EFFECT OF RESIDUAL TREES ON NATURAL REGENERATION IN A TUPELO-CYPRESS SWAMP AFTER 24 YEARS [1]

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Abstract. Experimental harvests were made in a 500 acre non-alluvial swamp on the Francis Marion National Forest in the mid 1960's to test for effects of residual trees on natural regeneration of the swamp tree species. Treatments were clear cut, leave 90, 30, and 15 trees per acre, and no cutting. All leave trees were swamp tupelo (*Nyssa sylvatica* var *biflora*), about 90 years old. First year seedling establishment of swamp tupelo varied from 12,460 seedlings per acre (s/a) with 30 leave trees per acre to 5,270 s/a with 15 leave trees per acre. However, within a few years after harvest, loblolly pine (*Pinus taeda*) seedlings became an important component of the regenerating stand and were the largest individuals on the site at age 24. Bald cypress (*Taxodium distichum*) was next in size. Swamp tupelo trees were smaller than the above species. All large loblolly pine occurred on hummocks whereas swamp tupelo occurred in the matrix of the swamp. Growth of swamp tupelo was sensitive to number of residual trees and appeared to stagnate at high densities. Pre- and post-harvesting measurements of water table levels showed that roads and harvesting had little or no affect on water table levels in the swamp. Hurricane Hugo reduced the basal area and density of loblolly pine in the treatment plots by as much as 80 %. It appears that periodic hurricanes may play an important role in reducing the stocking of loblolly pine in shallow swamps in coastal plain shallow swamps.

Introduction

A regeneration experiment was established in a 500 acre non-alluvial swamp on the Francis Marion National Forest in 1963. The swamp was composed of an even-aged stand of swamp tupelo (*Nyssa sylvatica* var *biflora*) and baldcypress (*Taxodium distichum*) that was approximately 90 years old. Bayboro series (clayey, mixed, thermic Umbric Paleaquults) cover the entire site and are listed as hydric soils by the Soil Conservation Service (1991). The stand contained 245 stems per acre that were 5 inches or greater in diameter, had 168 sq ft basal area per acre, and 24,000 bd ft per acre (Scribner rule) of saw log sized timber.

Objectives

The objective was to determine how different residual levels of swamp tupelo trees affected regeneration and subsequent growth of tree species in the swamp.

Methods

A study area containing fifteen 4.9-acre plots was laid out in the swamp during the summer of 1963. Before harvesting the entire experimental area (about 75 acres) was sprayed with 2, 4, 5-T by a mistblower mounted on a small tractor. After harvest stumps were sprayed with 2, 4, 5-T and large undesirable trees were poisoned. The five treatments were: clearcut, leave 15, 30, and 90 seed trees per acre, and a control. All leave trees were swamp tupelos and were spaced as evenly as possible within the treatment area. The treatments were arranged in three blocks. One block was located above a logging access road that was built across the swamp in the fall of 1965 and two blocks were located below the road. Five shallow wells (about 3 feet deep) were established in each plot and water table levels were recorded every two weeks from March 1964 until 1969. Block I was harvested during the dormant season of 1965-66, Block II in 1966-67, and Block III in 1967-68. The harvest was done under a regular U. S. Forest Service Contract and rubber tired skidders were used to log the area.

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[1] Paper presented at the Seventh Biennial Southern Silvicultural Research Conference, Mobile, AL, November 17-19, 1992.

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In the summer of 1992, three 0.1 acre circular plots were randomly established within the central one acre area of each plot in each treatment for a total of 45 plots. The diameter of all stems 4.5 feet and taller were measured and species were recorded on each plot. Hurricane Hugo damage was documented for each stem as to whether it was leaning, bent, or broken. All blown down or broken loblolly pine stems were measured at dbh and recorded as dead in each plot.

The data was analyzed as a randomized complete block design. Regressions were also used to test for trends.

Results

The main skid trails were deeply rutted and although relatively obscure, can be seen today. Virtually no regeneration occurred in the main skid trails but all of the surrounding area regenerated quickly (after one year there were about 12,000 seedlings per acre in the leave 30 and control areas and over 5,000 seedlings per acre in the clearcut and leave 15 trees per acre; see DeBell and Auld, 1971). Analyses of water table levels among the three blocks before and after the harvest showed that there may have been slightly more water in Block I (above the road) than in Blocks II and III when the water table was above the soil surface (Figure 1). However, there were no major changes in pattern of water table responses among blocks.

A total of 35 herbaceous and woody species with individuals 4.5 feet or taller were found within the study area. After 25 years, red maple (*Acer rubrum*), swamp tupelo, baldcypress, and loblolly pine (*Pinus taeda*) were the dominant tree species in all of the regeneration plots. Basal area per acre, number of stems per acre, average basal area per tree, and average stem diameter varied by species and treatment and average basal per tree and average diameter had a species x treatment interaction for the four species (Table 1 and Figure 2).

Hurricane Hugo blew down 47 to 81 % of the loblolly pine basal area in the four treatment areas and 46 to 71 % of the stems per acre (Figure 3). Few or none of the other species were blown down by Hugo but they were bent or leaning from wind and falling trees. Red maple basal area remained essentially constant across treatments but the basal area of the other three species tended to decrease with increasing number of residual trees (Figure 2).

Table 1. *Tukey mean separation of treatment effects on the four major tree species in Bluebird Swamp 24 years after regeneration cuts.*

Species Basal Area	Species Stems per Acre	Average Basal Area	Average Diameter
RM A*	ST A	LP A	LP A
LP A	RM B	BC B	BC B
ST A B	BC C	RM B C	RM C
BC B	LP C	ST C	ST C

RM = Red Maple; LP = Loblolly Pine; ST = Swamp Tupelo; BC = Baldcypress

* Species with the same letter in the column were not significantly different at the 0.05 level.

Swamp tupelo and red maple had the highest stocking in number of stems per acre, ranging from 998 to over 2,500 stems per acre among the four treatments (Figure 2). Number of stems of red maple was very consistent across the four treatments and control (Figure 2).

Loblolly pine had the largest average diameter and basal area per tree (ba/t) on all regeneration cuts (ba/t ranged from 0.29 to 0.56 sq ft per tree among the four cuts; Figure 2). Baldcypress had the second highest average diameter and basal area per tree (ba/t ranged 0.08 to 0.18 sq ft per tree among the four cuts; Figure 2). Average diameter of swamp tupelo and red maple were much smaller than loblolly pine and baldcypress (Table 1 and Figure 2).

Only 12 species ranked among the top ten species in importance values for all treatments and control (Figure 4). Swamp tupelo, red maple, and loblolly pine were among the top 5 in importance values in the four harvest cuts whereas red maple, swamp tupelo, and fetterbush (*Leucothoe racemosa*) were the top 3 and loblolly pine was 9th in the control plots (Figure 4). Wax myrtle (*Myrica cerifera*) and fetterbush were among the top 10 in importance values in all treatments. Baldcypress ranked 5th in importance value in the clearcut and 6th in the leave 15 and 30 tree cuts, and 10th in the control. It was not among the top ten in the 90 leave tree cut.

Discussion

The establishment and rapid growth of loblolly pine was not expected and to our knowledge has not been previously reported in a swamp of this type. Also, the extremely slow growth of swamp tupelo was not expected. The species is not know for fast growth but an average diameter breast height

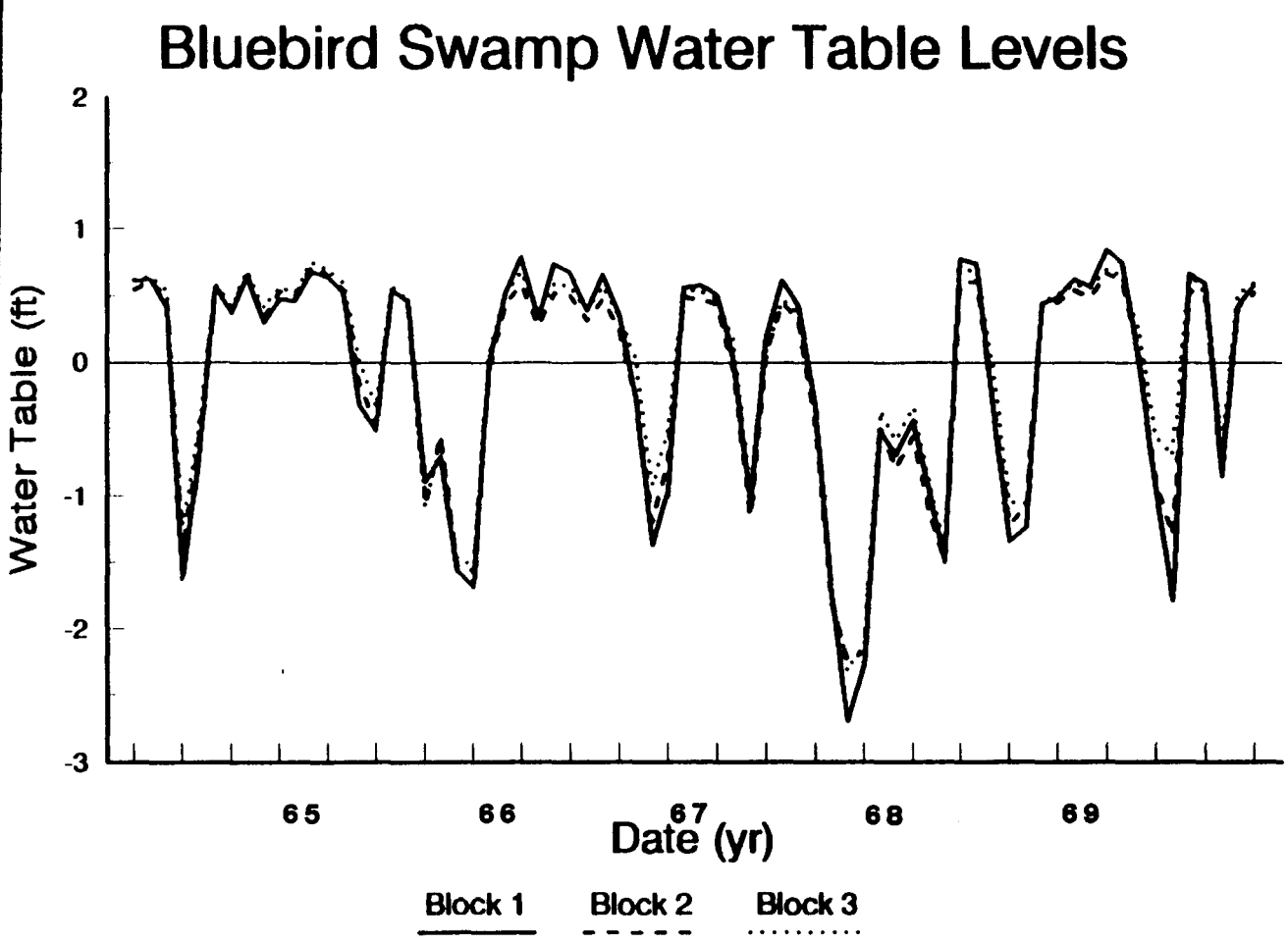


Figure 1. *Water table levels in Bluebird Swamp from March 1965 through 1969 by Block and year.*

(dbh) of less than 2 inches after 25 years was less than expected. Six years of water table data (1964-69) showed that the swamp was flooded 56 % of the time during the growing season (mid March to mid October). Also, there were about 2,800 stems per acre of the four dominant species at age 25 and swamp tupelo accounted for over 50 % of the stocking. It appears that swamp tupelo does not readily express dominance and may stagnate at these high stocking densities. A thinning study by Westvaco in a water tupelo (*Nyssa aquatica*) stand showed that stems in non-thinned stands were about 6 inches dbh and in thinned stands were about 10 inches dbh at 25 years (John Martin, personal communications).

The composition of the regenerating stands were remarkably similar despite the differences in number of leave trees. Although growth of the regeneration appeared to be impacted by the number of leave trees, the impact was less than expected. Finally, the high impact logging done in the late 1960's appeared to have had little affect on the composition, hydrology, and growth of the vegetation in this swamp. The road probably causes some minor ponding.

Initially, we thought that the deep skid trails may have caused some internal drainage of the swamp and resulted in the establishment of loblolly pine. However, close examination of the area showed that every rapidly growing loblolly pine was on a natural hummock in the swamp. No loblolly pine existed in the matrix of the swamp (i. e. loblolly pine did not exist in the areas where water stands about 0.5 feet deep during flood stage; see Figure 1). In contrast, swamp tupelo was located primarily within the matrix of the swamp floor. The hummocks function essentially as a natural bed, permitting seedling establishment above the general water level, providing limited amount of aerated root environment.

Results from controlled flooding studies have shown that the lateral roots of loblolly pine which develop under non-flooded conditions survive subsequent flooding events and contribute to the tolerance of the species to prolonged soil waterlogging (Hook et al., in prep). McKee, Hook, DeBell, and

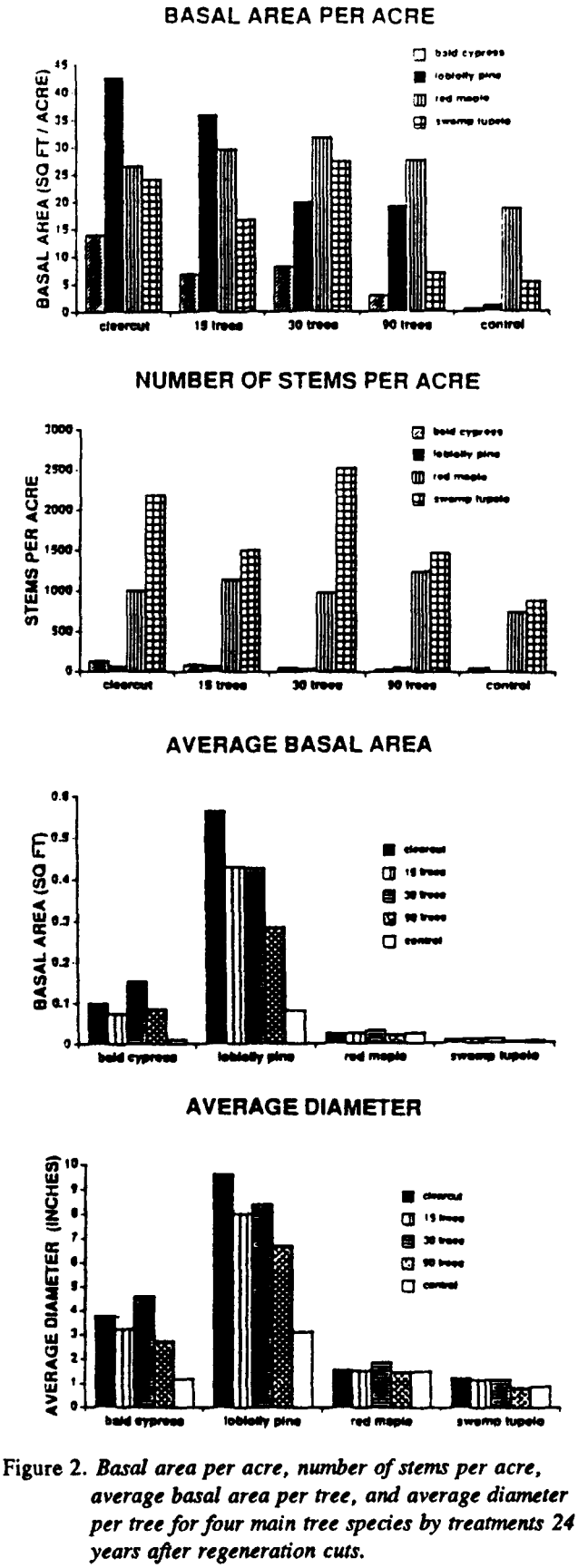


Figure 2. *Basal area per acre, number of stems per acre, average basal area per tree, and average diameter per tree for four main tree species by treatments 24 years after regeneration cuts.*

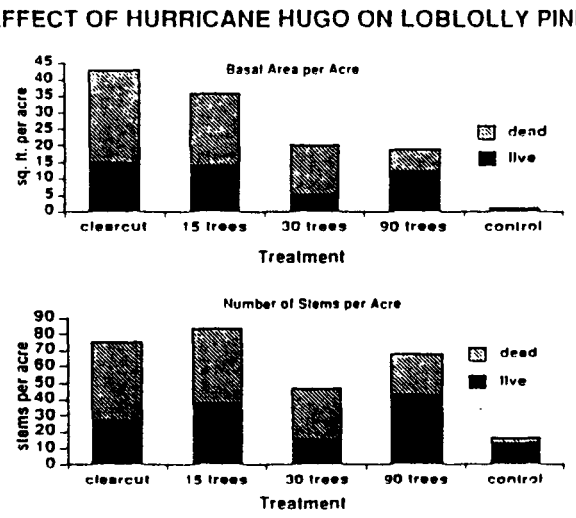
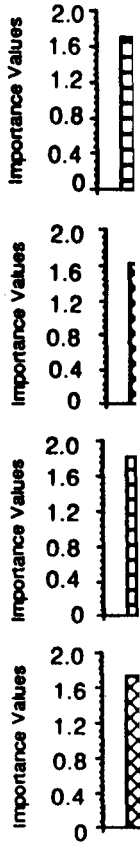


Figure 3. *Impact of Hurricane Hugo on basal area per acre and number of stems per acre for loblolly pine by treatment 24 years after regeneration cuts.*

Askew (1984) showed if sufficient phosphorus was available in the flooded soil that loblolly pine will survive and grow well in periodically waterlogged soils. Analyses of the soils in this swamp showed that soil phosphorus levels were relatively high.

If loblolly pine survives and grows so well in this swamp: Why was there little or no large loblolly pine trees in the parent stand or control plots? The answer to this is incomplete, but it appears that hurricanes probably play a major role in removing the larger loblolly pine from shallow swamps. Hook, Buford, and Williams (1991) reported that the largest and most dominant individuals suffered the most damage due to Hurricane Hugo. Gresham, Williams, and Lipscomb (1991) also reported that bald cypress and swamp tupelo suffered less than 5 % damage whereas loblolly pine suffered 47 % losses on Hobcaw Experimental Forest from Hurricane Hugo. Hooper and McAdie (in prep.) reported that the Francis Marion National Forest can expect maximum sustained winds of 91 mph every 50 years from tropical cyclones. Hence, on the average a stand over 100 years old will have been exposed to two or more hurricanes. It appears that hurricanes may remove a sufficient amount of loblolly pine from the shallow non-alluvial swamps under natural conditions so that only scattered individuals persist in mature stands.

The similarity of composition among the stands in the various treatments indicates that trees left for seed production or to moderate the environment had little or no influence on the composition of future stands on this site. However, there was a general



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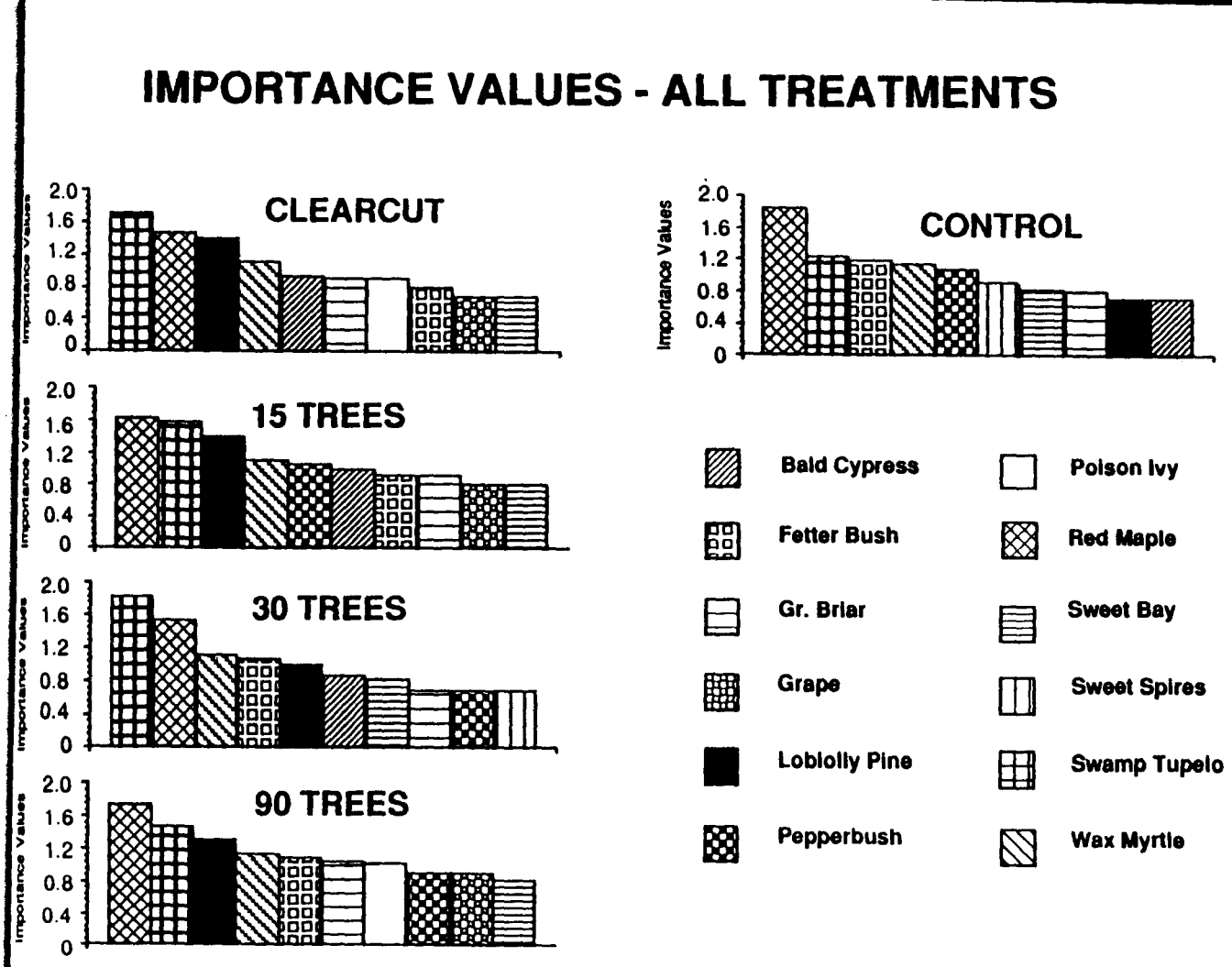

Figure 4. *Top ten species for each treatment as ranked by importance values 24 years regeneration cuts.*

trend of decreasing growth rate of the regenerating stand with increased numbers of residual trees. This trend was evident in total basal area, average basal area per tree, and average tree diameter for loblolly pine, swamp tupelo, and bald cypress but was not evident for number of stems per acre. Red maple, a more shade tolerant species, showed no change in these trends with increasing number of residual trees.

There is no convincing evidence that the residual trees had much effect on the understory species either. The composition of the ten dominant species, based on importance values, differed only slightly among the four regeneration cuts and the control. Hence, composition and stocking of the overstory and understory did not appear to be readily controlled by residual tree competition but growth of the dominant tree species in the stands appeared to be reduced by a greater number of leave trees.

Only 35 plant species (4.5 feet or taller) were found in the swamp. The lack of variation in the composition of stands in the various treatments was probably related to the hydric nature of the swamp. There is a limited menu of species, especially tree species, that can tolerate the frequent and long duration of soil waterlogging that is characteristic of this swamp. The wind damage susceptibility of other species which persist primarily on hummocks appears to play a role in maintaining the relatively simple species composition of non-alluvial swamps.

These shallow non-alluvial swamps appear to be very dynamic in nature. The presence of moving water in the swamp encourages water root development which promotes development of hummocks around most mature swamp tupelo trees (Hook, 1968). When the overstory is removed, loblolly pine has a competitive advantage on the hummocks and dominates the early stages of development in the swamp. Over time hurricanes and other natural phenomena appear to remove the pines. When the pines are blown over by wind, additional hummocks are formed by the root tip-ups. Thus, the combined actions of tupelo hummocks and pine tip-

ups create more hummocks. As a consequence of these processes, it appears, in the absence of fires, some of the shallow non-alluvial swamps in the South Carolina coastal plain may progress fairly rapidly from a swamp to a mesic pine site --perhaps within a few hundred years.

Acknowledgements

Thanks to Dave Gartner for the data analysis, Missy Huneycutt for the Figures and Beth Davis and Andrew Hulin for collecting the field data.

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