatures are probably the important factors.

CONCLUSIONS

This report on Bluebird Swamp has shown that:

(1) Seedling establishment is related to seed production. Swamp tupelo is a prolific seeder and other factors probably are more limiting to initial establishment in most years.

(2) Germination and early growth are extremely dependent upon water levels.

(3) First-year seedlings are most abundant in partial cuts with more than 30 trees left per acre and in the uncut control plots. Fewest seedlings are found in clearcuts and partial cuts with 15 trees left per acre; those present are congregated in piles of slash and on the shady side of logs and stumps.

(4) Major skid trails are unfavorable for seedling establishment.

Because competition from other vegetation is severe, the success or failure of regeneration established in the various cutting treatments cannot be fully determined for some time. In the interim, we recommend that owners of swamp tupelo stands consider other regeneration methods--advanced reproduction, stump sprouting, and planting nursery grown stock --where early establishment is not so dependent upon favorable water levels.

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