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WHY DON'T WEST LOUISIANA BOGS AND GLADES GROW UP INTO FORESTS?

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ABSTRACT

We studied trees in bogs, glades, and pinewoods in the Kisatchie National Forest, Louisiana, to determine tree species size and density. Bogs and glades are relatively open habitats with stunted trees, many of which are old growth. One reason why trees do not grow well in these habitats involves edaphic factors. The soil is nutrient poor, it is underlain by an impermeable layer, and it is either waterlogged or dry much of the year. Fire is probably more important in keeping bogs open, while desiccation is probably the most important factor for glades.

KEY WORDS: Tree growth, forest opening, bog, glade, Kisatchie National Forest, Louisiana

INTRODUCTION

There are two naturally open terrestrial habitats in the Kisatchie Ranger District of the Kisatchie National Forest. These are bogs, often referred to as hillside seepage bogs or pitcher plant bogs, and glades. Bogs are open, species rich environments which are hydric but not inundated, and which have acidic and nutrient poor soils. Glades are xeric, species poor environments often with sandstone at or near the surface with thin nutrient poor acidic soils (MacRoberts & MacRoberts 1990, 1991, 1992a, 1992b; Frost *et al.* 1986; Martin & Smith 1991; Nixon & Ward 1986; Streng & Harcombe 1982).

In this paper we address the question: why are these habitats open? Since trees and woody vegetation grow in them and both are subject to invasion by woody plants and herbaceous weeds, some factor or factors must be keeping this vegetation out (DeSelm 1986). Among reasons that have been suggested are fire frequency and intensity, poor soils, and hydric conditions. Streng &

Harcombe (1982), for example, have studied this problem in similar habitats in southeastern Texas and have found that edaphic factors may be responsible for keeping grass/sedge meadows open, while pyric factors appear to be responsible for keeping bluestem savannas open. Other workers have made similar suggestions about various open habitats in the eastern United States (see Frost *et al.* 1986; and Olson 1992; reviews including relevant literature).

METHODS

We made five sets of observations for this study.

I. To compare the spatial distribution and size of trees in glades with those of bogs and pinewoods, we ran transects through the middle of five glades. These totaled an area 416 meters long and 3 meters wide (1248 square meters). Within this area we mapped all trees over 1.5 meters tall, measured their diameter at breast height (dbh), and recorded their species. We had previously collected these same data for bogs and pinewoods (MacRoberts & MacRoberts 1990).

II. We cut at ground level four small longleaf pines from each of three samples of each habitat; that is, a total of twelve trees from bogs, twelve trees from glades, and twelve trees from pinewoods. The sample was matched for size (tree height and diameter) and for the amount of solar radiation received (the twelve trees from pinewoods were taken from areas that had been clearcut, that had grown up since the cut; otherwise they would not have received the same solar radiation as trees from bogs or glades). The trees were measured and photographed and a cross section from the base of each was preserved for later microscopic examination. The purpose of these observations was to determine the growth rate of pines in different habitats.

III. We made increment borings of seven "relict" longleaf pines (dbh 28-38 cm) in two glades and one longleaf pine (dbh 33 cm) in a pinewoods. Relict trees are trees that were not cut during the "big cutover" that occurred in the early part of this century (Caldwell 1991); they are often flat topped, stunted, and have few branches. Our purpose here as in II, was to gain insight into growth rates of longleaf pines in these habitats.

IV. In each of five glades and five bogs we randomly selected ten temporary one meter square plots, giving us fifty one meter square plots for each habitat. In each plot, we counted pine seedlings (first and second year plants) to see if pine establishment differed among these habitats and could shed light on tree productivity. We did not collect the same data for pinewoods since it is obvious that pine germination is optimal in that habitat. We counted the trees in the plots in July 1991.

V. We followed the fate of pine seedlings in four permanent plots: two in a glade and two in a bog. The plots were established in March 1991 and re-

Table 1. Number of trees by species and their size in glade transects.

Species	No. in Glades	Average dbh (cm) (range)
Pinus palustris	25	14.0 (1.5-41)
P. taeda	18	8.4 (2-33)
P. echinata	3	3.5 (3-4)
Quercus marilandica	6	10.3 (1-25)
Q. stellata	1	16.0

examined periodically until November 1992 to determine survivorship of pine seedlings in these two habitats.

RESULTS

The results of our observations on item I above are in Tables 1 through 3. These tables are almost identical to Tables 1 through 3 in our previous paper on the size distribution and density of trees in bogs and pine woodlands (MacRoberts & MacRoberts 1990), and those tables should be consulted for information not repeated here. Table 4 summarizes the results of the present observations and our previous observations on bogs and pinewoods. In pinewoods there was one tree per eleven square meters, in glades there was one tree per 23.5 square meters, and in bogs there was one tree per 35 square meters. Median tree sizes in glades, bogs, and pinewoods (Table 2) were significantly different (median test, χ-square = 5.99, $P < .05$). We did not do a formal, aposteriori pairwise test of the three habitats, but it is clear by inspection that the pinewoods contributed most to that difference. The growth rate of trees in bogs, glades, and pinewoods as measured by rings per cm (see Table 5) was significantly different among habitats (ANOVA, $P < .001$). An aposteriori test showed that the mean for each habitat was significantly different from the mean of each other habitat. As Figure 1 shows, trees in pinewoods grow much faster than trees in bogs, which in turn are faster growing than trees in glades. The correlation coefficients between age (number of rings) and tree height and diameter are high (between .73 and .89) and are significant at the .01 level for both measures (height/age, diameter/age) in all three habitats. It is therefore possible to accurately predict the age of a tree (knowing the habitat) from either its height or its diameter.

In this regard our increment borings (cores) are interesting. We found that the larger pines in glades (between 28-38 cm dbh) ranged from about 120 to 380 years old and are thus truly old growth, while one tree of comparable size (33 cm dbh) from a pinewoods was only about 50 years old. Martin & Smith

Table 2. Tree size in glade, pinewood, and bog transects.

Diameter Class dbh (cm)	No. of Trees		
	Glade	Pinewoods	Bog
1-5	19	24	19
5-10	12	18	7
10-15	6	17	3
15-20	8	12	5
20-25	3	8	0
25-30	2	14	2
30-35	2	18	0
35-40	0	7	0
40-45	1	0	0

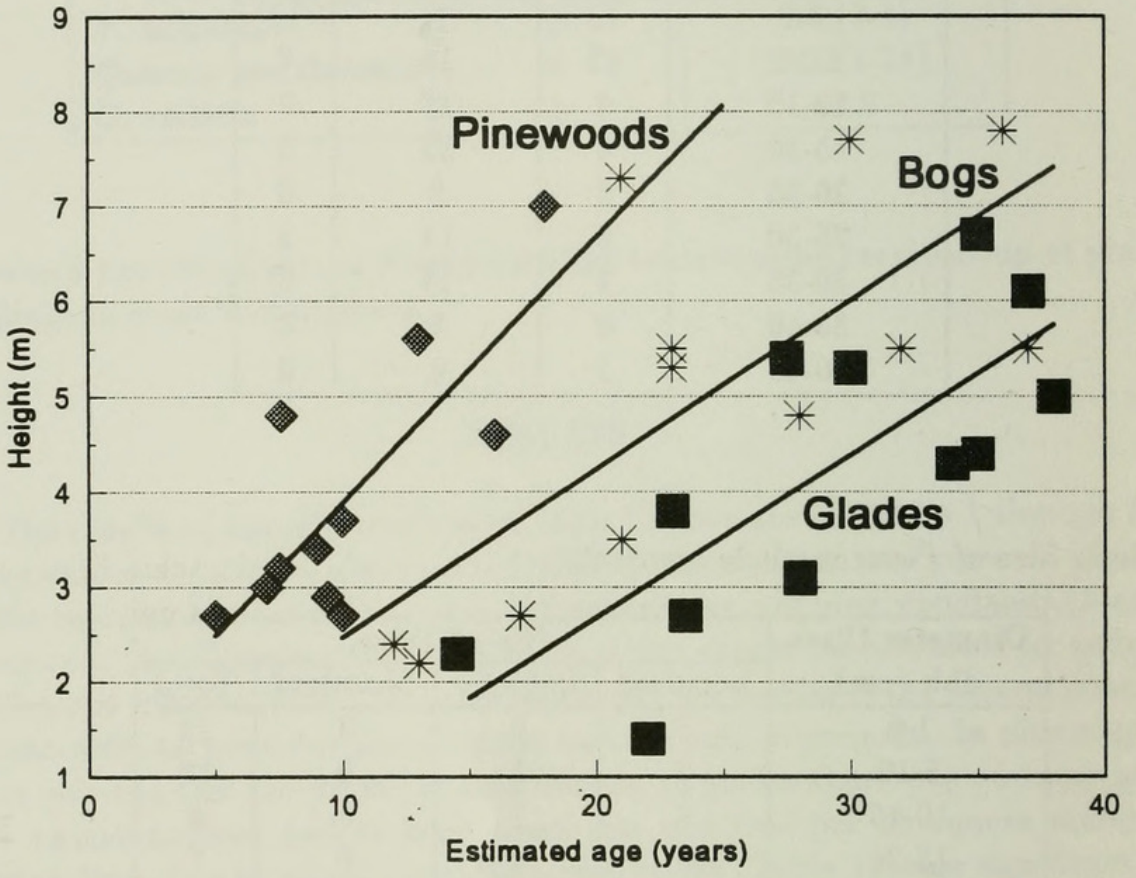
Table 3. Size of *Pinus* in glade transects.

Diameter Class dbh (cm)	No. of Trees			
	Longleaf	Loblolly	Shortleaf	Total
1-5	3	9	3	15
5-10	7	5	0	12
10-15	5	1	0	6
15-20	5	2	0	7
20-25	2	0	0	2
25-30	1	0	0	1
30-35	1	1	0	2
35-40	0	0	0	0
40-45	1	0	0	1

Table 4. Comparison of trees in transects of equal size in bogs, glades, and pinewoods (all measurements in cm).

	Habitat		
	Bogs	Glades	Pinewoods
No. of Trees	36	53	118
Mean tree dbh	7.8	11.1	16.8
Range	1-28	1-41	1-40

Figure 1. Regression slope of tree height and diameter as an expression of age in *Pinus palustris* in pinewoods, bogs, and glades.



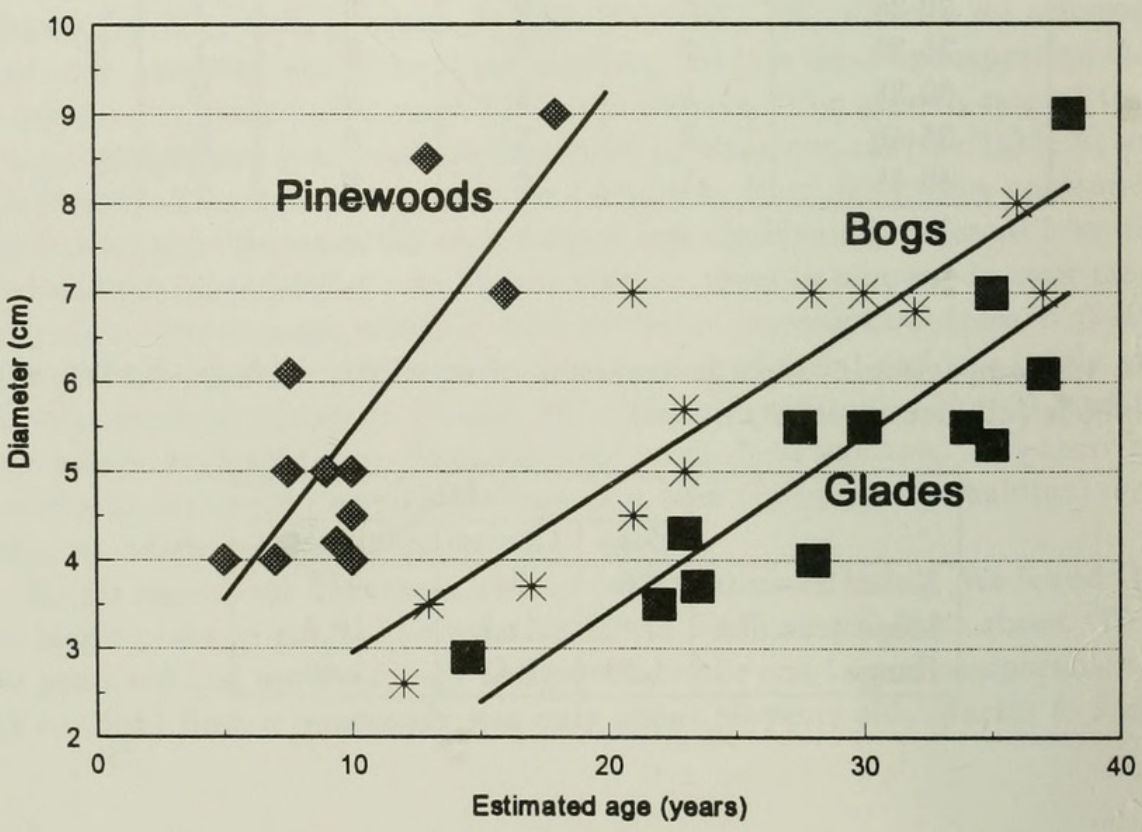


Table 5. Tree ring data for glades, bogs, and pinewoods.

Habitat	Rings per cm		
	Mean	Range	s.d.
Glades	11.5	8.5-14.0	1.6
Bogs	8.6	6.0-10.5	1.2
Pinewoods	3.7	2.5-5.0	0.8

Table 6. Number of pine seedlings found in sample plots.

Habitat	Tree Type		
	Longleaf	Other Pines	Total
Glade	30	139	169
Bog	17	12	29

(1991) cored nine relict longleaf pines in two stands in the Kisatchie Ranger District with similar results; for example, one tree with a dbh of only 23 cm was about 200 years old.

Table 6 gives the number of pine seedlings found in fifty randomly selected one meter square plots in bogs and glades. Table 7 summarizes the pine seedling survival in four permanent study plots.

DISCUSSION

We found that tree number and size in glades falls between those in bogs and pinewoods but that growth is slower than in either. While the reasons for the differences in number of trees and growth rates are not entirely clear, pyric and edaphic factors are undoubtedly important. Both bogs and glades are embedded in the fire dependent longleaf pine community and are consequently

Table 7. Pine seedling survival in four plots.

Plot	Trees Alive			
	March 1991	November 1991	November 1992	Percent Survival
Bog 1	19	17	7	37
Bog 2	19	14	7	37
Glade 1	27	10	6	22
Glade 2	26	0	0	0

subject to periodic burns (Smith 1991; Olson 1992). In presettlement times, while fires probably occurred once every two to three years, they were relatively cool and did not kill all pine seedlings. However, the edaphic conditions of bogs (highly acidic, waterlogged, nutrient poor, impermeable bedrock) and glades (seasonally desiccated, hot, nutrient poor, impermeable bedrock) (Martin *et al.* 1990) retard tree growth, making young trees extremely vulnerable to fire where herbaceous growth is extensive as, for example, in bogs dominated by *Ctenium* and other densely growing herbaceous plants (see discussion in Streng & Harcombe 1982).

In our bog plots, while pine seedlings sprouted and survived well, there was no evidence that they continued to survive beyond their first few years: slow growth makes them extremely vulnerable to fires over many years. Longleaf pines are notoriously slow growing in their early years, and although they are resistant to fire, mortality is very high when the fire is hot (Schwarz 1907; Mohr 1897; Wahlenberg 1946). Loblolly pines, while faster growing initially, are very susceptible to fire.

In glades, seedling survival was poor but better than we expected; however, this may have been the result of 1991 having been an extremely wet year with drought infrequent and of short duration. Even so, in glades, most seedlings were either scorched by the summer sun or died of desiccation during the short periods of drought. In their exposed condition they were subject not only to the direct rays of the sun but to intense ground reflection. By November, the few survivors all had brown lower needles. Certainly seed production as measured by cone production was adequate in these two habitats. Large pines in both habitats were cone producing, attested to by green cones on trees and by old cones on the ground from previous years.

In both bogs and glades, it is common to encounter trees felled by windthrow, erosion, or saturation with their shallow root systems exposed. Such mortality from falling in these two habitats is probably quite high, especially among the larger trees.

Clearly, more information on the life history of trees in these habitats would be welcome. But, as a number of workers have pointed out, instead of looking for a set of common factors, it is probably more profitable to recognize that the pattern found in open habitat of a few stunted, gnarled, slow growing trees is produced by widely differing causes. In bogs, fire is undoubtedly important in thinning the tree population since species are slow growing and therefore subject to many fires. Few escape to grow to maturity. In glades, fire is probably less important since litter accumulation is less extensive than in bogs; desiccation caused by drought and prolonged sunlight are probably more important.

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