

Natural and Management-Related Variation in Cypress Domes

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ABSTRACT. Fifteen cypress domes located within an extensively managed slash pine plantation were characterized according to the presence and nature of ditches and berms. Mean water depth and hydroperiod for the year 1978-79 were generally greater in the domes without these alterations. Cypress importance values were significantly higher in the unaltered, wet domes whereas hardwood importance values and shrub density were higher in the altered, drier domes. The abundance of grasses and sedges in the domes was more closely correlated with the amount of light reaching the dome floor than with the degree of wetness.

Acid-extractable phosphorus, iron, and aluminum concentrations in the dome soils were positively correlated with mean water depth. Carbon concentration in the dome soil was positively correlated with hardwood importance value.

Cypress tree growth rates increased significantly following ditching in four domes. This was probably the result of increased soil aeration and increased nutrient inputs from ditch inflow. Cypress growth rates in other altered and unaltered domes were not significantly different before and after intensive forest management of the study site. Although dome alterations sometimes increased cypress tree growth, the associated changes in hydrological conditions, vegetation composition, and soil parameters may inhibit cypress regeneration. *FOREST SCI.* 29:627-640.

ADDITIONAL KEY WORDS. Nitrogen, phosphorus, iron, slash pine, hydrology.

CYPRESS DOMES are small forested wetlands that commonly occur in shallow depressions within the pine flatwoods of the southeastern coastal plain. The dominant tree in these wetlands is the deciduous conifer, pondcypress (*Taxodium distichum* var. *nutans* (Ait.) Sweet). Cypress domes are normally open, ponded areas with little understory, and are dominated by cypress with swamp blackgum (*Nyssa sylvatica* var. *biflora* (Walt.) Sarg.) occurring occasionally and pines (*Pinus* spp.) occurring rarely (Harper 1914, Mattoon 1915, Gano 1917). In Florida, slash pine (*Pinus elliottii* Engelm.) is being intensively managed for pulp and paper production on approximately 10 million hectares. Swamps comprise about 33 percent of these commercial forest lands, with half of that area in cypress domes (Anonymous 1978). Although commercial use of pondcypress has generally been restricted to mulch, railroad crossties, and fenceposts, recent advances in chipping have made it more attractive, and interest in long-term management has increased. Moreover, the potential use of cypress domes for wastewater recycling (Ewel and Odum 1978), for water conservation (c.f., Burns 1978, Brown 1981), and for

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production of wildlife diversity (McElveen 1977) raises concern about the indirect effects that management practices in surrounding uplands may have on ecological processes in the cypress domes.

Drainage using ditch construction is a standard management practice on many industrial forest lands to increase the survival and growth of slash pine seedlings planted on poorly drained sites (Schlaudt 1955). Cypress domes are often part of the drainage system on industrial forest lands in Florida. They may be drained themselves or used to facilitate drainage of surrounding pine sites. Alterations of the natural hydrologic cycle of cypress domes can affect cypress regeneration due to the dependence of seed germination and establishment upon seasonally fluctuating water levels (Demaree 1932, DuBarry 1963).

Fire as a management tool may also have a significant effect on ecological relationships in cypress domes. On most intensively managed slash pine plantations today, wildfires are suppressed and controlled burning is confined to the upland areas where the pines are planted. Fire, which has historically occurred in cypress ecosystems during the dry seasons, is an important factor in preventing the dominance of cypress wetlands by other tree species (Cypert 1961, Gunderson 1977, Ewel and Mitsch 1978). Another management practice affecting cypress domes is logging. Although cypress trees can reproduce vegetatively from stumps, logging in cypress wetlands has been reported to result in poor cypress regeneration and in changes in species composition (Bull 1949, Allen 1962, Gunderson 1977).

The objectives of this research were to determine the effects of intensive slash pine management on cypress dome hydrologic conditions, vegetation composition, soil nutrient status, and growth and regeneration of cypress trees. Assessment of this impact with regard to the role of cypress in the landscape will provide information useful in the management of both pine and cypress ecosystems.

METHODS

Site Description.—The study site was located approximately 3 km northwest of Gainesville, Florida. A portion of the area was originally cleared and planted with slash pine (about 1,000 stems/ha) during 1955 and 1956. At that time, piles of soil and debris from the clearing operations were pushed into the margins of many nearby cypress domes to provide more area for planting pine trees. Many of these piles are still nearly continuous around the edges of the domes and appear to function as berms, interfering with overland flow. Complete berms were constructed around additional domes during clearing and planting operations from 1961 to 1964. Also during this period, a series of ditches was dug to connect many cypress domes with each other and with a roadside ditch system, which expedited runoff and prevented water from standing on the newly planted pine sites.

Fifteen domes were selected in this area, representing a range from unaltered domes to domes affected by both berms and ditches. Each berm was classified as extensive or partial according to the proportion of dome margin occupied by the berm and the relative size of the berm. The location of each dome and the nature of its alterations are shown in Figure 1.

Water and Light Measurements.—A staff gauge was placed in the lowest part of each dome and water levels were read every 2 weeks from September 1978 to September 1979. A portable solar radiometer (Sol-a-meter by Matrix, Inc.) was used to obtain relative estimates of the amount of light penetrating the canopy in each dome. The scale of the solar radiometer was set at 100 percent light transmission in full sunlight, and then 50 random light readings were taken under the canopy of each of the 15 study domes. Readings were taken in September 1978 at about 1.8 m above ground level. To correct for variation due to the time

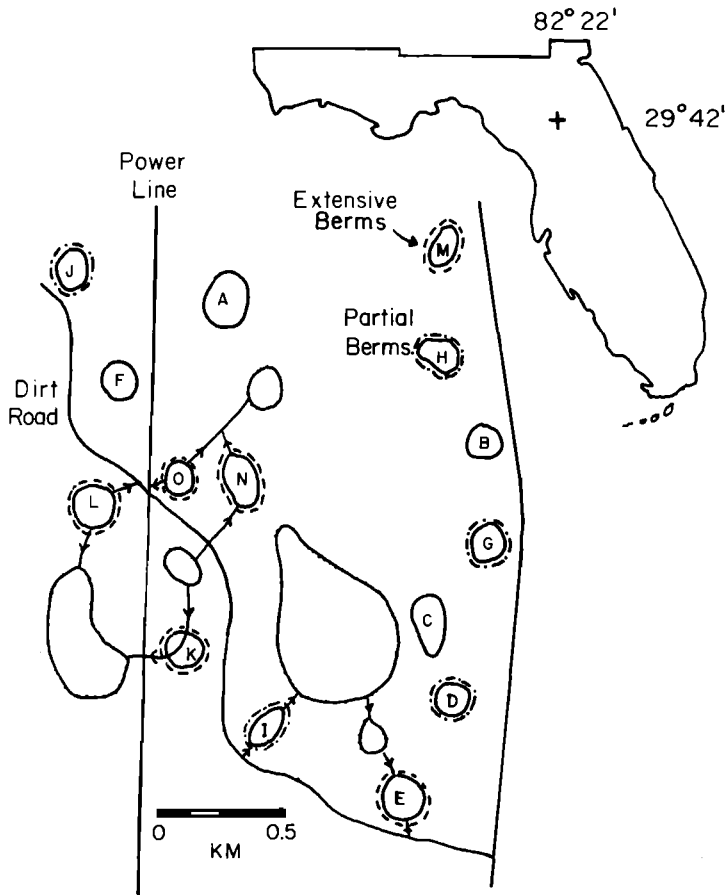


FIGURE 1. Cypress domes, with associated berms and ditches, at study site. The direction of water flow is indicated by arrows. Extensive berms are indicated by a dashed line; partial berms are indicated by a dot-dashed line.

of day, the angle of the sun from the vertical was measured before each set of readings, and the values were standardized using the formula:

$$\text{percent light transmission} = X/\cos \theta$$

where X is the mean radiometer reading and θ is solar altitude measured from the vertical (Brown 1981).

Tree Growth Rates.—Annual radial increase was measured on 12 trees from each dome. Trees greater than approximately 16 cm diameter at breast height were randomly selected from deep, intermediate, and shallow parts of each dome: three from the center, four from halfway between the center and edge, and five from the edge of each dome. A 5-mm diameter increment borer was used to extract a core of wood from each tree above the butt swell at breast height. Each core was mounted on a grooved strip of wood, and then was sanded using 100, 320, and 400 grit sandpaper sequentially until a smooth cross-section of the annual growth rings was clearly visible. The sanded cores were examined at 25 \times to discriminate true annual rings from the false rings that are common in cypress (Beaufait and Nelson 1957). Ring widths were measured with an ocular micrometer and then

converted to basal area increment per tree using a formula reported by Bray and Struik (1963).

For each tree, the mean basal area increment for the most recent 10 years (1969–79) was compared to the mean basal area increment for a 10-year period before ditches and berms were constructed (1939–49). An earlier study (Nessel and others 1982) demonstrated no significant change in average annual basal area increment per tree in 100-year-old trees in an undisturbed cypress dome when a 14-year average was compared with the subsequent 41-year average. A paired *t*-test was used to determine if there were any significant changes in the growth rates within individual domes. An analysis of variance and Duncan's new multiple range test were used to detect significant differences in the growth rates between domes. Almost all of the cypress trees in one dome (J) were logged between 1961 and 1964 and had coppiced, so rates could not be compared with the other domes.

Soil.—Cypress dome soils were sampled using a 3.2-cm diameter, 1.5-m-long coring tube to obtain an intact segment of a soil profile. Three cores were taken from each of the 15 study domes: one at the center, one halfway between the center and the edge, and one at the edge. The depth of each horizon in the profile was measured, and then sampled separately for element analysis.

Samples were air-dried, sieved through a 2-mm screen, and ground with a mortar and pestle or a Wiley mill. Total nitrogen in the soil was measured using the macro-Kjeldahl method and total organic carbon was measured using the Walkley-Black method (Hesse 1971). All other chemical analyses were performed by the University of Florida Soil Testing and Analytical Laboratory using a double acid extraction procedure as described in Mitchell and Rhue (1979). Iron and aluminum concentrations were determined using a Perkin-Elmer atomic absorption spectrophotometer. Orthophosphate concentrations were determined colorimetrically on a Technicon Autoanalyzer II using ascorbic acid and ammonium molybdate. An Orion pH meter with a glass electrode was used to determine pH.

Analysis of variance with horizon as a factor was used to test for significant differences in concentrations of soil elements between domes. Mean concentration of each element in each dome was determined from three samples per dome, in which all horizons were included. Duncan's new multiple range test was used to compare mean concentrations between each dome.

Vegetation Composition.—To determine the density, frequency, dominance, and importance values of tree species within the domes, the point-centered quarter method (Mueller-Dombois and Ellenberg 1974) was used to sample trees greater than 2 m tall. Eighteen stratified random points were chosen in each dome such that three were in the center of the dome, six were halfway between the center and the edge, and nine were along the edge. At each point, four quarters were established using a compass, and the distance to the nearest tree in each quarter was recorded along with the species and diameter at breast height. From these data, density, frequency, dominance, and importance values were calculated for each dome, using the following formula (Smith 1980):

$$\begin{aligned}\text{Relative density} &= \frac{\text{individuals of species A}}{\text{total individuals of all species}} \times 100 \\ \text{Relative dominance} &= \frac{\text{total basal area of species A}}{\text{total basal area of all species}} \times 100 \\ \text{Relative frequency} &= \frac{\text{frequency value of species A}}{\text{total frequency value for all species}} \times 100 \\ \text{Importance value} &= \text{Relative density} + \text{Relative dominance} \\ &\quad + \text{Relative frequency.}\end{aligned}$$

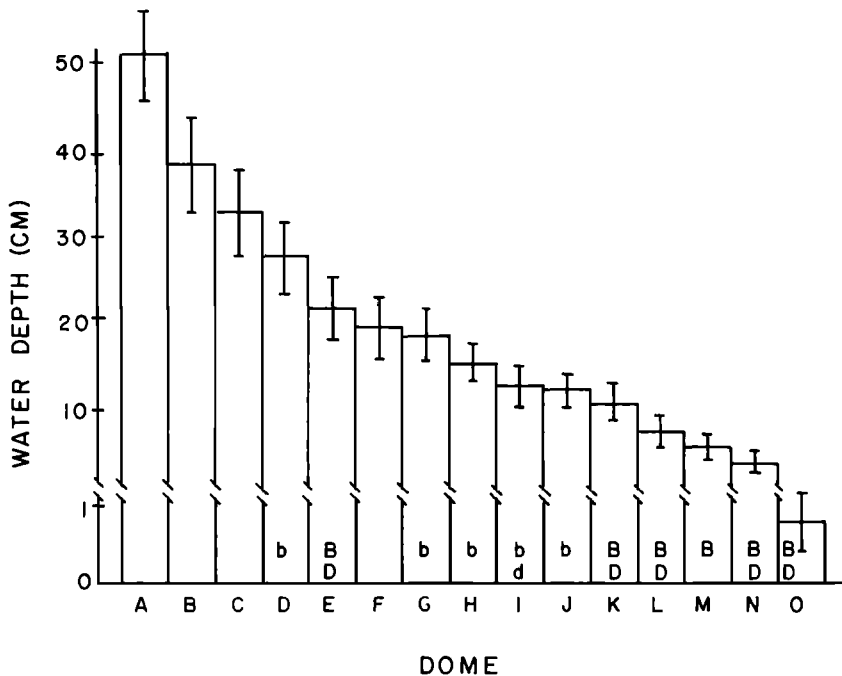


FIGURE 2. Mean water depth (\pm SE) in each of 15 cypress domes. Some domes had been altered by berms (B, b) and/or ditches (D, d); capital letters denote extensive alteration.

Understory vegetation was sampled using a 0.25-m² wooden frame to delineate 18 random plots stratified in the same manner as for the tree sampling. Species within each plot were identified and the number of individuals of each species was counted. This information was used to obtain density and frequency values for each species in each dome, as described above.

The extent of logging and burning in the domes was estimated from transect counts of charred trees and stumps, cut stumps (coppiced or uncoppiced), and unaffected trees reaching the canopy. A north-south transect and an east-west transect were established in each dome and trees of all species within 3 m on either side of the transects were included in the counts.

RESULTS

Hydrology.—Hydrologic conditions in the domes were related to the terrain alterations that occurred during site preparation in the pine plantation. For reference purposes, domes were assigned the letter A through O according to their relative mean water depths (where A was the deepest and O was the shallowest) (Fig. 2). Domes A, B, C, and F had no ditch or berm alterations, and, when compared with altered domes, had significantly higher ($P \leq 0.05$) mean water levels.

Altered domes had either berms or both ditches and berms, and their water levels were related to the nature and severity of these alterations. Domes D, G, H, and J had only small partial berms and no ditches, and had intermediate water levels. Dome M, however, was surrounded by a nearly continuous high berm and had a relatively low water level. Water levels in the ditched and bermed domes (E, I, K, L, N, and O) were among the lowest, except for dome E which was unique in having two inflowing ditches and no outflowing ones. Direction of water flow in the other ditched domes is noted in Figure 1.

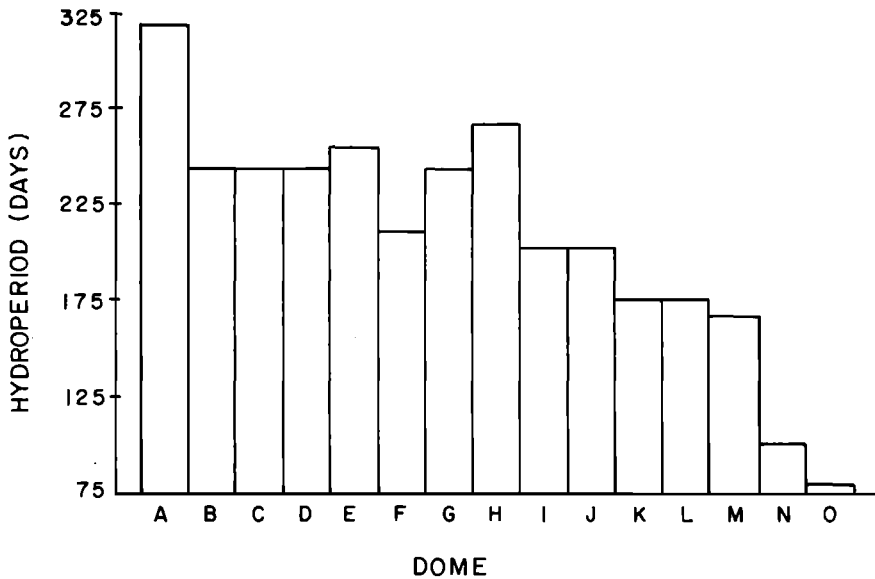


FIGURE 3. Hydroperiod in each of 15 cypress domes. Hydroperiod is the length of time water stands on the surface of the ground.

Mean water depth and hydroperiod (length of time that standing water is present) for all 15 domes were closely correlated ($r = 0.83$) although hydroperiods were not significantly different between unaltered and altered domes (Fig. 3). The shortest hydroperiods, however, occurred in the same extensively altered domes that also had the lowest water levels (domes K, L, M, N, and O).

The driest period during the study was October through December, when all domes were dry for at least part of the time. In some of the altered domes there were additional dry periods but dome F was the only unaltered dome to have an additional dry period, which occurred from late June to early July.

Vegetation.—Cypress was the most important species in the study domes (Fig. 4). Cypress importance values were moderately well correlated with mean water depth ($r = 0.72$) but poorly correlated with hydroperiod ($r = 0.52$). Cypress importance values from the unaltered, wet domes (A, B, C, and F) were significantly higher ($P \leq 0.05$) than values for the heavily altered, drier domes (I, K, L, N, and O).

Swamp blackgum was present in all domes except dome J and its highest importance values were found in domes A, H, I, and M, which span a wide range of hydrologic conditions. Overall, blackgum importance values were poorly correlated with mean water depth ($r = 0.46$) and hydroperiod ($r = 0.30$).

Slash pine occurred in all but three domes (C, D, and I), which had intermediate hydroperiods, medium to high water depths, and a high percentage of charred trees, indicative of past fires. In two other domes (N and O) with high percentages of charred trees but dry conditions, however, slash pine was also relatively important. Slash pine was moderately correlated with hydroperiod and percentage charred trees as cofactors ($r = 0.65$), and with mean water depth and percentage of charred trees ($r = 0.61$).

Other important tree species found in the domes included wax myrtle (*Myrica cerifera* L.) and a variety of hardwood species that occurred mainly near the edges of the domes. In general, domes with shallow water had higher total hardwood importance values than domes with deeper water, although the overall correlation

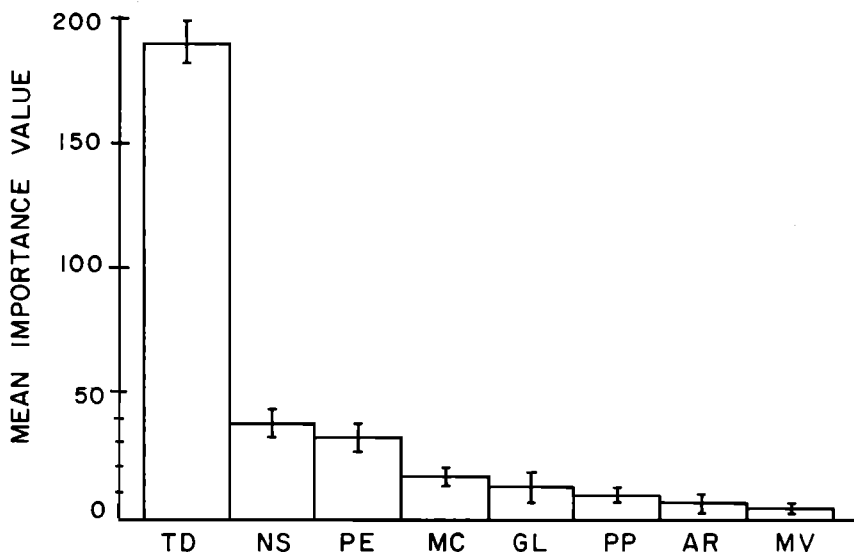


FIGURE 4. Mean importance value (\pm SE) of major tree species in 15 cypress domes. Importance value is equal to the sum of relative density, relative frequency, and relative dominance. TD = *Taxodium distichum* var. *nutans* (Ait.) Sweet; NS = *Nyssa sylvatica* var. *biflora* (Walt.) Sarg.; PE = *Pinus elliottii* Engelm; MC = *Myrica cerifera* L.; GL = *Gordonia lasianthus* (L.) Ellis; PP = *Persea palustris* Sarg.; AR = *Acer rubrum* L.; MV = *Magnolia virginiana* L.

with mean water depth was poor ($r = -0.30$) (Fig. 5). The high hardwood importance value in altered but relatively wet dome E was due almost entirely to one species, loblolly bay (*Gordonia lasianthus* (L.) Ellis). This species did not occur in any other dome. If this dome is excluded from the overall comparison between hardwood importance values and mean water depth, the correlation is considerably higher ($r = -0.63$). The increase in absolute density of hardwood

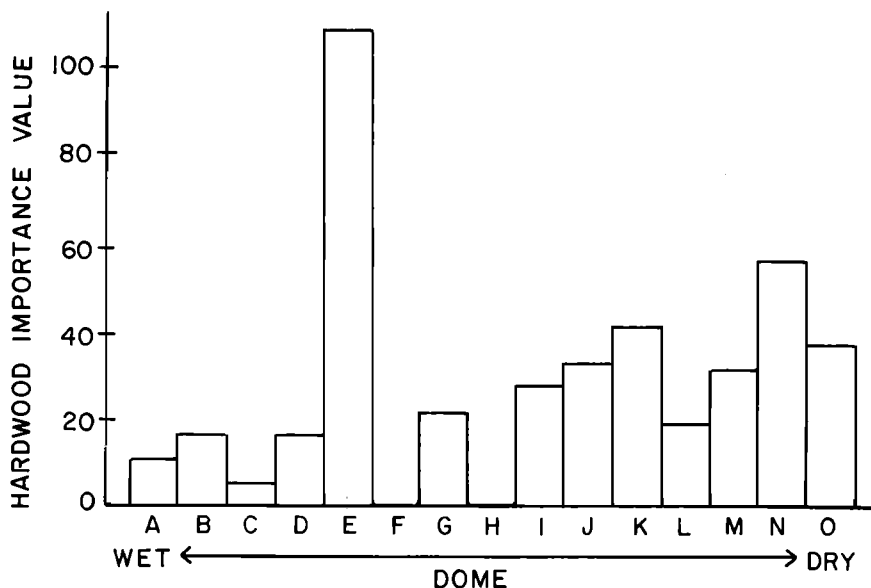


FIGURE 5. Importance value of hardwood trees in 15 cypress domes.

TABLE 1. Mean concentrations of soil elements in the cypress domes. Within a column, means not followed by a common letter differ significantly at the 0.05 level. Values include measurements from all horizons at three sampling points per dome.

Dome	Element concentrations			Total N	Total organic C	pH
	P	Fe	Al			
	ppm	ppm	ppm			
A	7.87a	78.4abc	296.8a	0.44cd	2.17d	4.4
B	9.46a	85.6ab	206.9bc	0.29cd	2.49cd	4.5
C	8.47a	109.4a	272.3ab	0.33cd	1.91d	4.9
D	4.94abc	43.0cd	271.2ab	0.29cd	2.16d	4.1
E	1.73c	32.9d	249.1abc	0.38cd	5.80a	4.1
F	1.37c	49.4bcd	130.9de	0.91b	2.37d	4.3
G	2.48bc	28.4d	204.0bc	0.34cd	4.84abc	4.0
H	2.03bc	55.9bcd	194.3bc	0.71bc	1.85d	4.2
I	2.49bc	55.8bcd	104.5e	0.26cd	3.81abcd	5.0
J	6.96ab	60.5bcd	216.3bc	1.51a	3.83abcd	4.0
K	3.14bc	34.8d	86.3e	0.27cd	2.35d	4.3
L	2.33bc	30.7d	118.0e	0.24d	1.94d	4.1
M	5.59abc	45.4cd	248.0abc	1.08ab	3.15bcd	4.2
N	1.82bc	28.6d	119.4e	0.29cd	5.04ab	4.4
O	2.31bc	30.0d	115.7e	0.33cd	2.86bcd	4.2

species was significantly greater ($P \leq 0.05$) in the four most disturbed domes (L, M, N, O) than in the four undisturbed domes (A, B, C, F).

More tree seedlings occurred in the altered, drier domes than in the unaltered, wetter domes. The most abundant and widely occurring tree seedlings were swamp redbay (*Persea palustris* Sarg.). Cypress seedlings were uncommon.

The Virginia chain fern (*Woodwardia virginica* (L.) Smith), which occurred in every dome, was the most abundant and ubiquitous of the 21 understory species. The abundance of grasses and sedges within the domes was correlated with the amount of light reaching the dome floor ($r = 0.85$). Herb abundance was not as highly correlated with light ($r = 0.66$) because a few species such as lizard's tail (*Saururus cernuus* L.) and red root (*Lachnanthes caroliniana* (Lam.) Dandy) occurred in more shaded domes.

Vines (including the woody, vinelike blackberry, *Rubus* spp.) were more abundant in the heavily altered, dry domes (I, K, M, N, and O) than in the unaltered, wet domes (A, B, C, and F). However, domes D and I, which varied considerably in wetness and disturbance, had the greatest occurrence of poison ivy (*Rhus radicans* L.).

Fetterbush (*Lyonia lucida* (Lam.) Koch) and Virginia willow (*Itea virginica* L.) were the most common of the nine shrub species found in the domes. Shrub density was inversely correlated with mean water depth, using percentage cut trees as cofactor ($r = -0.68$). In the heavily altered dry domes (I, K, L, N, and O), shrub density was significantly higher ($P \leq 0.05$) than in the unaltered wet domes (A, B, C, and F).

Soils.—A typical soil profile consisted of an O horizon composed mainly of litter, an A1 horizon of black sandy loam high in organic matter, an A2 horizon of leached light gray sand, and a Bt horizon of gray sandy clay loam. These horizons were not always distinct, and there were usually transitional subhorizons within the profile. Occasionally, a Bh horizon of organic matter accumulation occurred at dome edges. More detailed descriptions of dome soil morphology for this area

TABLE 2. Mean concentrations of elements in cypress dome soil horizons. Within a column, means not followed by a common letter differ significantly at the 0.05 level. Values are means of three sampling points in each of 15 domes.

Horizon	Element concentrations			Total N	Total organic C	pH
	P	Fe	Al			
	ppm	ppm	ppm			
O	11.3a	156.8a	370.2b	1.16a	32.0a	3.7
A1	2.3c	24.6c	187.5d	0.83b	8.4b	4.1
A12	2.1c	14.6c	97.6e	0.31c	2.1c	4.4
A2	1.0c	10.3c	77.7e	0.07c	0.7d	4.6
A22	2.0c	7.1c	54.7e	0.07c	0.3d	4.9
A3	0.4c	9.3c	53.2e	0.01c	0.3d	4.9
Bt	5.6b	59.0b	253.3c	0.09c	0.5d	4.7
Bh1	3.3bc	10.2c	294.0bc	0.08c	0.6d	4.4
Bh2	2.1c	8.0c	574.0a	0.47bc	1.4cd	4.2

are reported elsewhere (Soil Conservation Service 1975, Coultas and Calhoun 1976).

The soils were fairly acidic with pH ranging from 3.2 to 6.7; they are generally less acidic with increasing depth. Soil phosphorus concentrations in the deepest domes, A, B, and C, were significantly higher ($P \leq 0.05$) than in all other domes except D, J, and M (Table 1). The correlation coefficient for phosphorus concentrations and mean water depth in all domes was 0.67. Within the soil profiles, highest phosphorus concentrations occurred in the O and Bt horizons (Table 2).

Iron concentrations in the dome soils closely paralleled phosphorus. Although the iron concentrations in domes A, B, and C were not significantly different from some of the drier domes, the overall correlation with mean water depth was higher than for phosphorus ($r = 0.79$). Iron was found in greatest abundance in the O and Bt horizons.

Domes A and C also had high aluminum concentrations but they were not significantly different from domes D, E, and M, and dome B was only intermediate in aluminum concentrations. Nevertheless, the overall correlation with mean water depth ($r = 0.68$) was almost the same as between phosphorus and mean water depth. Highest aluminum concentrations occurred in the O and Bt horizons.

Nitrogen concentrations in dome J were significantly higher than in any other dome except M. Domes F, H, J, and M, which had the four highest nitrogen concentrations of all the domes, were all unburned; however, another unburned dome (K) had significantly lower nitrogen concentrations. Consequently, the overall correlation between percentage charred trees and nitrogen concentrations in the dome was poor ($r = -0.44$). The O and A1 horizons had the highest levels of nitrogen in the soil profiles.

Carbon concentrations were positively correlated with importance values of hardwoods other than swamp blackgum ($r = 0.78$), and were significantly higher in the center than on the edges. Carbon analyses were not done on the O horizons due to equipment failure; however, in the mineral soil horizons, highest carbon levels occurred in A1 horizons.

Cypress Tree Growth.—The mean growth rate of cypress was significantly faster ($P \leq 0.05$) in domes E, I, K, and N for the 10-year period (1969–79) after intensive slash pine management than for the 10-year period (1939–49) before (Fig. 6). The other domes did not show any significant difference in growth rates before and after intensive management of surrounding pinelands. Domes E, I, K, and N all

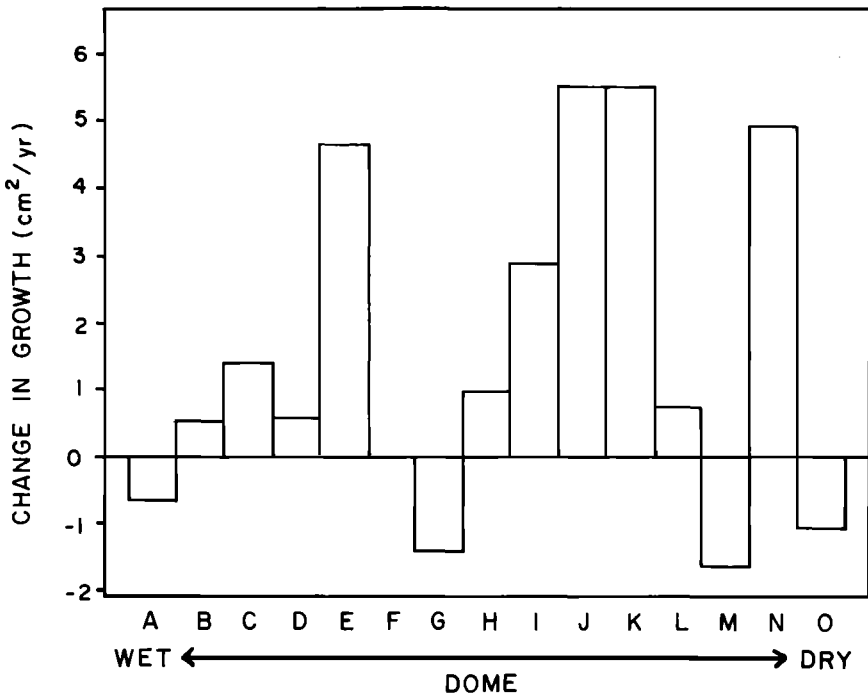


FIGURE 6. Differences between cypress tree growth rates before and after intensive management around 15 cypress domes. Each value is the difference between the mean basal area indices of 12 trees per dome for 10 years of growth after intensive management (1969–79) and before intensive management (1939–49).

had ditches and at least partial berms. There was no significant difference in rainfall between these decades.

Domes A, G, M, and O showed the greatest decrease in growth rate following intensive forest management, although the differences were not highly significant. Of this group, dome O, which is extensively bermed and ditched, is the driest of all the study domes and unaltered dome A is the wettest.

DISCUSSION

The variation in vegetation diversity and density among the cypress domes described in this study cannot be attributed to natural variation alone. Brown's (1981) demonstration of the water-conserving characteristics of pondcypress suggests that a long hydroperiod is maintained by the community, preventing most hardwoods from becoming established except around the edges. We therefore conclude that the nature and extent of the ditch and/or berm alterations around the domes affected their hydrologic conditions. Berms probably inhibited the inflow of runoff into a dome, as evidenced by the pools of water that would collect behind the berms, outside the domes. Ditches, however, could have increased or decreased dome water levels depending upon the direction in which they channeled water. In addition to ditch and berm alterations, evapotranspiration rates and topography, both of which can affect hydrology, may also have been changed as a result of intensive slash pine management practices. Although the exact causes of the water levels and hydroperiods in each dome cannot be determined, an overall comparison shows that mean water depth was 65 percent lower and mean hydroperiod 25 percent shorter in the altered domes than in the unaltered domes.

We could find no relationship between the time of alteration (1955–56 or 1961–64) and the degree of change in either hydrology or vegetation.

The drier conditions of the more disturbed domes were associated with changes in vegetation composition: an increase in the importance and absolute density of hardwood species, and in shrub density. The increase in hardwoods is a result of these species' ability to become established where flooded conditions previously kept them out. Most hardwood species are not as flood-tolerant as cypress (Gill 1970, Hook and Scholtens 1978), and therefore do not usually occur with cypress on the wettest sites (Conner and Day 1976).

The increase in shrub density in the drier domes is probably also a result of these species' no longer being restricted by prohibitively deep or persistent water. Similarly, Flinchum (1977) found that the aboveground biomass of the understory vegetation in a bottomland hardwood swamp varied inversely with the yearly number of inundation periods.

The decrease in importance of cypress in the drier domes may result from its being unable to compete successfully with hardwoods and slash pine on drier sites (Mattoon 1915, Fowells 1965, Mitsch and Ewel 1979). For instance, the hard cypress seedcoat requires soaking before good germination can occur (Demaree 1932, Murphy and Stanley 1975), whereas hardwood and slash pine seeds are less demanding. The high shrub densities found in the drier, disturbed domes may also adversely affect cypress regeneration by decreasing the amount of sunlight reaching the dome floor. Browder and others (1974) found that cypress seedlings grew best under conditions of 80 percent full sunlight. Most hardwoods, by comparison, are more shade-tolerant than cypress and would be less affected by lower light conditions (Fowells 1965).

Another vegetation change that occurred in the drier domes (but was not exclusive to them) was the invasion of slash pine. Highest importance values of slash pine occurred in domes that were very dry and/or had not recently burned. This observation agrees with the hypothesis proposed by Ewel and Mitsch (1978) that periodic fires will not significantly affect the vegetation composition of a normally wet dome but will keep dry domes cypress-dominated by killing small invading slash pines. McCulley (1950) also noted that slash pine seedlings and saplings are usually killed by surface fires. Since fire suppression is a standard practice today in young slash pine plantations, it is likely that this species will further increase in importance in cypress domes with altered hydrologic regimes.

Unlike the management practices of drainage and fire suppression, which may be detrimental to the vegetational stability of cypress domes, clearcutting may be beneficial. In the clearcut dome J, cypress trees coppiced prolifically; however, few cut cypress in the selectively harvested domes were observed to have vegetatively reproduced. As compared with the more shaded, selectively logged domes, the increased light conditions of the clearcut site probably had a positive effect on vegetative regeneration of cypress.

Abundance of grasses and sedges in the domes was also positively related to light conditions. Highest percentages of light were found in domes B, D, and F, which were unaltered or only slightly altered; and in dome J, which, as discussed above, was clearcut. The near absence of grasses and sedges in the more heavily altered domes resulted in decreased diversity of ground layer vegetation in these domes.

Highest concentrations of phosphorus, aluminum, and iron were found in the wettest domes, which suggests that reduced soil conditions might be occurring there, or that the higher water table was preventing leaching of these elements. Cypress has been shown to respond to increased levels of phosphorus and nitrogen in flooded soils (Dickson and others 1972, Nessel and others 1982) although transformations of inorganic phosphorus to insoluble organic combinations in

flooded soils have been reported to reduce phosphorus availability (Bartholomew 1931, Vijayachandran and Harter 1975). The phosphorus in the O horizon may occur in immobilized and relatively unavailable organic combinations, but phosphorus in the Bt horizon could be available if cypress roots extend that deep. Coultas and Calhoun (1976) hypothesized that cypress should have an ample supply of phosphorus from this horizon.

High iron and aluminum concentrations in the soil are toxic to certain plants and may prevent establishment of many species in anaerobic soils (Martin 1968, Clarkson 1969). The highest concentrations of aluminum and iron in the mineral soil of the dome profiles were found in the Bt horizon, and were probably associated with clay minerals. These concentrations do not approach toxic levels.

Soil nitrogen concentrations did not correlate with mean water depth or hydroperiod in the study domes. Severity of fire and time elapsed since burning, which could not be accurately determined, may account for some of the variation in nitrogen concentrations. Sampling variability, which has been reported to be higher for nitrogen than for other soil parameters (Keeney 1980), may also be responsible for the weak relationship between nitrogen concentration and dome perturbation.

The relationship between high carbon concentrations and high hardwood importance values is a result of the contribution of these species to the organic component of the mineral soil. In a comparison between evergreen and deciduous shrub species in the Okefenokee Swamp, Schlesinger and Chabot (1977) found evergreen, sclerophyllous shrub leaves to be higher in structural components, hence carbon, than leaves of deciduous species. Cromack and Monk (1975) have shown the lignin concentration of a substrate to be a good predictor of its decomposition rate. Since the majority of the hardwood species in the domes are evergreen with sclerophyllous leaves, their decay-resistant structural components may persist in the organic fraction of the A1 horizon, causing relatively high carbon concentrations.

The growth rates of cypress trees in domes E, I, K, and N increased significantly following intensive slash pine management. These domes were characterized by medium to low water levels, intermediate to short hydroperiods, and at least one inflowing ditch. We believe that these conditions influenced cypress growth through their effect upon specific growth factors such as soil aeration and nutrient input. Moderate hydrologic conditions in domes E, I, K, and N may have increased cypress tree growth by improving soil aeration. Dickson and Broyer (1972) found that cypress trees grew best under saturated but aerated soil conditions; however, growth in saturated anaerobic soils was as good as or better than growth rates in unsaturated soils. Some of the slowest cypress growth rates occurred in domes A and O which were the wettest and driest, respectively. It is possible that anaerobic conditions in dome A and moisture stress in dome O adversely affected cypress growth in these two domes. Mitsch and Ewel (1979) also found best growth of cypress to occur on sites that were neither extremely wet nor extremely dry.

The inflowing ditches in domes E, I, K, and N were unique to these four domes and drained runoff into them from a larger area than normal. Additional nutrients in this runoff may have contributed to the increased cypress growth rates in these domes. The positive effect of nutrients supplied by flowing water systems upon cypress growth has been documented by Mitsch and Ewel (1979) and Brown (1981).

Growth rates are an important consideration if cypress trees are to be harvested as a wood resource. In domes E and K, fairly extensive logging may have contributed to increased cypress growth rates by decreasing competition. Thinning in forest stands is known to cause an increase in growth of the remaining trees (Daniel and others 1979). While some drainage proved to be beneficial to cypress

growth rates, the long-term effect of intensive management practices upon cypress regeneration will be the most critical factor in determining the future of cypress as a renewable resource and as a component in dome ecosystems. The increase in hardwood and shrub densities in domes that have been drained and/or selectively harvested may decrease regeneration rates and speed succession toward a swamp that contains few commercially important species. The increased fuel in these drier swamps, however, both in the peat and in the shrub layer, may increase fire susceptibility, insuring return to a cypress swamp. But too severe a fire could destroy many of the trees, perhaps even producing a titi- or willow-choked swamp that could take decades to return to cypress (Gunderson 1977). Fire management may therefore be a much more crucial element in cypress swamp management than is currently recognized. Consideration of the special needs of both components in the flatwoods-dome matrix in producing renewable resources may enable forest managers to increase total harvest and diversity of wood products, and to protect more subtle roles that less commercially important ecosystems may be playing in the landscape.

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