Environmental Sciences

THE EFFECTS OF FIRE ON SPECIES COMPOSITION IN CYPRESS DOME ECOSYSTEMS[1]

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ABSTRACT: *Cypress trees were more successful than pines and hardwoods in surviving a fire which destroyed 42% of the trees in two cypress dome ecosystems. Cypress trees had comprised nearly half the trees in the domes, which had been drained for several years. After the fires, an average of 89% of the trees were cypress, 9% were hardwoods, and 2% were pines. Greatest mortality was in the center of the dome, where organic matter was deepest.*[*]

BALDCYPRESS (*Taxodium distichum* (L.) Rich.) and pondcypress (*Taxodium distichum* var. *nutans* (Ait.) Sweet) are commonly found in swamps throughout the southeast and as far north as southern Illinois and southern New Jersey. In Florida, small, circular swamps (usually less than 5 ha) are frequently called domes, because the trees are taller in the middle than at the edges, giving the swamps a dome-shaped profile. Cypress ecosystems normally have standing water at least part of the year; many are dry from late fall through late spring. It has long been recognized (e.g. Harper, 1927; Garren, 1943) that cypress swamps are often burned during the dry season, yet there is little documentation of the effects of fire on the ecosystems.

Beaven and Oosting (1939) mentioned that a fire that burned for 6 months in the cypress-dominated Pocomoke Swamp in Maryland destroyed the trees as well as most of the peat that had accumulated. Cypert (1961) described the damage done by fires in the Okefenokee Swamp in 1932 and in 1954 and 1955. All but the largest pondcypress trees were killed in two areas, although more trees survived on the site where peat deposits were shallower. In both areas, most of the regrowth was by coppicing. Kurz and Wagner (1953) postulated that the characteristic shape of cypress domes is due to the greater likelihood of fire around the outside of the swamp, where the ground may be dry for a greater part of a year.

Researchers at the University of Florida are currently investigating the feasibility of utilizing cypress swamps for the disposal of secondarily treated sewage. Part of the field work for the project is being carried out at a site near Gainesville,

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Florida, where several small cypress domes are located in a slash pine plantation (*Pinus elliottii* Engelm.) Following an unusually dry fall, a forest fire swept the site in December 1973; the location of the domes and the extent of the fire are shown in Fig. 1. Two of the severely burned domes have been studied intensively since then.

When the project began in June 1973, pondcypress, black gum (*Nyssa biflora* Walt.), sweet gum (*Liquidambar styraciflua* L.), and sweet bay (*Magnolia virginiana* L.) were the most common trees in the domes. Since the area had been drained by a series of ditches for many years, several slash pines grew in the domes as well. The understory was very dense, but had not been characterized prior to the fire.

The floor of the two burned domes smoldered for several weeks after the fire, but did not burn extensively enough to expose the mineral soil. After the fire, no standing water was present in the domes until March 1974, when secondarily treated sewage effluent was pumped into one and groundwater into the other. Pumping rates varied initially from 0 to 14 cm/wk, but have been constant at 2.5 cm/wk since April 1975.

Many trees in the two badly burned domes perished in the fire. The differential rates of mortality among the three kinds of trees (cypress, pines, and hardwoods) were of interest because of their implications for long-term survival of cypress ecosystems in areas where invasion by other species follows drainage.

METHODS—After the fire, maps were made of the two badly burned domes. Both live and dead trees were recorded for Dome 1, but only live trees were mapped in Dome 2. Heights and diameters of all live and dead trees in both domes were recorded. Another survey was conducted the following year to determine delayed tree mortality. In both surveys, dead hardwoods were grouped together because they could not be positively identified to species.

RESULTS—The numbers of live and dead trees before and one yr after the fire are shown in Table 1. In both domes, the majority of pine trees and hardwoods were killed, while only a small percentage of the cypress were killed. Cypress comprised about half the trees in the dome before the fire, and 80 to 90% after the fire. Cypress in Dome 2 suffered heavier mortality than in Dome 1, but a

TABLE 1. Effects of fire on numbers and biomass of cypress trees in cypress domes.

Dome	Kind of Tree	% of Trees Before Fire	% Decrease	% of Living Trees
1	Cypress	51.9	18.0	96.2
	Pines	27.2	95.7	2.6
	Hardwoods	20.9	97.6	1.1
	TOTAL	(599 trees)	55.7	(265 trees)
2	Cypress	43.6	22.5	81.6
	Pines	14.2	95.8	1.4
	Hardwoods	42.2	83.3	17.0
	TOTAL	(1334 trees)	58.5	(553 trees)

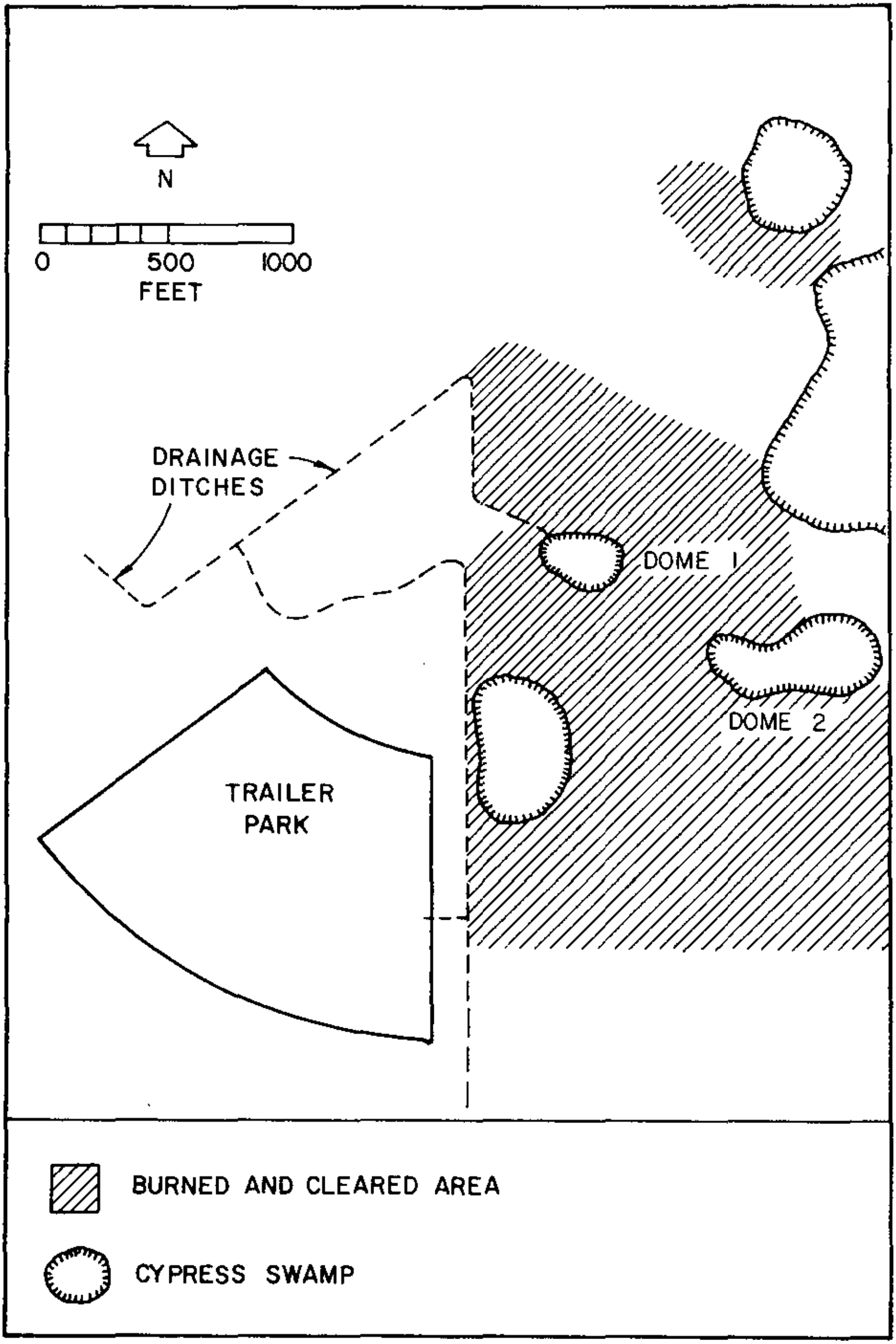

FIG. 1. Location of burned cypress domes at the experimental site of the cypress wetlands project near Gainesville, Florida.

larger proportion of the hardwoods, which had equalled cypress in number before the fire, survived. Dome 2 is the larger of the two (0.69 ha and 0.57 ha) and had a higher density of trees both before and after the fire. It had not been so severely drained originally, and had a considerably lower percentage of pine trees than did Dome 1. Table 2 shows the differences in size between live and dead trees in the domes. With the exception of pine trees in Dome 2, the surviving trees tended to be larger than the trees killed.

TABLE 2. Mean heights and diameters of three classes of trees in two burned cypress domes. Mortality was determined one year after the fire.

Class	Dome 1		Dome 2	
	Mean Height (m)	Mean DBH (cm)	Mean Height (m)	Mean DBH (cm)
Cypress:				
Live	17.3 °°	24.0 °°	17.7 °°	21.6 °°
Dead	10.5	12.3	11.3	12.0
Pine:				
Live	14.2	17.9	9.6	10.6 °°
Dead	13.9	16.3	12.8	14.7
Hardwood:				
Live	10.1	17.7	8.6 °°	10.4 °°
Dead	8.3	10.7	6.8	7.2

°°Significant difference at 1% level.

Distribution of surviving cypress trees in Dome 1 after the fire is outlined in Table 3. Density of the trees varied from $0.17/m^2$ in the center to $0.09/m^2$ at 30-40 m. The highest mortality occurred in the 315-m^2 central area where there were 55 trees before the fire: 29 cypress, 19 hardwood, and 7 pine. Only 10 trees survived, all cypress. Average height and DBH of the trees that died were close to the averages given for dead trees in Table 2.

DISCUSSION—Hare (1965) analyzed fire resistance in 14 southern trees, finding that, for trees of equal bark thickness, longleaf pine (*Pinus palustris,* Mill.) and slash pine are the most resistant to cambial damage, followed by loblolly

TABLE 3. Pattern of survival of trees in Dome 1. Areas are given for concentric rings in the dome at specified distances from the center.

Distance from center (m)	Area (m^2)	Survivors (%)
0-10	315	18
10-20	942	54
20-30	1571	48
30-40	1363	33
40-50	405	59
50-60	216	50

pine (*Pinus taeda* L.) and baldcypress, then by several hardwoods, of which the least resistant are sweetgum, black cherry (*Prunus serotina* Ehrh.), and American holly (*Ilex opaca* Ait.). For a given tree, fire resistance generally increases with tree diameter, since thicker bark and a higher crown prevent damage to either cambium or crown. Both cypress and pine might therefore be expected to survive burning better than hardwoods. However, the cypress trees at the experimental site were larger than either the pines or the hardwoods.

Since crown damage is usually more likely to kill a slash pine than is bole damage (Cooper and Altobellis, 1969), slash pine less than 1.5 m tall are easily killed in a light fire. Control burning is therefore inadvisable before the trees are 3.5 m tall (Cooper, 1965). The pine trees in the plantation surrounding the experimental site averaged 4.5 m tall, so they probably could have withstood a light fire. Nevertheless, all these trees were destroyed.

Hardwoods, on the other hand, are seldom completely destroyed by a fire, particularly in the winter when rootstocks are healthiest (Cooper, 1961). The fact that many of the hardwoods in the cypress domes were killed attests to the intense heat that must have built up in the organic matter on the floor of the cypress dome. Komarek (1972) observed that the bark of the cypress is fairly thick and fire-resistant, and that the formation of adventitious buds even after severe damage assists recovery. The majority of the cypress trees burned at the experimental site did put out adventitious branches, and some of the more severely damaged trees survived by coppicing.

In this case, the fire had a "cleansing" effect on the cypress dome, destroying most of the pines which were growing in the dome. Many of the hardwoods were also destroyed, but cypress trees are clearly capable of surviving a very damaging fire. Cypert (1961) observed that greater mortality of cypress on one burned site at the Okefenokee Swamp may have been due to greater depth of organic matter, since a smaller proportion of the roots would have extended into the mineral soil where they might have been more protected from fire. In a study of 15 cypress domes in north-central Florida, Monk and Brown (1965) found more organic matter (25-33 cm) in the soil beneath the central pool than at the edges (5-10 cm). Accordingly, Coultas and Calhoun (1975) had found that the organic and A1 horizons were 43 cm deep in the center of Dome 1 and 13 cm deep halfway to the edge. The Ap horizon was 15 cm deep at the edge. No measurements had been made in the other dome. The unusually low proportion of cypress trees that survived in the center of Dome 1 therefore supports Cypert's conclusion, and suggests that a fire which is hot enough to burn into the peat may have more serious consequences in the center than around the edges.

In a cypress dome with a normal hydroperiod, the existence of an open central pool may be attributed to both the effects of an occasional fire during a dry spell as demonstrated in this study, and the prevention of germination by the presence of standing water during normally wet years as shown by Demaree (1932). Pine trees invade cypress domes which remain dry for several years. Other work at the cypress dome experimental site indicates that decomposition of cypress needles occurs more slowly in dry areas than in wet areas (Deghi, 1976). Moreover, net productivity appears to be greater in drained domes than in undisturbed ones (Carter et al., 1973; Mitsch, 1975), so litter will accumulate fairly rapidly on the surface of a dry dome. Fires which burn through cypress domes after longer and longer drying periods will therefore do progressively greater damage, since the organic layers on the floor of the domes will have built up to a greater extent.

Cases have been documented in which cypress have been eliminated entirely from a burned site. Wells (1928) described shrub-choked bogs which developed after North Carolina swamp forests (characterized by *Nyssa, Taxodium,* and *Chamaecyparis*) had been damaged by fire. When wet conditions prevailed in such bogs, titi (*Cyrilla racemiflora* L.) predominated. Cypert (1961) showed that fires in 1954 and 1955 caused the formation of prairies in the Okefenokee Swamp by burning into the peat bed and killing the trees. No other fires since 1844 had had such a severe impact on the swamp.

Periodic fires will have little effect on the species composition of a cypress dome under normally wet conditions, and cypress will continue to be dominant in a drained cypress dome that is swept by periodic fires. Lack of fire in drained or dry cypress domes will allow a mixed stand of cypress and pine to develop. A fire which occurs after a long drying period in either case will do its greatest damage in the center of a dome, and may eliminate cypress altogether if sufficient organic matter has accumulated around the edges.

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Earth Sciences

THE TAMIAMI FORMATION—HAWTHORN FORMATION CONTACT IN SOUTHWEST FLORIDA

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ABSTRACT: *Stratigraphic placement of the Tamiami Formation—Hawthorn Formation contact has been arbitrary in subsurface investigations in southwest Florida. This contact is properly positioned beneath a dark colored carbonate mud unit, which contains large concentrations of detrital phosphorite, quartz sand, and various clay minerals. The mud unit, known informally as the Fort Myers clay member of the Tamiami Formation, covers the Hawthorn Formation in nearly all of southwest Florida. The formational contact is distinctive in western Lee and Charlotte Counties, where it is a stratigraphic disconformity, and becomes less distinctive to the south and east, where deposition has been continuous and no break in the stratigraphic record is evident.*[*]

PROPER DELINEATION of the contact between the Tamiami Formation and the underlying Hawthorn Formation in stratigraphic and hydro-geologic investigations has been a recurring problem in south Florida. Both units are lithologically complex and contain numerous differing sediment facies. Although these formations are separated in part by an unconformity, the lower-most Tamiami sediments sometimes have a similar composition to the uppermost Hawthorn sediments. Different contact placements have been made on the same stratigraphic sequence with early investigators placing the contact high in the sequence (Cooke, 1945; Klein, Schroeder and Lichtler, 1964; Puri and Vernon, 1964) and later investigators placing the contact at a lower stratigraphic position (Sproul, Boggess and Woodard, 1972; Boggess and Missimer, 1975; Missimer, 1975; Peck, Missimer and Wise, 1976; Peck, 1976).

The increased emphasis being placed on groundwater investigations in southwest Florida necessitates the need for detailed, accurate, stratigraphic control in order to properly delineate regional hydraulically connected aquifers. New paleontologic data and better stratigraphic control have now permitted the es-

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