

CYPRESS WETLANDS FOR WATER MANAGEMENT, RECYCLING AND CONSERVATION

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X. CORKSCREW SWAMPS

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ECOSYSTEM ANALYSES AT CORKSCREW SWAMP

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Introduction

A main objective of work on the virgin cypress strand and other vegetation at the Corkscrew swamp is to relate tree growth of cypress and composition of plant communities to climate, hydroperiod, and nutrient regimes. Virtually all fieldwork for this phase was finished by January, 1977. In order to obtain data for three full annual cycles, we continued to monitor the wells (at monthly intervals) through May, and the main weather station through August. By June we had dismantled all other field equipment except that which will be used for long-term monitoring.* We took advantage of special opportunities for conducting short-term research on freeze effects, cypress leaf-out sequences, and Sabal palmetto ecology. Results of these studies are included in this report.

Laboratory analyses of vegetation, soil, and water chemistry and soil physical characteristics were completed by summer, 1977.

*Equipment inventoried to the Center for Wetlands, Univ. of Florida is authorized for use on other projects with which the University is officially in collaboration.

Analysis of data on chemistry and vegetation biomass and productivity is scheduled for completion in spring, 1978.

Hydroperiod Analyses

In our 1975 report we discussed hydroperiod-plant community relationships based on 1974-1975 water level data from 30 wells in six major habitats at Corkscrew Swamp Sanctuary. We now have 2 more years' data from these sites, and we have correlated water level data from these three annual cycles with 14 years of data from a staff gage located in one of the sanctuary's deeper sloughs. When water levels are above-ground, measurements at the staff gage correlate well with those at the other sites and we feel we can accurately extrapolate surface water levels and hydroperiods from the staff gage records. However, substrate characteristics create localized variations in the groundwater table and prevent extension of below ground water level information to distant sites.

We used the staff gage-well site correlations to calculate the 14-year hydroperiod record for each well site. Since the wells were situated along surveyed transects, through a cross-section of habitats with elevation and vegetation type data recorded at 7.6 m intervals, we were able to calculate average hydroperiods for each habitat. This gave us a 14-year hydroperiod record for 43 sites representative of all major Corkscrew habitats. Mean hydroperiods ranged from 10 to 346 days (Fig. 1) and standard errors were consistently between 7 and 22 days.

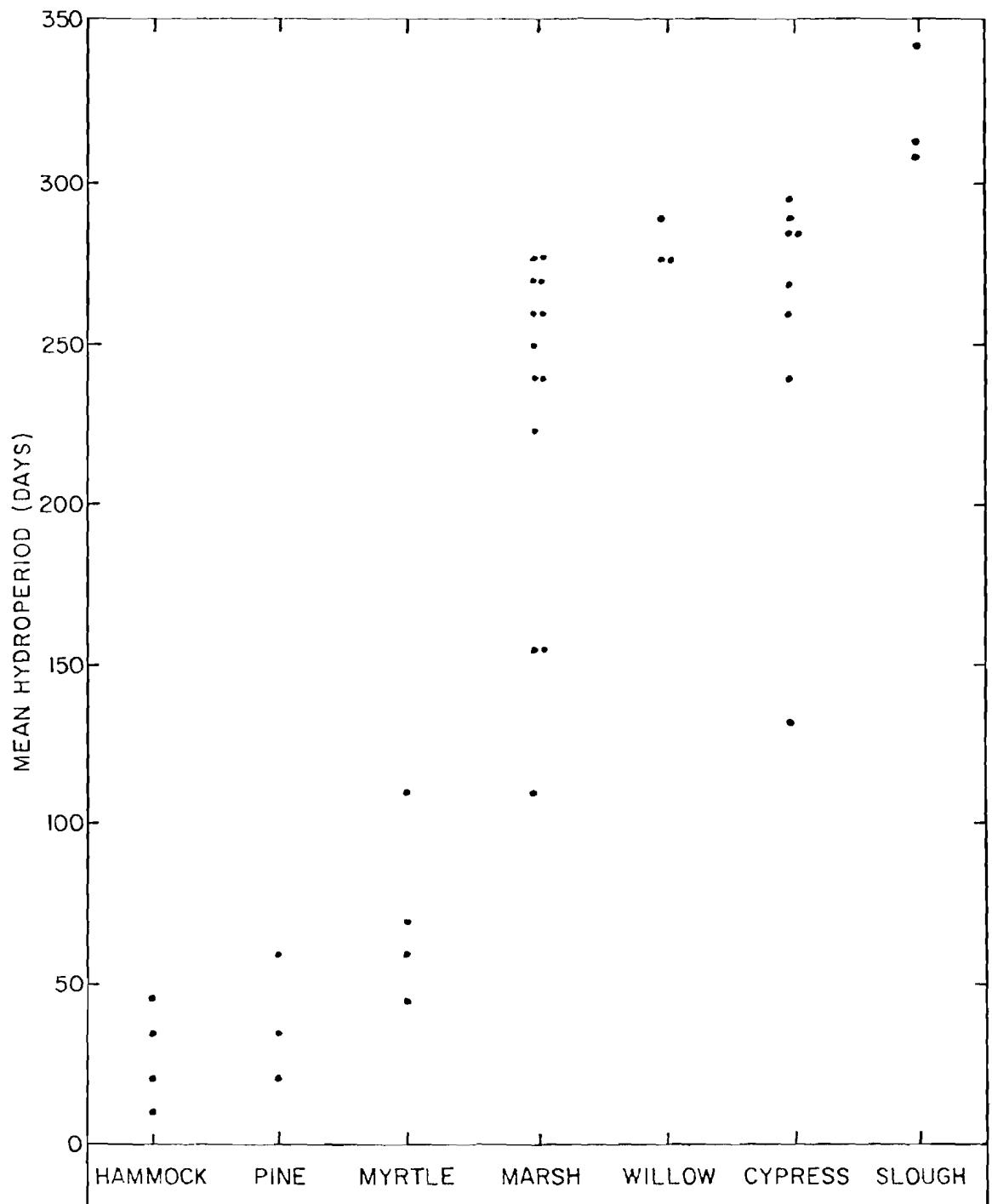


Fig. 1. Mean hydroperiods for 43 sites at Corkscrew Swamp Sanctuary over a 14-year period.

These data generally support the conclusions on habitat-hydroperiod relationships presented in our 1975 and 1976 reports although they modify our understanding of transition zones between certain plant communities. Data from additional pine and hammock sites indicate that two habitats are not significantly different. Apparently atypical hydroperiods can be explained in terms of special site characteristics.

Marsh hydroperiods normally fell in the range of 224 to 278 days per year, but three sites had shorter hydroperiods (111-155 days). These sites are somewhat different in species composition than the wetter marshes and are probably more appropriately termed "wet prairie" than "marsh." They are essentially myrtle prairies where fire has limited shrub invasion. The two marsh sites with unusually long hydroperiods (286-296 days) are affected by impoundment by and seepage from a dike.

The four sites with the largest and fastest-growing cypress (Taxodium distichum) had hydroperiods of between 286 and 296 days. Tree-ring analyses indicate that longer hydroperiods (306-325 days) at four cypress sites along the dike are slowing tree growth. Cypress growth rates were also relatively slow on the four sites with the shortest hydroperiods (133-270 days). Poor growth was particularly obvious on the 133 day hydroperiod site, where there was a vigorous shrub stratum of wax myrtle (Myrica cerifera), a species characteristic of sites with hydroperiods between 45 and 155 days. The cypress sites with hydroperiods of 260 and 270 days were severely burned in 1962 and, although the species is still present, the sites can no longer be considered healthy cypress communities.

All four of the sites with low hydroperiods and slow cypress growth rates are located in the periphery of the main strand or in a smaller nearby strand, and all but one of them are underlain (at depths of less than 1.5 m) by a stratum of almost pure shell. Although these shell beds serve as groundwater conduits, they also tend to depress the water table in the vicinity.

At our study sites willows grow where hydroperiods are between 278 and 291 days, but we have observed them growing well elsewhere on canal banks or in similar situations where their bases are in much shorter hydroperiod sites, but their root systems have access to water most of the year.

Sloughs, Corkscrew's deepest habitats, had average hydroperiods of 310 to 346 days. No natural habitat was continuously inundated; within the 18 years of record through 1977 there were three times when no natural surface water was present at Corkscrew Swamp.

Actual habitat hydroperiods are not evenly distributed over the theoretically possible range of hydroperiods. Our nine upland sites had hydroperiods of between 10 and 70 days, and five other sites had hydroperiods of under 156 days. The twenty wetland habitats had hydroperiods of between 224 and 296 days, and the sloughs had hydroperiods of up to 346 days. Thus there were very few sites with hydroperiods between 70 and 224 days, and none with hydroperiods between 155 and 224 days.

From the 14 years of staff gage data we calculated the average hydroperiod for each 2.54 cm interval from the ground surface to the highest recorded water level. When these hydroperiods were plotted against the corresponding water levels (Fig. 2) it became obvious

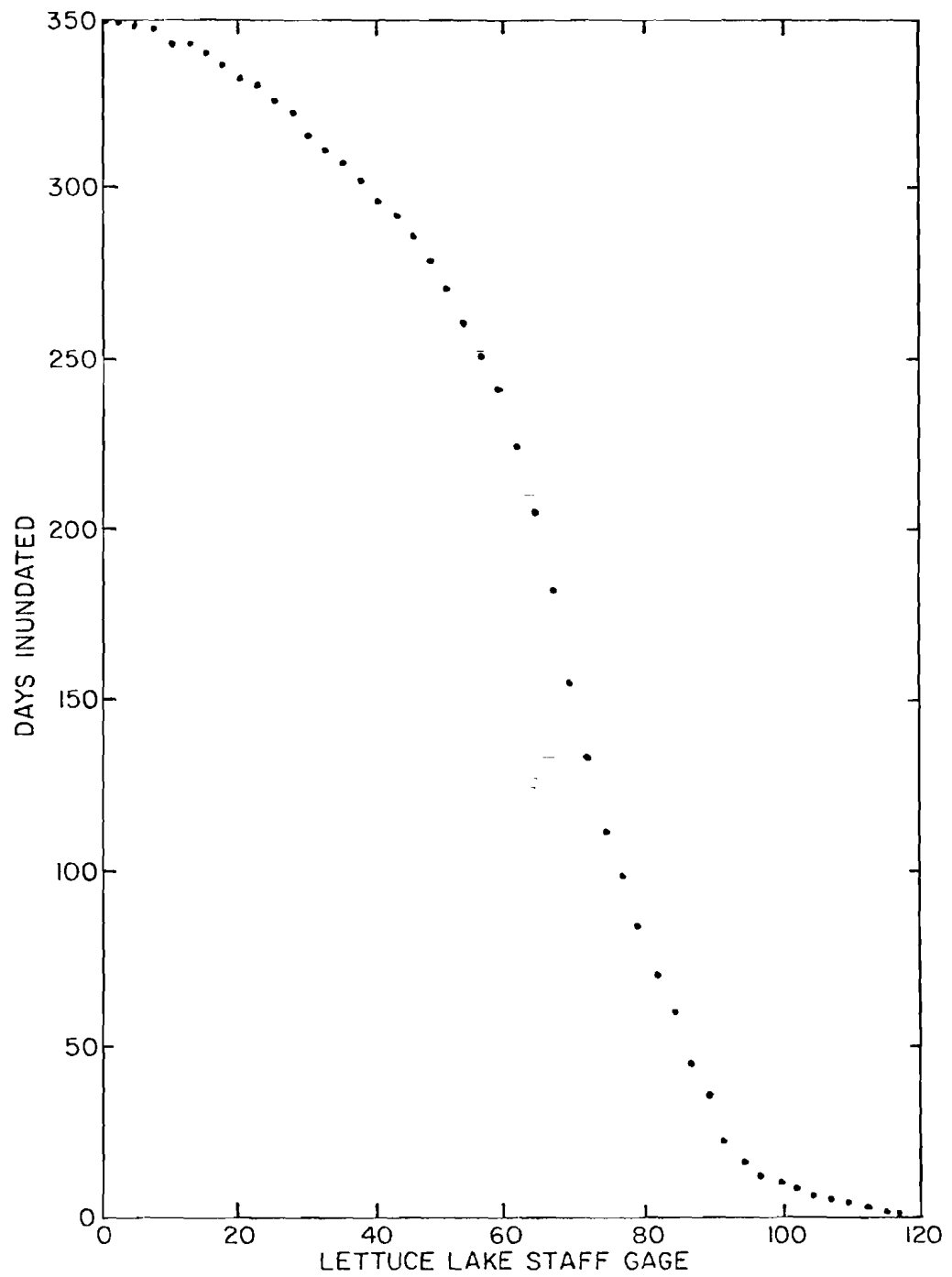


Fig. 2. Mean number of days per year that water levels were above given points on the Corkscrew Swamp Sanctuary staff gage.

that intermediate water depths were by far the most significant in terms of length of hydroperiod. Variations in high or low water levels had relatively little effect on hydroperiod, but the 12 cm difference between water depths of 69 and 81 cm caused a 113 day increase in hydroperiod.

This "vacant" hydroperiod range corresponds to the transition between upland and wetland habitats. Although the narrow bands of land at this hydroperiod are undoubtedly vegetated, no plant community seems to find optimum conditions here. This is at least partially because sites at this hydroperiod are actually scarce due to topographic characteristics and seasonal weather patterns.

Wetland habitats had hydroperiods of over 223 days. Peat accumulation was insignificant at sites with hydroperiods of less than 241 days, but peat deposits were characteristic of habitats inundated for longer periods. Extensive shallow wetlands are formed by peat filling in deeper depressions and building them up to an elevation where additional organic matter oxidizes instead of accumulating. As peat deposits fill the lower parts of ponds and sloughs, they force water up onto higher ground and increase hydroperiods in surrounding areas. Because of these processes, large areas of wetlands are maintained at hydroperiods near the peat accumulation-oxidation balance point.

South Florida's sharply defined wet and dry seasons accentuate the distinction between upland and wetland hydroperiods. Figure 3 illustrates the seasonal rainfall pattern. The rapid transition between summer and winter water levels (and vice versa) prevents intermediate water levels from prevailing for very long. In such

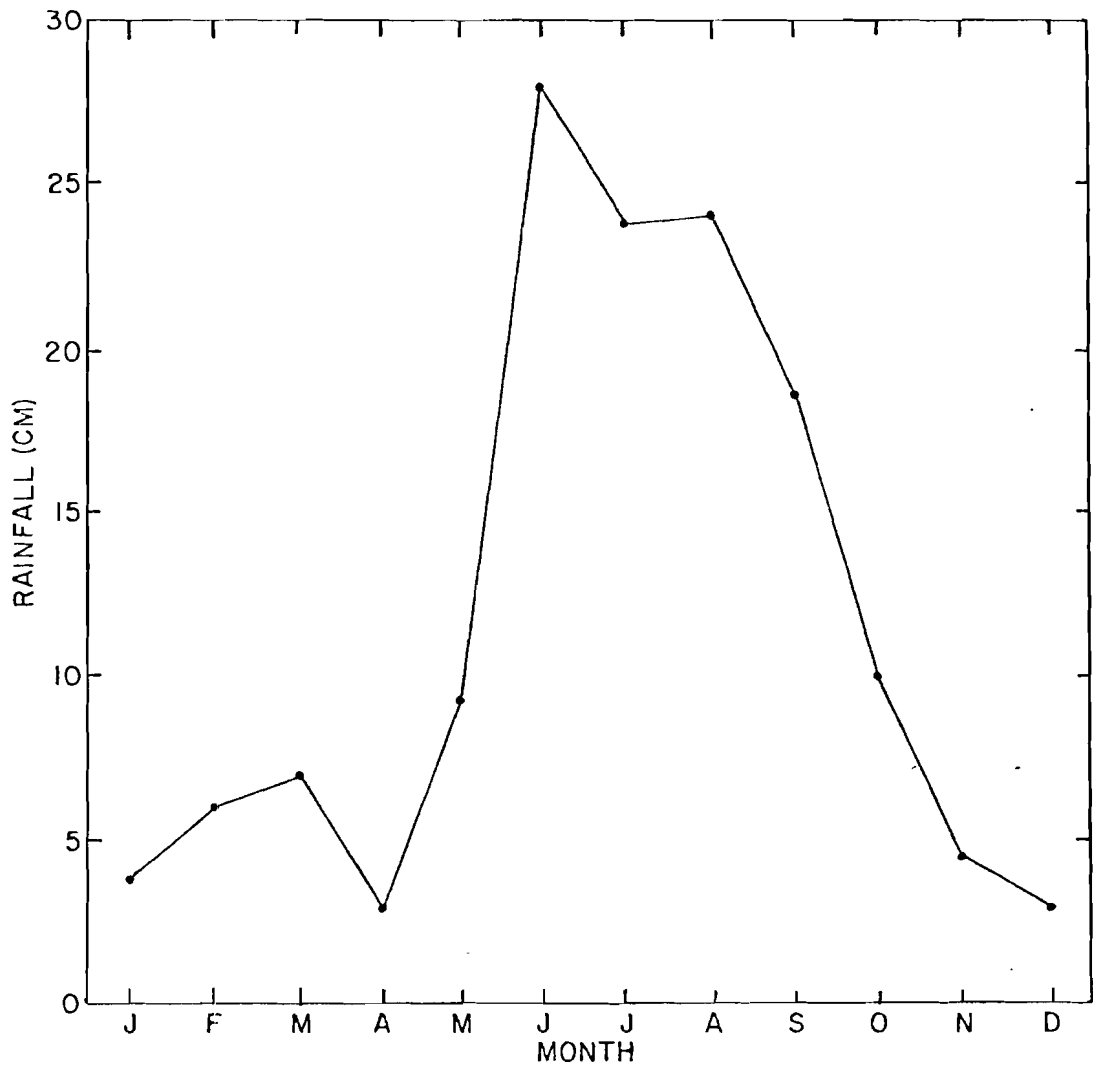


Fig. 3. Average monthly rainfall at Corkscrew.

extremely flat terrain this means that most of the time either practically every place is under water or only the deeper marshes, swamps and sloughs are wet.

Although hydroperiod appears to be the primary determinant of wetland community distribution, water levels are also an important influence. Excessively high or low water could threaten cypress survival, but natural cypress strand water levels are most significant in terms of understory composition and animal populations.

Table 1 gives average first-of-the-month water levels at the boundaries between marsh and pond cypress and between bald cypress and slough (Lettuce Lake) at Corkscrew Swamp. The values are extrapolated from 16 years of water level records from two staff gages along the sanctuary boardwalk. Extreme values associated with unusual drought or rainfall were excluded from the averages and "normal" ranges.

The range of water level variation was greatest (58-66 cm) during the dry season-wet season transition period, due to year-to-year variability in drought severity and timing of rainy season onset. Water levels were most consistent for December and January, cold months with low and constant evapotranspiration rates. These winter months are also the driest, so rainfall variations are on a relatively small scale.

The average water depths were typically skewed towards the maximum "normal" values, although less so during the wet season. This suggests that there have been more "wet" than "dry" years during the period from 1959 to 1975.

Our 1975 report discussed the effects of canals, dikes, and

Table 1. "Normal" Corkscrew Surface Water Depths (cm).

	Pond Cypress - Marsh Edge			Bald Cypress - Lettuce Lake Edge		
	Minimum	Average	Maximum	Minimum	Average	Maximum
Jan	10	17	20	33	39	43
Feb	-3	13	20	20	36	43
Mar	-5	10	20	18	33	43
Apr	-18	1	15	5	24	38
May	<-58	-23	0	<-36	0	23
Jun	<-58	-28	5	<-36	-5	28
Jul	-25	9	41	-3	32	64
Aug	5	23	43	28	46	66
Sep	20	29	43	43	52	66
Oct	8	32	43	30	55	66
Nov	10	25	33	33	48	56
Dec	10	22	28	33	44	51
Hydro- period (days inun- dated)	155	240	290	270	290	320

pumps on water levels at the staff gages. Deletion of data for periods when such influences were operating did not significantly affect the mean water depth values for the months from November through April. However, the May and June average depths are approximately 3 cm higher than would have been the case if years when pumps were run during the dry season were excluded, and dike effects raised average depths 2-6 cm above what they would be under "natural" conditions. In view of normal year-to-year variability, these deviations are probably significant only in terms of lengthening hydroperiods.

It is important to recognize that the relationships between water depths and hydroperiods observed at Corkscrew Swamp are a function of that particular strand's topography. The Corkscrew cypress forest has a ground elevation range of 23 cm from the strand interior to the periphery. Since hydroperiod is a more important factor than water depth, we expect that other cypress forests would have similar hydroperiods (Table 1), although they might have quite different topographic gradients and hence different water depths. Seasonal water level fluctuations would probably be minimal in swamps situated in large shallow depressions, or on coastal plains or deltas, and greatest in river valleys, especially those with rivers fed by large watersheds.

As we discussed in our 1975 report, rainfall and water levels at Corkscrew Swamp Sanctuary correlate well. Since rainfall measurements were not taken at Corkscrew prior to 1959, we compared Corkscrew and Fort Myers precipitation records to see if Fort Myers rainfall data, which has been recorded since 1892, could be used to calculate earlier Corkscrew water levels. We correlated the two sets of rainfall data by comparing: 1) each month ($r = 0.81$);

2) each January-May period ($r = 0.97$); 3) each June-September period; and 4) each June-May period ($r = 0.98$). Thus it appears that we will be able to reconstruct hydrologic data for Corkscrew Swamp from 1892 to the present with reasonable accuracy. In addition to giving us valuable information on year-to-year variability, a record of this length should permit us to relate variations in cypress growth rates (as determined through tree-ring analysis) to climatic events.

A preliminary examination of Fort Myers precipitation data revealed no major changes in rainfall patterns during the period of record. We calculated the mean annual Fort Myers rainfall and its variability for each 10-year period from 1901 to 1970 and for the shorter periods from 1892 to 1900 and from 1971 to 1975 (Table 2). Since this analysis revealed no major changes in precipitation patterns during the period of record, we feel that the water level data gathered since 1959 is probably representative of hydrologic conditions at Corkscrew over the entire 1892-1975 period.

Preliminary Notes on 1977 Freeze Effects in Collier County

The severe winter of 1976-1977 brought record cold temperatures to South Florida on January 19-20, 1977; temperatures were the lowest ever recorded in Collier County. Many large and obviously quite old trees and shrubs were killed or severely damaged and it was evident that the extreme weather had had significant impact on the region's plant communities. Therefore, we undertook a vegetation survey to document the effects of this rare natural "catastrophe." We did one survey on January 21, immediately after the freeze, and another on March 25, after the surviving plants had put out spring foliage.

Table 2. Precipitation Patterns at Fort Myers, Florida.

	N	\bar{X}	S.E.	Min	Max
1892-1900	9	55.77	2.94	41.17	69.65
1901-1910	10	50.50	1.85	38.99	56.84
1911-1920	10	51.33	3.00	40.06	74.69
1921-1930	10	55.13	3.79	32.85	77.35
1931-1940	10	51.66	2.77	42.00	67.13
1941-1950	10	53.00	4.37	34.17	80.17
1951-1960	10	55.33	2.86	39.85	66.68
1961-1970	10	53.49	3.81	32.83	71.94
1971-1975	5	50.50	2.16	44.33	56.71

We made observations of native vegetation, but paid particular attention to exotics, especially those considered to be naturalizing. These include melaleuca (Melaleuca quinquenervia), Brazilian pepper (Schinus terebinthifolius), Australian pine (Casuarina sp.), guava (Psidium guajava), and Java plum (Syzygium cumini). The sites that were surveyed are shown in Fig. 4.

In the inundated cypress forest at Corkscrew Swamp Sanctuary (1) few plants were damaged. Outer leaves of pond apple (Annona glabra) and strangler fig (Ficus aurea) were withered, but their woody tissues were unaffected. In exposed sites at the edge of the strand or in the wet prairie, small pond apples and strangler figs lost all their leaves and some outer branch tips. At these open sites primrose willow (Ludwigia peruviana) also lost most leaves. As expected, temperate species such as cypress (Taxodium distichum), cabbage palm (Sabal palmetto), red maple (Acer rubrum), dahoon holly (Ilex cassine), coastal plain willow (Salix caroliniana), red bay (Persea borbonia), and popash (Fraxinus caroliniana) were not affected.

In the Big Corkscrew Island pinelands (2), between Corkscrew Swamp and Immokalee, small strangler figs (less than 3 m tall) were killed back to the main stem, but large specimens (over 9 m) suffered only slight browning of the upper leaves. Small Java plums lost upper leaves and small branch tips. Large Java plums were undamaged. Guavas in low marshy spots or along pond margins lost only upper leaves, while those growing on higher and drier sites such as pinelands and road berms lost most or all leaves.

At Immokalee (3), Brazilian pepper, Australian pine, melaleuca, Norfolk Island pine (Araucaria excelsa), queen palm (Arecastrum

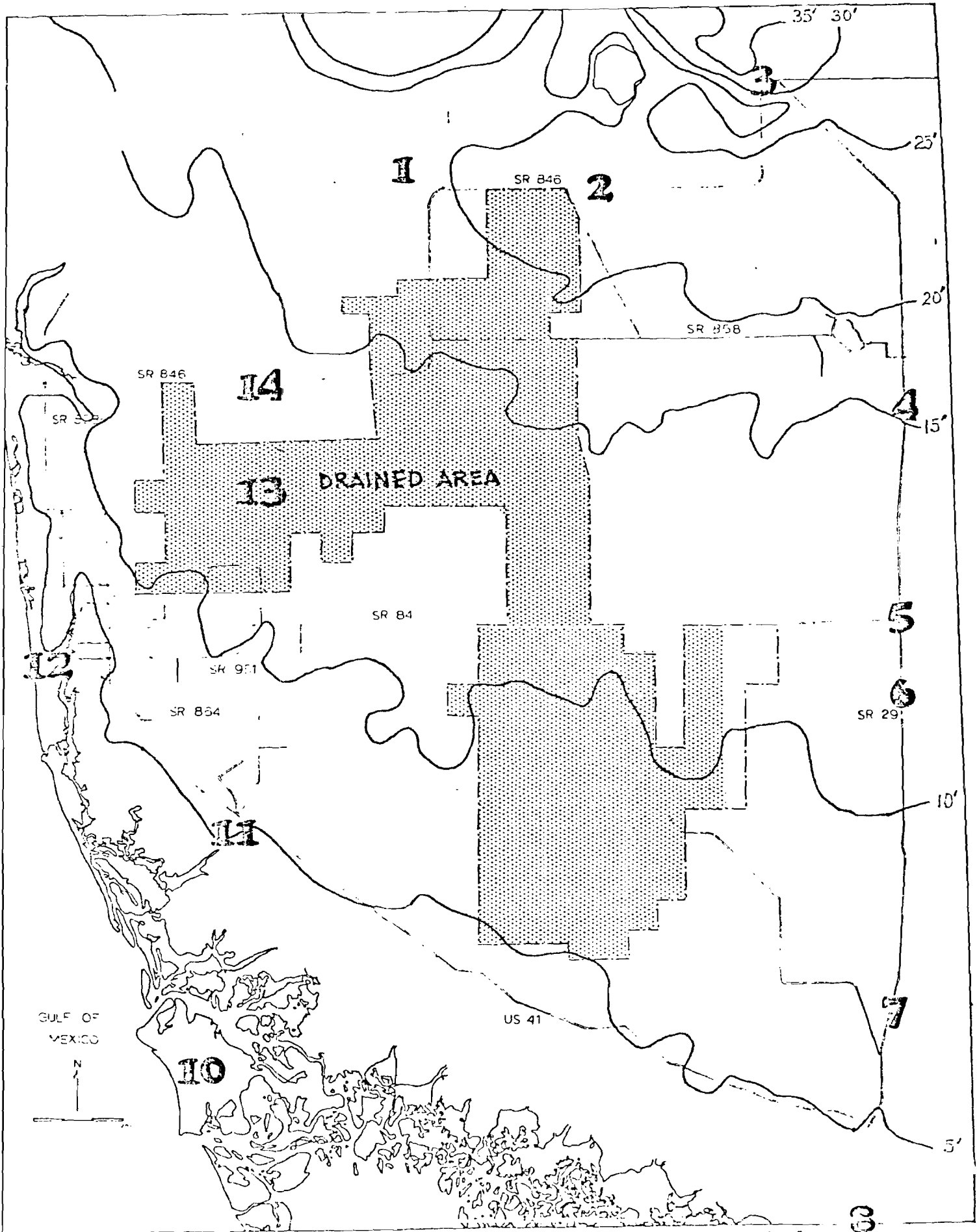


Fig. 4. Collier County freeze survey sites. Adapted from Tropical Bioindustries, Inc. 548

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romanzoffianum), bischofia (Bischofia javanica), Eucalyptus sp., and Mexican avocado varieties (Avocado americana) were not damaged. Only a few outer leaves were killed on Java plum, royal palm (Roystonea elata), seagrape (Coccoloba uvifera), mahoe (Hibiscus tiliaceus), castor bean (Ricinus communis), screwpine (Pandanus utilis), and banyan (Ficus sp.). Guava, papaya (Carica papaya), schefflera (Schefflera actinophylla), India rubber tree (Ficus elastica 'Decora'), coconut palm (Cocos nucifera), mango (Mangifera indica), banana (Musa sp.), orchid tree (Bauhinia sp.), bougainvillea (Bougainvillea sp.), and most avocado varieties were killed back to main stems 10-15 cm in diameter.

Along SR 29, 29 km south of Immokalee (4) all gumbo limbo (Bursera simaruba) leaves were dead and Florida trema (Trema micrantha) was killed to the ground. Strangler figs were killed back to major (10-15 cm) branches.

At the intersection of SR 29 and Alligator Alley (5) Brazilian pepper had lost most leaves, but these were small chlorotic-looking plants which could have been weakened by some other stress. Three to eight km south of Alligator Alley along SR 29 (6) damage was minimal. Brazilian pepper was unaffected and guava and strangler fig retained most leaves. Further south (7) Brazilian pepper, guava, and strangler fig all lost their leaves.

The mangroves furthest inland, in the vicinity of US 41 and SR 29, were killed. Varying degrees of mangrove injury were noted closer to the coast. Generally, red mangroves (Rhizophora mangle) growing along the water's edge suffered only a few browned upper leaves, whereas black (Avicennia nitida) and white (Laguncularia racemosa)

mangroves at these sites lost all upper leaves and branch tips. However, the warming effect of the Gulf waters was apparently more important than species sensitivity to cold. Inland along the tidal creeks small mangroves of all species were killed to the base of the main stem.

At Everglades City (8) melaleuca, Australian pine, coconut palm, seagrape, screwpine, bougainvillea, bischofia, and manila palm (Veitchia merrillii) were undamaged. Uppermost leaves were browned on gumbo limbo, strangler fig, mango, schefflera, African tulip tree (Spathodea campanulata), and royal poinciana (Delonix regia). Papaya, banana, and frangipani (Plumeria sp.) were more extensively damaged. On Chokoloskee Island (9) papayas and very small gumbo limbos were slightly injured.

The only effects observed on Marco Island (10) were browning of leaves on frangipani and ixora (Ixora coccinea). Travelling inland (north) on SR 951, we first encountered more severe effects 0.8 km south of US 41 (11). There was moderate damage to coconut palm, schefflera, India rubber tree, mango, and manila palm in this area.

Along Gulfshore Drive in Naples (12) no frost effects were evident. Moving inland, first signs of damage were noticed near US 41, where palm, ixora, and seagrape leaves were discolored. The part of Naples between US 41 and the coast was generally unaffected.

In the severely drained Golden Gate area (13) all tropical exotics appeared to be damaged to some degree. Bischofia, Australian pine, and eucalyptus were least affected. Small Brazilian peppers lost all their leaves, but only the upper leaves were killed on

large specimens. Java plum, melaleuca, and weeping fig (Ficus sp., probably benjamina) were moderately damaged. Leaves and outer branch tips of strangler fig, trema, and cocoplum (Chrysobalanus icaco) were killed. Seagrape lost only upper leaves, but coconut palm, manila palm, ixora, schefflera, papaya, and India rubber tree lost almost all foliage.

Most severe melaleuca damage occurred north of Golden Gate at the intersection of SR 951 and SR 846 (14) where trees up to 3 m tall were killed to within 0.3 m of the ground.

The spring survey generally confirmed our initial assessment of freeze damage. Few native trees were dead. Some of the smaller strangler figs in exposed locations were dead to the ground and showed no signs of new growth, but larger figs were vigorously resprouting. Few of them seemed to be set back more than 6-8 years' growth, and most of them looked like they would be fully recovered in 1-2 years. Only small branch tips had been killed on the defoliated pond apples. Florida tremas and cocoplums in exposed sites in Golden Gate were killed, but in other areas they were resprouting from their bases. Lightly damaged species such as royal palm, seagrape, and primrose willow were recovering by March.

Most exotic trees also survived. We observed several neglected mangos and avocados that had died, but most of those under cultivation or on protected sites were alive. Generally, mangos and strangler figs were affected similarly and many large mangos were killed back to major stems 5-15 cm in diameter. These and other sensitive species (banana, papaya, schefflera, coconut palm, India rubber tree, orchid tree, guava, and certain avocado varieties) were showing healthy new

growth in all locations by March, and lightly damaged exotics were recovering.

Except for the coastal islands and the narrow band between the beaches and US 41, cold damage was not directly correlated with distance from the coast, as is usually the case, due to the temperature-moderating influence of large bodies of water. In the center of the peninsula near Conservation Area III, an extensive shallow impoundment which was full of water at the time, such sensitive species as banana, papaya, and cocoplum were not significantly injured. Nor was the severity of the freeze within Collier County consistently related to distance north or elevation above sea level. Immokalee, the highest and furthest north location surveyed, suffered only minimally, perhaps because of the large wetland areas in the vicinity. Although the greatest damage occurred in the severely drained Golden Gate area, the undisturbed swamp forest at nearby Corkscrew Swamp Sanctuary was virtually unaffected. Therefore, it appears that wetland drainage enhances the severity of freeze damage in southwest Florida.

Cold temperatures cannot be expected to limit the spread of common exotic plants in Collier County. The exotics naturalizing in the county (melaleuca, Brazilian pepper, Australian pine, guava, and Java plum) are apparently more cold hardy than such common native species as strangler fig, pond apple, cocoplum, and trema.

Cypress Growth Rates

Our 1976 report described hydrologic patterns, substrate characteristics, and forest structure along a transect across the

Corkscrew cypress strand and hypothesized that minimum dry season water levels, peat depth, and fire frequency and severity are the key factors responsible for the observed community structure. Figure 5 shows the relationship between tree size and peat depth along the eastern part of the Central Marsh Transect. A similar analysis of the western arm of the horseshoe-shaped strand yielded virtually identical results, although variability was greater because of a smaller sample size.

There are certain consistent deviations from the otherwise excellent correlation of tree age and diameter (DBH): the intermediate-size trees towards the outside edge of the strand are smaller than would be expected for their ages and the trees growing along both the inner (Central Marsh) and outer borders of the strand are large for their ages. This suggests that other factors also significantly affect cypress growth rates. In an attempt to identify these other influences, we have examined tree-ring growth patterns of cypress from a wide variety of sites.

Growth rate can change as a tree ages, even if environmental conditions remain constant. Therefore, we felt it was important to define the normal growth patterns associated with each stage in the life of a cypress tree before we tried to relate growth changes to external factors. Computer plots of tree-ring widths versus age of several hundred cypress trees indicate that poor growing conditions cause similarly slow growth in trees of all ages, but young trees apparently have a greater capacity to respond to optimum conditions (Fig. 6). Young trees regularly put on ring width increments of up to 5-6 mm in a good growth year, whereas older trees rarely produced

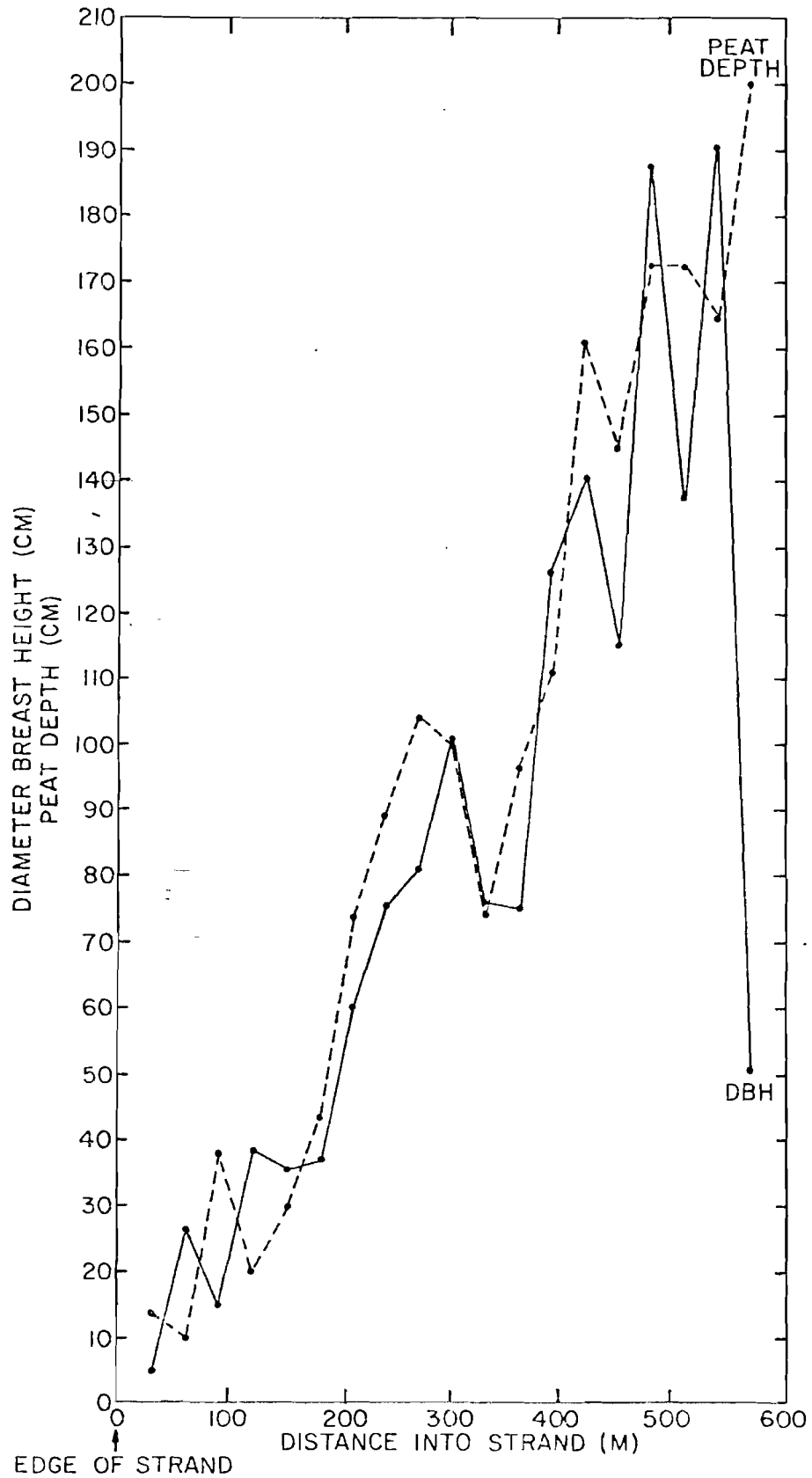


Fig. 5. Cypress DBH and peat depth; central marsh transect, east strand.

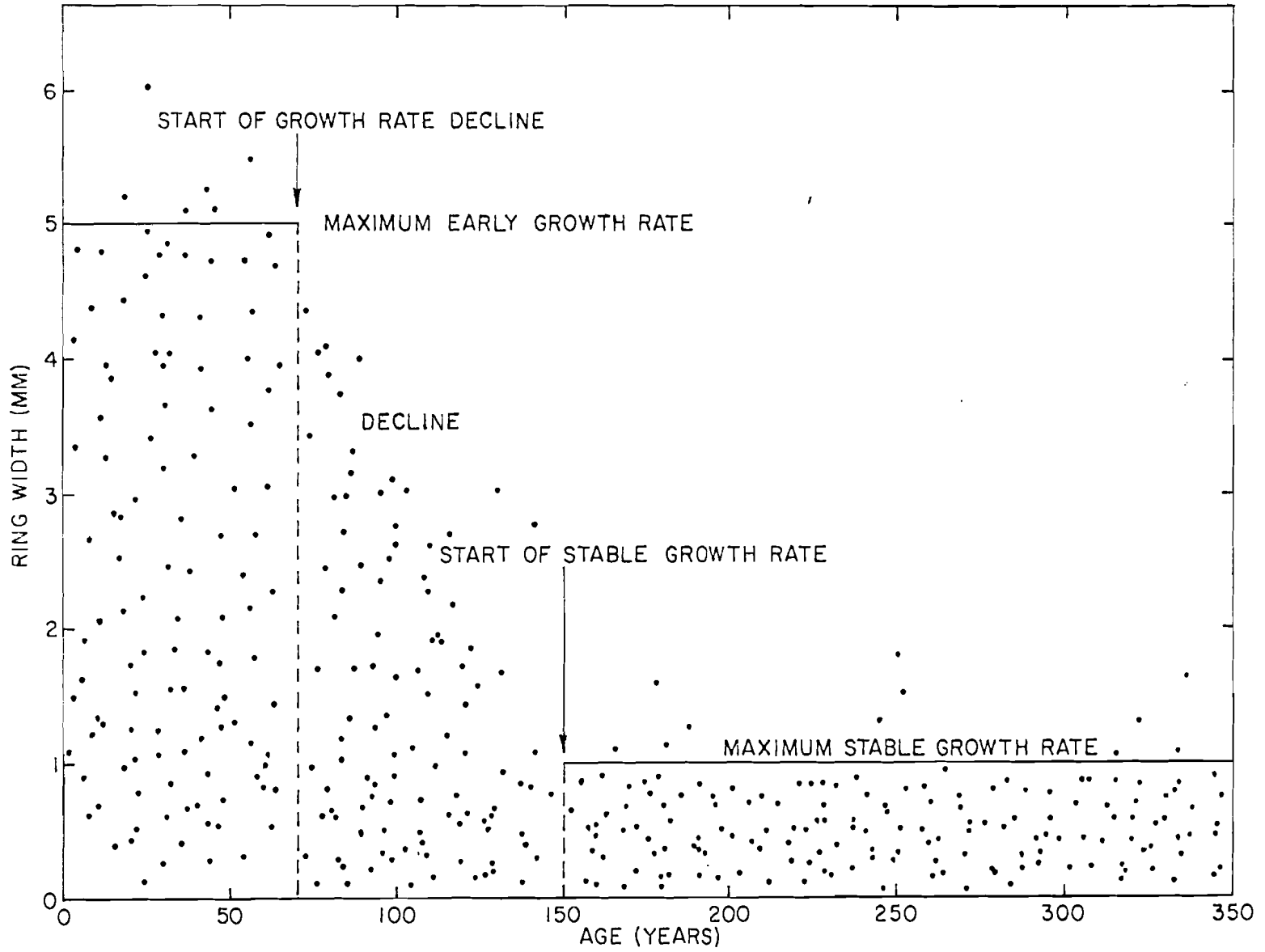


Fig. 6. Cypress growth rate patterns (schematic representation).

more than 1-1.5 mm in even the best growth years. Figure 7 illustrates the ages at which Corkscrew trees underwent the transition between the youthful high growth potential phase and the mature stable growth phase.

It has been suggested that the huge trees in the interior of the Corkscrew strand are the result of the optimum cypress site conditions. In order to better evaluate this hypothesis we plotted the maximum early growth rates and maximum stable growth rates of trees along the Central Marsh Transect (East Strand). Maximum stable growth rates were uniform across the strand (Fig. 8). Maximum early growth rates, however, generally increased from the strand edge towards the center, confirming the better quality of the interior sites. Growth rate analysis of the western arm of the strand revealed the same patterns. Higher growth rates were observed at three points along the Central Marsh Transect and all of them were places where the trees had greater than usual access to sunlight: at both the inner and outer edges of the strand and in a canopy opening beside a lettuce lake.

Figure 9 illustrates the relationship between age and DBH of cypress from a variety of sites. With a few easily explained exceptions, age and DBH correlate well. However, trees growing in marls or in shallow soils with rock near the surface (usually sites with short hydroperiods) are generally small for their ages. This is most dramatic in the bonsai-like dwarf or scrub cypress with very enlarged buttressed bases and small boles and crowns. Understandably, stump sprouts regenerating from the root system of large cut trees grow faster than seedlings. Not only do they have the advantage of the same deep peat soil which produced the original big tree, but they have

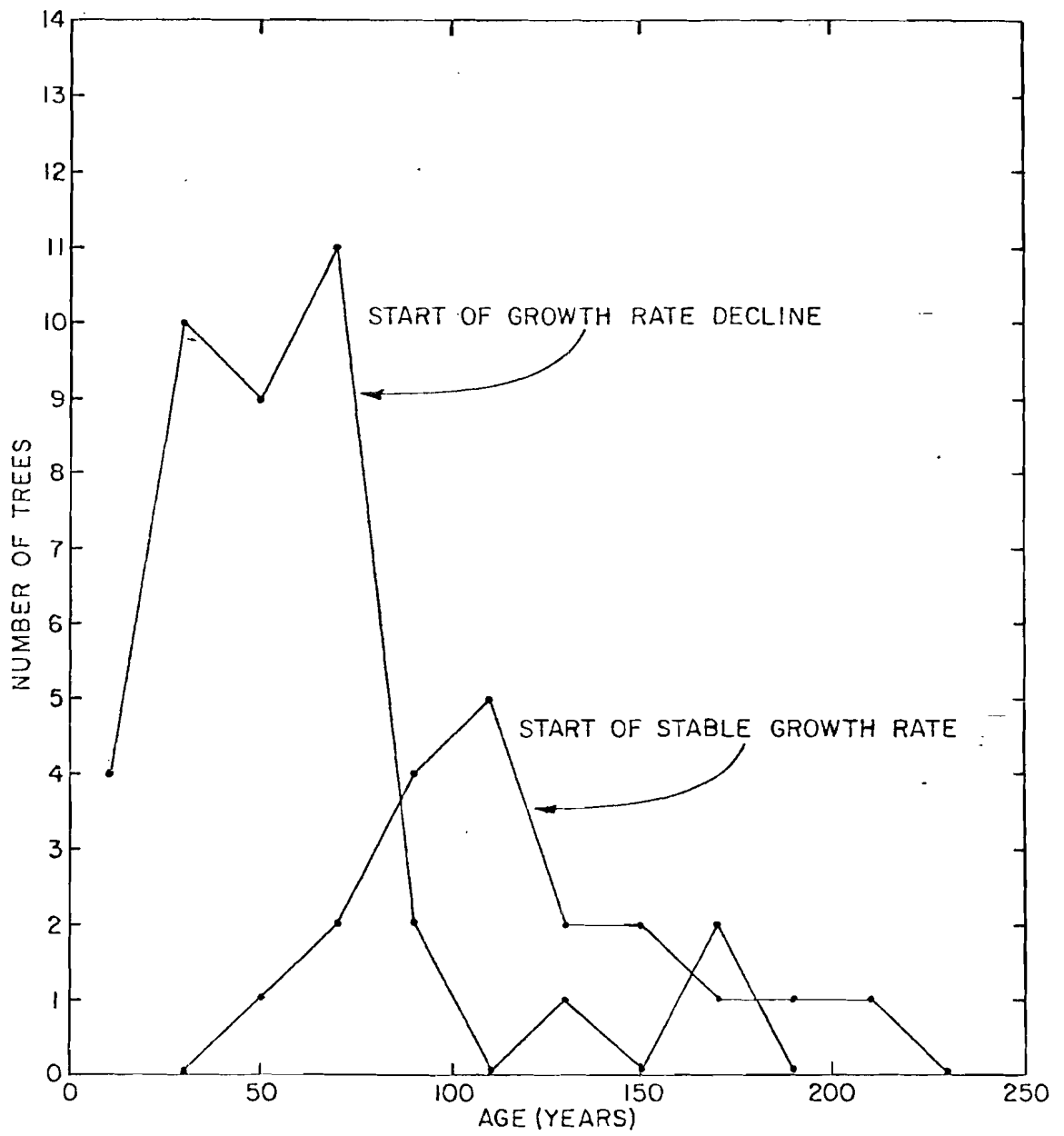


Fig. 7. Onset of cypress growth periods.

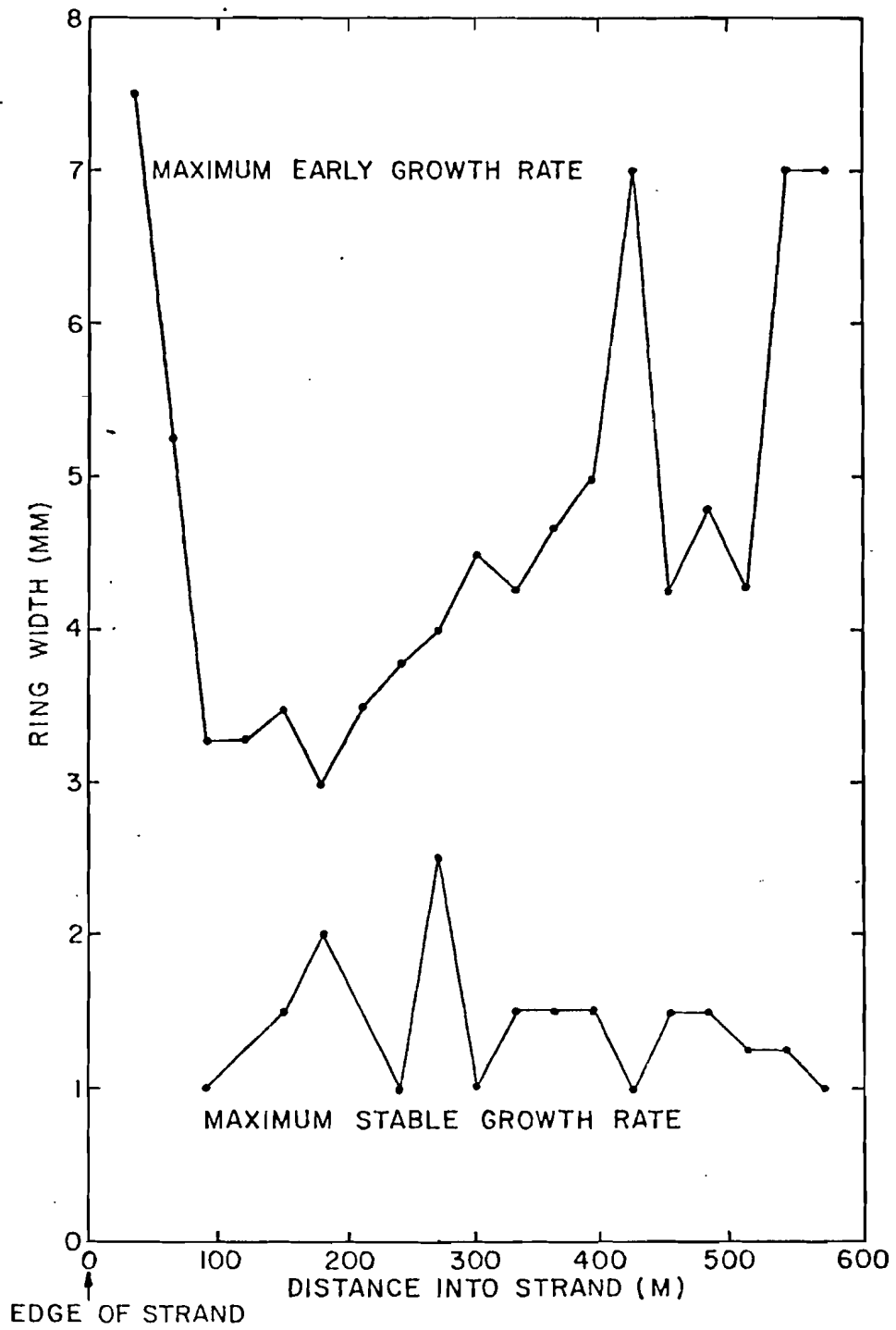


Fig. 8. Cypress growth rate patterns; central march transect; east strand.

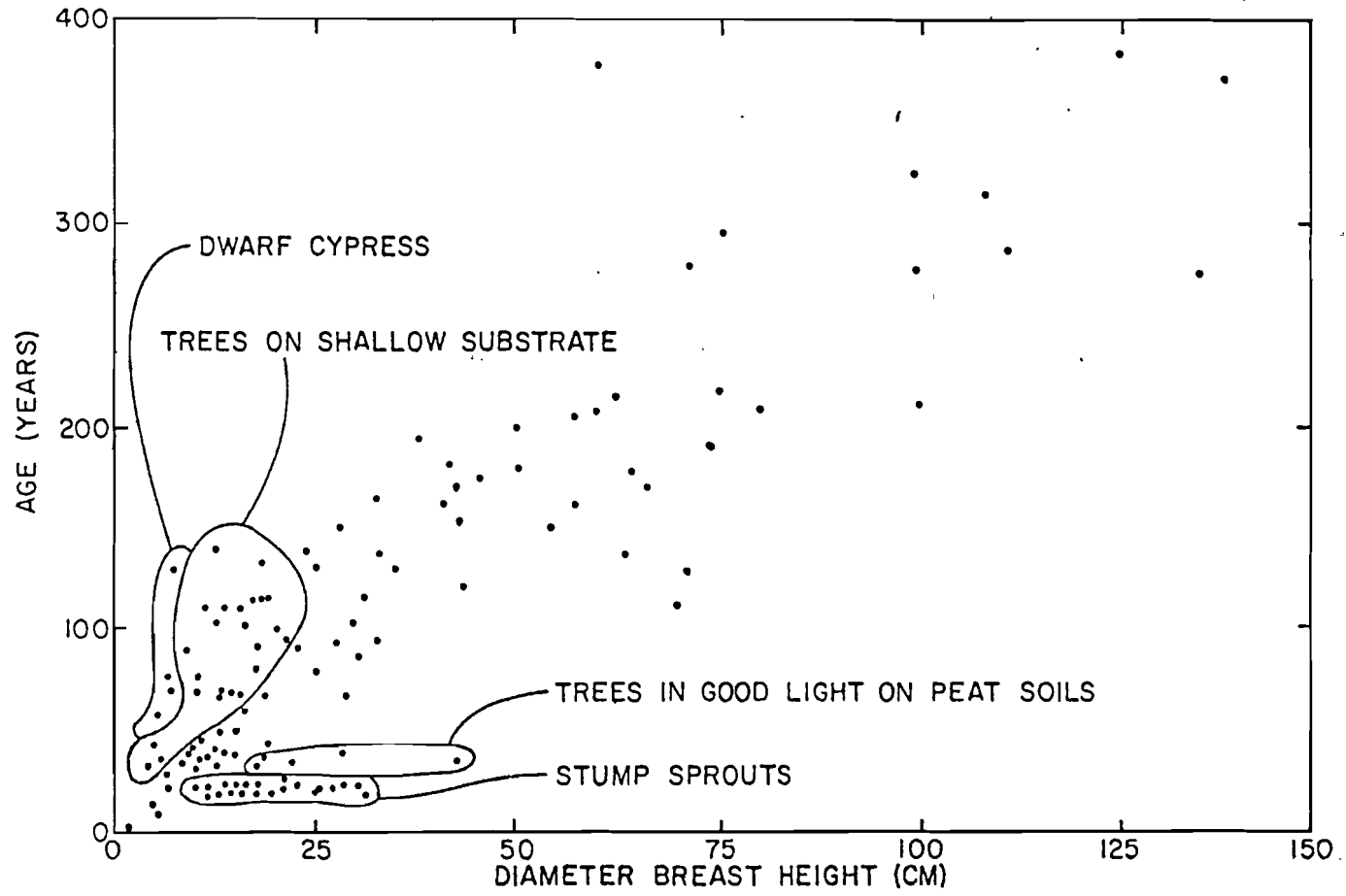


Fig. 9. Correlation between cypress age and DBH.

full access to sunlight. The relatively rapid growth of trees along strand edges and in canopy openings is also simple to explain in terms of light availability to trees on deep peat soil.

In order to assess the generality of conclusions based on data from the Corkscrew Swamp strand, we analyzed cypress age, growth rates, and DBH in relation to ground surface elevation and peat depth along a transect through Gordon Swamp, a strand of smaller cypress in the southwest part of the sanctuary. We found that this strand occupies a shallow depression and the trees grow on peat soils up to 0.5 m deep (Fig. 10). However, the size (DBH) of the trees was quite variable, perhaps partially due to small sample size, and we did not detect the largest-in-the-center pattern observed elsewhere. Tree-ring analysis indicates that this is because the youngest trees are in the interior in the Gordon Swamp strand (Fig. 11). Nevertheless, the trees in the center still exhibit the fastest maximum early growth rates.

Similar structure has been observed in burned cypress domes (Craighead, pers. comm.) and we feel that Gordon Swamp is a strand which has been burned out and is regenerating. Apparently, during a severe drought when the water table was below the shallow peat deposits, fire entered Gordon Swamp. Since the trees at the edges were rooted in mineral soil, they were singed, but survived. In the strand interior, however, a slower-moving peat fire consumed soil and roots, killing the cypress. In time, cypress trees became reestablished in the center of the strand, and, since they were on a higher quality site, rapidly grew to sizes comparable to those of the older peripheral trees.

Since the fire histories of cypress swamps are quite varied,

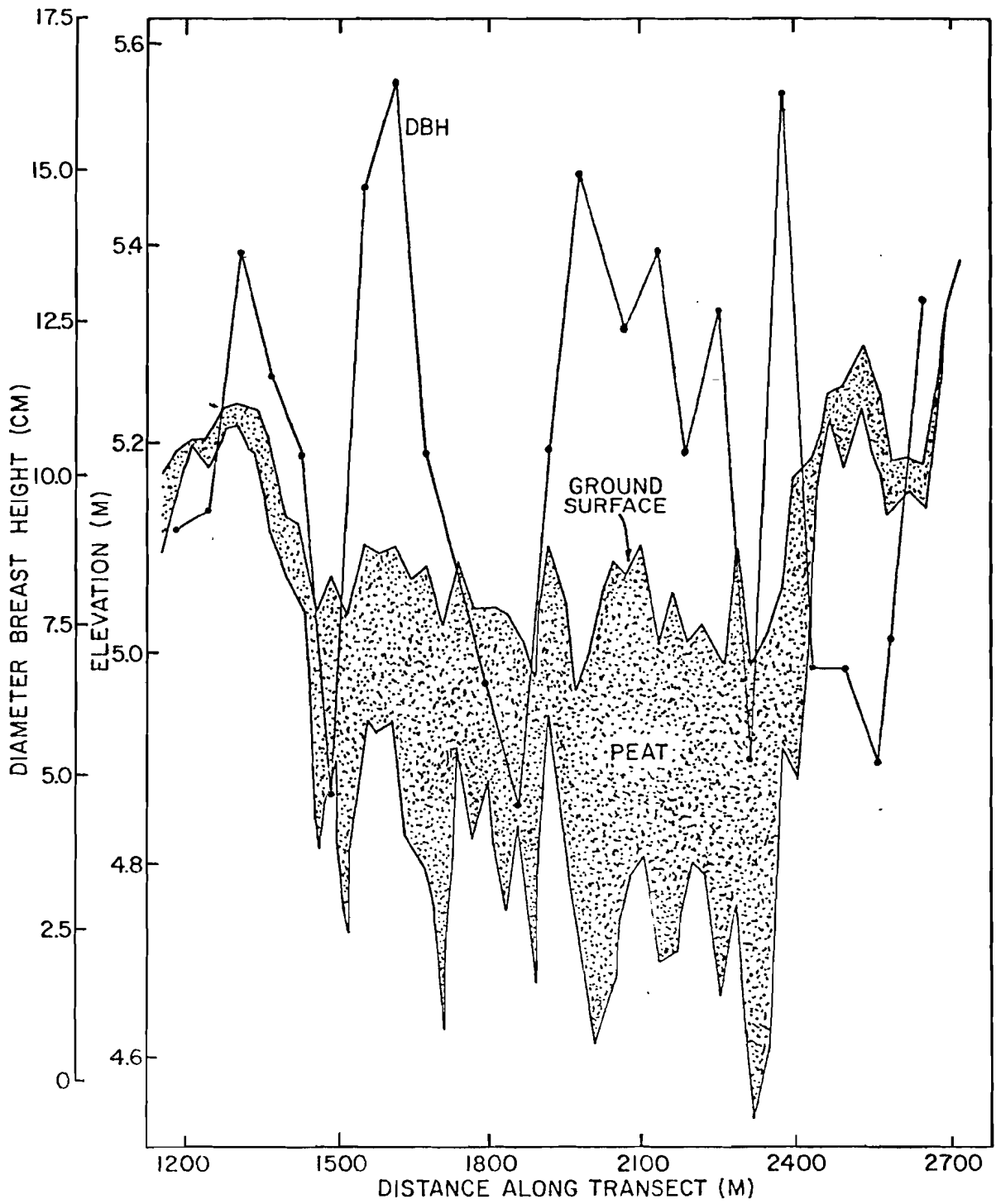


Fig. 10. Cypress DBH and peat depth for Gordon Swamp.

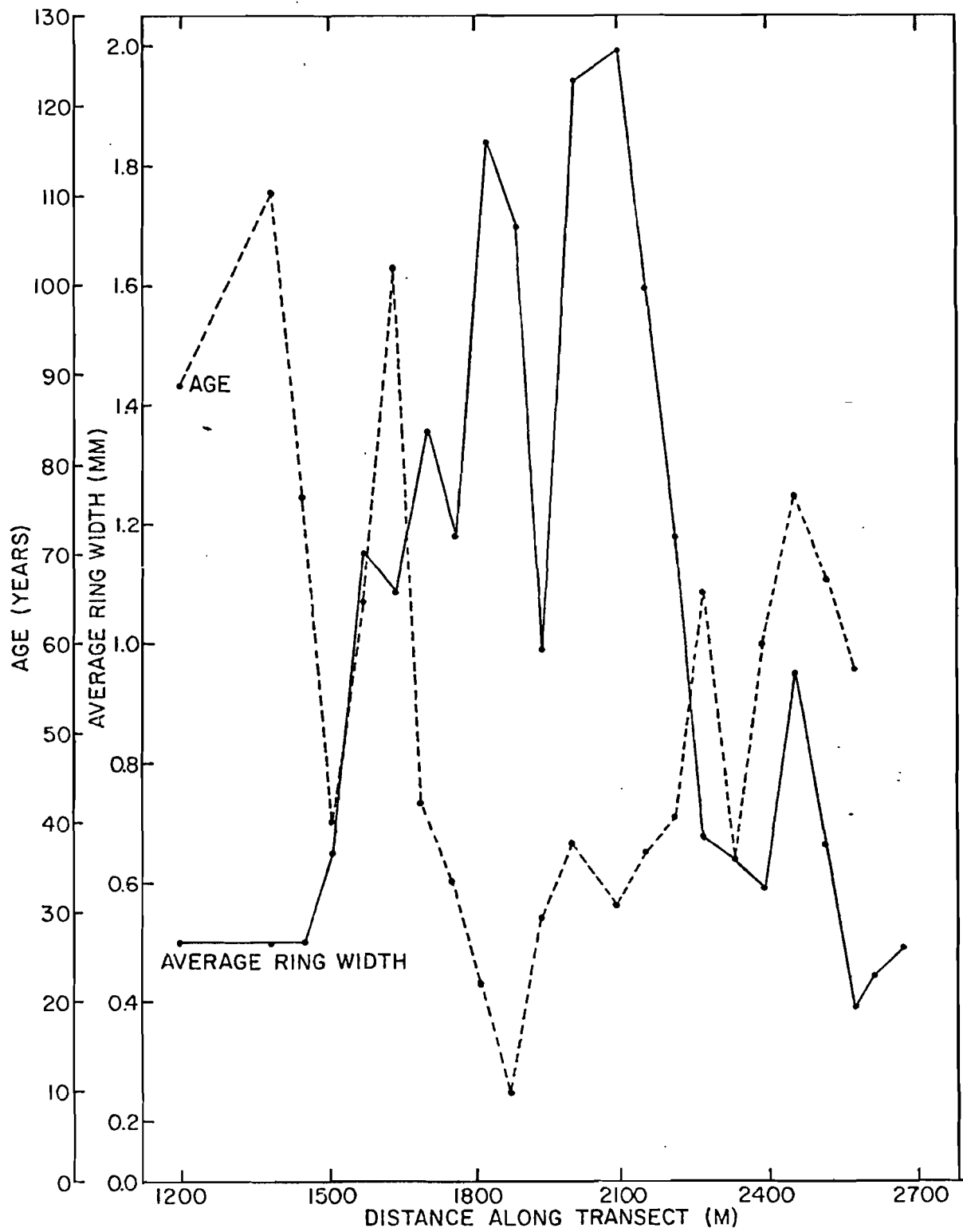


Fig. 11. Cypress age and growth; Gordon Swamp.

these processes can be expected to result in considerable site-to-site differences in forest size and age structure. Even so, in both strands and domes, the fastest maximum early growth rates should be found where peats are deepest.

In order to confirm that cypress trees at Corkscrew do indeed lay down annual growth rings, we counted tree-rings from cores of known age trees. One set of these cores came from stump sprouts of trees logged in the early 1950's in the vicinity of the South Dike, which impounded water flowing out of Corkscrew Swamp from 1967 to 1975. In the course of analyzing these samples, we noticed a dramatic difference in pre- and post-impoundment growth rates both above and below the dike (Fig. 12).

In addition to the expected general decline in growth rates with age, there were several abrupt growth changes which correlate closely with hydrologic conditions. Immediately after construction of the dike in 1967 there was a striking decrease in cypress growth rates. In 1968, when dike maintenance problems returned water levels and hydroperiods to pre-dike levels, growth improved, but was still not quite up to earlier rates. After dike repairs in 1969, the trees grew even more slowly.

Sanctuary hydrologic records reveal that abnormally high water levels and long hydroperiods prevailed above the dike from 1967 through 1973 (except for 1968). Dike seepage caused unusually long hydroperiods but not particularly high water levels below the dike. Since equally poor cypress growth was observed both above and below, it appears that hydroperiod was the responsible factor. Further evidence of this is that in 1960, the only year out of 7 years of

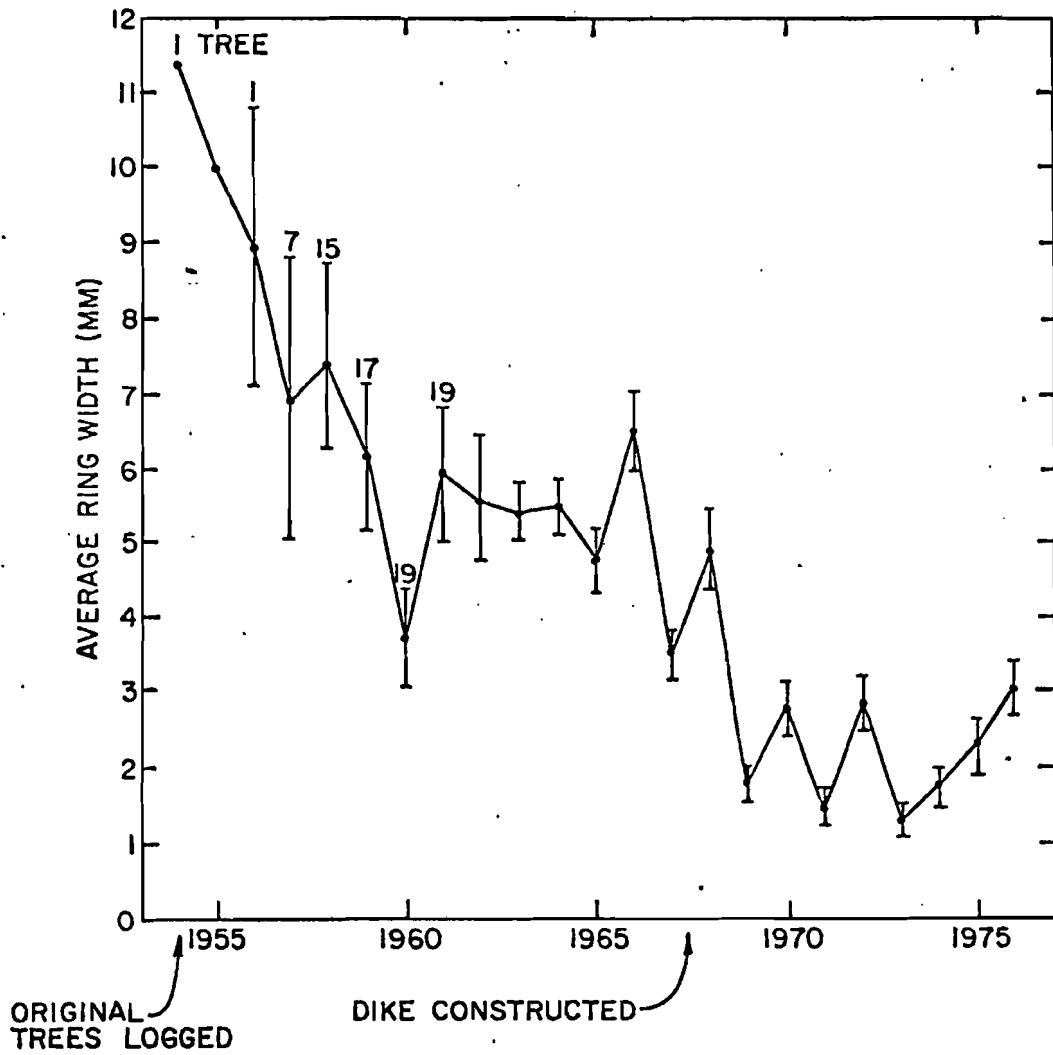


Fig. 12. Cypress stump sprout growth along dike (Trees both above and below dike).

record when natural hydrologic conditions resulted in year-round surface water, cypress growth was also extremely poor. Thus, it seems that even one year of continuous inundation can be enough to drastically slow cypress growth.

Although the trees immediately resumed rapid growth following a single year's flooding in 1960, recovery after lengthier inundation apparently takes much longer. The 1974 and 1975 droughts and opening of the dike culverts in 1976 permitted water levels to recede below ground each spring, but cypress growth rates remained below normal.