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Status of Exotic Woody Species in Big Cypress National Preserve

NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR

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INTRODUCTION

The National Park Service (NPS) was assigned administration of the Big Cypress National Preserve (BICY) in the 1974 congressional act which created the preserve (PL 93-440). In this act, the NPS was charged with assuring that the "natural and ecological integrity" of the BICY would be maintained in perpetuity. One of the management objectives set forth by the NPS in the 1980 Environmental Assessment (USDI, NPS 1980) was to "control exotic plant and animal species when necessary to prevent disruption of native floral and faunal communities." In light of this objective, up-to-date biological information is needed on the problem species; especially which species pose problems, what are the distributions of the problem species, and what are the prognoses for these distributions in the current framework of environmental conditions in BICY?

Exotic Plants in South Florida

Southern Florida is the only region of the continental United States where temperate and tropical floral elements coexist. High temperatures and rainfall create tropical conditions during the summer months. Infrequent freezes, associated with periodic winter cold fronts, prune-back cold sensitive tropical species. Temperate species are in a minority group comprising only 39 percent of the approximately 1650 species found in southern Florida (Long 1974). The bulk of the tropical species are herbaceous, but many native tropical trees are present.

Long (1974) determined that propogules of tropical species now in Florida must have crossed the sea because no land bridge existed between Florida and the Antillean area. Natural vectors such as birds, hurricanes, and ocean currents moved species to Florida. Also, some species may have been moved by early Florida inhabitants who traded with populations on the Carribean Islands.

The species introduction rate was probably slow because of few species adapted to surviving such trips and the infrequency of conveyors such as hurricanes. With the advent of modern civilization, many thousands of plant species were introduced to south Florida. Botanists, working for the U.S. Department of Agriculture, traveled to many lands and brought back species to improve genetic stock for agriculture. Gardeners and horticulturists also introduced many species to decorate and landscape homesites and gardens.

Since southern Florida is geologically young, there may be vacant niches for plant species. Species richness may not yet be optimized because of unique environmental conditions in south Florida and a naturally slow rate of species introduction. Therefore, it is possible that species introduced here may be able to compete and establish with the existing flora. Alteration of the landscape by water manipulation, land clearing, farming, etc., has no doubt favored these exotic plants, but these species also appear to exploit niches not optimized by native species (Myers 1975).

Duever et al. (1979) compiled a list of exotic plant species naturalizing in south Florida based on work of Austin (1978), Alexander and Crook (1975), Long and

Lakela (1971), and Sturrock (1968). The Duever et al. (1979) list of 300 exotic species enumerates species that may be naturalizing in the preserve, and is probably an overestimate of exotic species actually in the BICY. Black and Black (1980) listed 645 species (both native and exotic) as occurring in BICY; 76 (12%) of which were considered to be exotic in origin. They (op. cit.) listed an additional 40 species (all exotic) which persist from cultivation around homes and campsites. Therefore, based on the Black and Black report, roughly 1 out of every 7 plant species in the BICY is exotic.

Even though over 100 exotic species are currently in the BICY, only a handful have become conspicuous parts of the landscape. These few exotics are considered pests because of their ability to aggressively colonize a site (both native and disturbed) and to form virtually monospecific stands. The aggressive species in the BICY are Melaleuca quinquenervia cav. (Blake), Schinus terebinthifolius Raddi and Casuarina glauca Sieb. ex Spreng. Hereafter, in this report these species will be referred to by the genus name, lower case, and not underlined.

There are other exotic pest plants in the BICY. The most widespread species are the aquatic plants hydrilla, Hydrilla verticillata, and water hyacinth, Eichhornia crassipes. However, as Duever et al. (1979) point out, these species are largely restricted to the canals and borrow pits in the BICY, and are only rarely found in the native systems. These species probably do not pose an immediate threat of displacing native vegetation and are not discussed in this report. For more information, the reader is referred to Duever et al. (1979).

Historical Information

Early references about the vegetation on the BICY area do not mention exotic trees. Construction on US 41 was completed in 1928 so access prior to this time was probably limited. Davis (1943) does not mention any exotic trees in his primer on south Florida vegetation. Exotic species were around at this time though and largely restricted to coastal sites. Meskimen (1962) dates the introduction of melaleuca in south Florida to be 1906 on the east coast (Davie) and 1912 at the Koreshen Nurseries near Estero on the west coast. Nehrling (1944) reports that schinus was introduced on the west coast of Florida around Bradenton sometime in the early 1900's. Morton (1980) dates introduction of casuarina as 1898. Casuarina is evident in photographs of the Ochopee area (within BICY) taken in the mid-1930's (Nieland 1936).

Most of the populations of melaleuca and casuarina in BICY can be traced to intentional plantings. Meskimen (1962) states that the stand of melaleuca at Monroe Station was planted in 1944. The originial trees are still present, and are found immediately south and west of the buildings at Monroe Station. Meskimen (1962) surveyed this site and found no regeneration into the surrounding area as of 1958-59. Casuarina was planted for use as windbreaks, and probably as a safety barrier, between canals and roads by WPA projects in the 1930's. The stand along US 41 in Dade County has this history. The roadside stand also extended into Collier County, but was removed when the widening of US 41 was concluded in the early 1960's (Dayhoff pers. comm.).

The expanding populations of exotic trees, especially melaleuca and schinus, were first documented by Alexander and Crook (1975). They mapped the vegetation on 15-mile-square quadrats in the preserve (Fig. 1). In Section 11 (T535, R32E) (north of Monroe Station) Alexander and Crook in March 1973 found 6- to 30-ft.-tall (2-10m) melaleuca and 10-ft.-tall (3m) schinus in an abandoned farm field. The authors (op. cit.) found melaleuca on windrows left by bulldozing after farming, and on the periphery of a cypress strand. No exotics were identified on the map made from 1940 aerial photographs. In Section 22 (T54S, R33E) they (op. cit) found melaleuca establishing from roadside plantings into sparse cypress and low pine-lands south of the loop road. In 1970, thickets of schinus dominated the heavily impacted farm areas in Sections 19 and 30 (T52S, R30E), as well as a severely burned hardwood stand. Notable from their accounts is the absence of exotic species from the interior (away from major roads) quadrats located within the BICY.

Capehart et al. (1977) tried to map the distribution of melaleuca in southern Florida using LANDSAT imagery and computer-enhancement techniques. They could not find a characteristic spectral signature for melaleuca, as it was found in monospecific stands, or interspersed with pine, cypress, hardwoods, or mangroves. Each of these combinations results in a different signature, therefore, they could not accurately map the distribution.

Sweet (1981), however, determined that melaleuca could be identified in a pine-cypress vegetation mosaic by use of modified software in conjunction with LANDSAT imagery, but did not determine signatures of other melaleuca associations. Arvinitis (1978) thought false-color infrared photography would be useful in spotting melaleuca in various plant communities, but did not map distribution.

Ewel et al. (1976), based on fieldwork of Myers (1975), predicted that melaleuca would not be a conspicuous part of the landscape, but that areas adjacent to US 41 and Monroe Station may be locally dominated by this species.

Duever et al. (1979) mapped the distribution of melaleuca, schinus, casuarina, hydrilla, and hyacinth in the preserve and found these exotics to be mostly confined to roadside stands. Melaleuca was found to be expanding from plantings at homesites along Turner River Road. Rapidly growing populations were also located at Monroe Station, Paolito Station, and at one site off the Loop Road (SR 94). Schinus was found in association with mixed swamp hardwoods in the Ochopee area, as well as throughout hardwood hammocks along the southern boundary of the preserve.

Cost and Craver (1980) did an aerial survey of melaleuca distribution in southern Florida. They noted melaleuca in pure and mixed stands (with native vegetation) in the northern section of BICY, north of SR 84, an area where other authors have not found populations. Also, they did not locate any stands in the Monroe Station area, where known large stands do exist, leading one to question the accuracy of their survey.

OBJECTIVES

Two objectives were sought in this report:

1. To document current distribution of problem exotic species (melaleuca, casuarina, and schinus) and note occurrence of any species perceived to be a potential pest species.

2. To assess the stand dynamics for these exotic populations in the current framework of native plant communities and the disturbances that occur in the preserve.

METHODS

Many activities were done to compile the distribution map. All of the major roads in the preserve were surveyed, including US 41 (Tamiami Trail), SR 94 (Loop Road), SR 84 (Alligator Alley), SR 839 (Turner River Road), SR 841 (Birdon Road), and SR 837 (Wagon Wheel Road) (Fig. 2). Off-road surveys were done by foot and by Honda ATC in the areas around Monroe Station and Ochopee. Vegetation maps of five (5 x 10 km) areas in the preserve (Gunderson et al. 1980a; Gunderson et al. 1980b; Gunderson and VanHorn 1981a; Gunderson and VanHorn 1981b; and VanHorn and Gunderson 1981) were surveyed and used to locate exotic stands (Fig. 2). These maps were made from large-scale aerial photographs (1:7800) with extensive ground-truthing, so they are fairly comprehensive inventories of these areas. Aerial photographs (1:7800) of five other 50 km^2 areas in the preserve were studied to locate large exotic stands (Fig. 2). Photographs were viewed with a magnifying stereoscope of resulting resolution so stands on the order of 100 m^2 (0.01 ha) could be recognized. The photographs were made in spring and summer, when the cypress were leafed-out. Therefore, sub-cypress-canopy exotics could not be located by this method. For example, thickets of schinus in cypress-mixed hardwood swamps would not be detectable on the photographs. Melaleuca foliage appears as a darker green than the pine or cypress needles, and was, therefore, readily found on the photographs. None of these five study areas were checked on the ground. The other source of information on the distribution of exotics was Mr. Fred Dayhoff. He also supplied much information on recent (20-25 year) history of exotic plant spread based on personal knowledge and observation. Rangers Bruce Malloy and Robert Yates also added their knowledge of exotic plant location.

RESULTS AND DISCUSSION

The current distribution of woody exotic trees in the BICY is still largely restricted to roadside stands (map enclosed in back pocket of report). Letter symbols were used to represent each species as follows: M-melaleuca, S-schinus, C-casuarina. A letter is shown for each area of occurrence, regardless of stand size, density, or structure. In regions where the stand was expanding, such as the Monroe Station area, tall dense stands and scattered individuals of melaleuca were all enclosed within a single line and designated M. This was done because of the small scale of the map that covers the preserve, any actual depiction of stand size would be meaningless at this scale.

Native plant associations referred to in this report include hardwood hammocks, pinelands, cypress-mixed swamp forests, cypress domes, cypress prairie, Muhlenbergia (muhly) prairie, and mixed aquatic marsh. For more information on the description of these communities, the reader is referred to Duever et al. (1979), Gunderson et al. (1982), and Gunderson and Loope (1982a,b,c,d).

Melaleuca quinquenervia

Distribution

Areas of concentrated stands of melaleuca may be grouped into seven units. Large trees (20-30 meters tall) are found in these areas, but stand size and tree density within each stand is variable. The areas are designated as Monroe Station, Paolito Station, Loop Road, Jetport, Interior Pinelands, Ochopee, and Turner River Road (Fig. 3). The map (Fig. 3) is by Fred Dayhoff and he is responsible for supplying much of the following information on stand size and history.

Monroe Station Area. The original planting of melaleuca at Monroe Station is immediately south and west of the building complex. As of 1958-59 (Meskimen 1962), no expansion was noticed from the original stand. Many disturbances have occurred in the area since then and each has contributed to expansion from the one stand. Monument Lake and surrounding fill was created in the early sixties, in association with the widening of US 41. Bulldozing cleared areas north of US 41, first in the early sixties and later in association with a hog farm and nursery in the early seventies. Fires burned the area in 1962, 1971, 1974, and 1981. Hurricanes that affected the area in 1960 (Donna) and 1965 (Betsy) contributed to seed spread. Deer were held in a pen immediately west of SR 94 and south of US 41 sometime during the 1960's and disturbed the soil in the area. Farming of the prairies adjacent to US 41 also resulted in soil disturbance.

Dense stands of melaleuca are found on spoil material immediately south of Monument Lake. Bulldozed and burned windrows northeast and northwest of the intersection of US 41 and the Loop Road (SR 94) also support developed stands. Surrounding these dense stands are scattered individuals in the muhly prairies and pinelands. Outliers are found up to 3 miles north of US 41 (Dayhoff pers. comm.)

Dense stands are found just south of US 41 and west of SR 94. At least three age classes are seen in these areas and seem to correlate to the 1962, 1971 or 74, and 1981 fires. Scattered individuals are found southwest of these dense stands for at least five miles. The melaleuca are, for the most part, restricted to the pinelands and prairies, and infrequently found in cypress domes and strands.

South of US 41 and east of US 94, scattered large individuals are found as well as a few seedlings. Unsuccessful control attempts (1980) in an area south of US 41 resulted in a dense, coppice-growth from surviving root systems and downed trees.

Paolito Station Area. The areal extent of melaleuca in this area ranges from Fifty-Mile Bend to Trail Center along US 41 and southwest for 2 to 3 miles into the Loop Road area. The oldest trees are at Paolito Station and form a very dense stand adjacent to an old gas station. This heavily colonized area has a history of disturbance by bulldozer. Severe fires in 1971 and 1974 appear to have resulted in melaleuca colonization into surrounding cypress prairie areas. The major direction of stand expansion is southwest (probably due to sheet flow and previous ORV use), but scattered individuals are also found northwest of US 41.

Jetport Area. This area is made up of local stands from Fifty-Mile Bend west to Trail Town. The stands at Trail Town and Midway are small (area-wise), dense stands that do not appear to be spreading into surrounding areas. A small (3-4 acre) stand is south of Oseola Village, and originated in the early seventies. Many scattered trees are found up to 4 miles west and 1 mile east of the jetport road growing in cypress prairie vegetation. Myers (1975) used this area as one of his study sites and found successful germination and consistent, but slow growth of introduced melaleuca seed and seedlings. Obviously, proper conditions for establishment and survival are present, and this area may be one of the most susceptible throughout the BICY.

Loop Road Area. Two stands of melaleuca are in this area. The largest is located at the intersecton of Paces Dike and Loop Road. The original trees were planted near a camp in 1960. The camp burned in 1962 and subsequently spread into the surrounding area, mainly south, but also some short distance to the north. The second stand is inside the Loop Road and is, also, a result of intentional planting at a camp. Many seedlings are found at the second site. The native vegetation being displaced by both stands of melaleuca is a pine-prairie mosaic.

Interior Pinelands Area. Some trees were planted around a few hunting camps in the Raccoon Point region of the interior pinelands. From these trees scattered individuals and small stands have developed. These stands are, at this time, mostly restricted to the pine-cypress ecotone. However, a stand (approximately 100 m^2) of large trees is growing in a severely burned marsh just south of the end of the L-28 Tieback (Gunderson and Loope 1982c).

Ochopee Area. Scattered large melaleuca are found south of US 41 from the fire station on the east to the Golden Lion Motel on the west. This area is also heavily colonized by schinus. All of this area has been severely disturbed. Canals were dug to drain the area for farming. Borrow pits were dug and the fill deposited on nearby areas for housing development. Surrounding areas were also cleared for farming. Dense schinus stands on these distrubed areas seem to be keeping melaleuca expansion in check. North of US 41 three or four dense stands occur. They do not appear to be invading the surrounding prairie, even though the prairie was farmed at one time.

Turner River, Birdon and Wagon Wheels Road Areas. Melaleuca is found at homesites along these roads. Attempted control of the melaleuca at many of these sites has been done by NPS staff, but melaleuca at some of the sites have recovered by root sprout.

Factors affecting establishment

Establishment of a species is a function of the species seed production, germination, and seedling survival. Meskimen (1962), Myers (1975), and Woodall (1980a) have thoroughly investigated melaleuca capabilities for survival through these critical stages. A brief review of their work will follow to illustrate this species prodigous reproductive success.

The amount of seed produced by melaleuca is truly awesome. The species can flower up to five times a year, with good seed crops produced every 2-5 years (Meskimen, 1962). The tiny seeds (30,000 seeds/gram) are stored in small capsules along the branches. The seed capsules remain on the tree for as long as seven years (Meskimen 1962). Seed production can begin on an individual as young as 3 years old. Meskimen (1962) estimated as many as two million seeds may be stored on a large individual. Alexander and Hofstetter (1975) calculated 20 million seeds may be found on a 10 m individual. Even with low viability measurements of 20 to 30 percent (Meskimen 1962, Myers 1975, and Woodall 1980a) the potential regenerative capabilities of one individual tree is in the millions.

The seeds are released from the capsule when the capsule dries out. The dessication is usually caused by a break in the xylem tissue leading to the capsule. Catastrophic events, such as frosts, fire, or mechanical disturbance, can initiate seed release. Old capsules may also dry out as part of an aging process. Droughts can also trigger release. Since melaleuca stores seed, and these processes can occur randomly, the seed could be, theoretically, released any time of the year.

Once the seed is released, it may move some distance away from the parent tree before it reaches the ground. Meskimen said the seed fell within 1.5 times the height of the tree. Browder and Schroeder (1980) used a mathematical model to predict aerial seed movement. Their work determined the longest probable distance a viable seed would travel to be 1 km. The maximum distance of movement, during hurricane force winds, would be 7 km. Woodall (1980a) validated their model for distances up to 65 m with good correlation. Their model seems fairly realistic, with the main points being that the seed are not infinitely mobile, and that areas now free of melaleuca are not likely to be subjected to seed rain.

Other vectors, such as water, may contribute to seed movement, but as Woodall (1980a) points out, much resistance exists from native vegetation, and the tiny seed probably do not float for more than a couple of days.

Animals, especially humans, are also effective dispersal agents. Any mammal, such as deer, opossum, or raccoon, can conceivably "catch" a melaleuca seed and carry it for miles. Humans are probably more active in transport. Seeds which fall on off-road vehicles (ORV's) can be transported to most places in the preserve. Dayhoff (pers. comm.) feels, that the distribution of isolated melaleucas, southwest of Monroe Station, and north of Monument Lake, are a result of ORV's. He observed that the parking sites of vehicles was (and is) directly beneath the oldest, largest stand at Monroe Station. Most of the individuals to the south and north are adjacent to buggy trails and, probably, arrived via this means.

Once the seed reach the ground, successful establishment is determined by the proper environmental conditions for germination. Two factors influencing the germination of melaleuca are soil characteristics and hydrologic pattern.

Meskimen (1962) found that the dry, acid sands of the Bear Island Area were more conducive to germination than alkaline marls, and that generally, germination correlated well with soil pH. Soil characteristics though do not seriously inhibit germination, as abundant regeneration has been observed on many marl sites (Meskimen 1962, Duever et al. 1979). Successful germination usually occurs on seasonally dry sites (no standing water), but after the seed has been wet, a result of rain or heavy dew. Seed that fall into standing water can germinate on dry ground if the water quickly recedes. Germination can occur under water, but only if the dissolved oxygen concentration is relatiavely high (4.0 ppm; Myers 1975). Therefore, germination does not occur on sites with very low soil moisture, nor sites with extended inundation, yet can occur on intermediate sites.

It is currently unknown how long a melaleuca seed will remain viable once released from the tree. In Myers (1975) seeding trials, germination usually occurred within one month of seeding. Woodall (1980a) feels that the seed may last up to 2 years, and can definitely remain viable up to 10 months.

The earliest stages of the seedling survival are perhaps the most critical to the survival and may be the largest determinants of the species distribution. Once the seed has germinated, its immediate fate is determined by many factors, including soil moisture, soil chemistry, soil physics, competition with existing vegetation, fires, and frosts.

Melaleuca can survive a variety of soil moisture conditions once the seedling is developed to perhaps the ½ to 1 meter height range. The new germinant can survive inundation for at least 3 months (Meskimen 1962, Sena Gomes and Kozlowski 1980). Whereas Myers (1975) found survival after 6 months inundation, but mortality at less than 12 months. Growth of the terminal shoot was stopped while the seedling was inundated in all of these experiments. The seedling can also grow rapidly enough to maintain contact with receding soil water tables (Woodall 1980a). However, Myers (1975) observed seedling mortality during the dry season, so the species does succumb to a lack of soil moisture.

Woodall (1980a) discusses other factors of seedling survival, including soil temperature, nutrients, and soil pH. High temperatures, low nutrients, and high pH all can limit the growth and development of seedlings. These factors are not capable of being manipulated for management purposes. Also, melaleuca is already seen invading sites where a wide range of these conditions exist.

Fire can and will kill young seedlings, yet the use of fire for management must be judicious. Fires will kill new germinants found in a litter layer by consuming both the litter and seedlings. It is unkown about the survival of young seedlings in a grass-fuel fire, such as the muhly prairie, but it is presumed they would die. Once the seedling is in the ½ to 1 m range, the survival is probably good. Seedlings with a basal diameter of 2-3 cm have been observed to resprout following a burn.

Myers (1975, 1983) looked at growth rates on various communities in the BICY. Seedlings in disturbed sites such as drained cypress and burned cypress domes exhibited the greatest height increases. Dwarf cypress, muhly, and pine prairie sites showed slow, but consistent growth, with mean values for 15 months of growth being 40, 10, and 5 cm, respectively, for these undisturbed sites. No growth was measured in a native cypress-mixed swamp forest, as no seedlings survived at these sites due to extended inundation.

Natural disturbances

Fire: Melaleuca is surely one of the most fire adapted plant species in south Florida. The species can survive repeated fires and indeed thrives by fire. Seeds are released following a burn (Meskimen 1962) and dropped on the resultant fertile seed bed. The seed bed has readily available nutrients and little competing vegetation (Duever et al. 1979). The melaleuca bark is thin, papery and quite flammable. Volatile oils in the leaves also contribute to this species flammability. The fire does not damage the cambial layers because of many layers of bark, and only the dry outer bark is consumed while the central bark is too wet to burn. The bark also carries the fire up the tree, creating a crown fire, which is virtually unknown in south Florida (Myers 1975, Wade et al. 1980). After a fire, the burned individual usually has a charred stem and is defoliated. The species quickly refoliates, and produces epicormic sprouts.

Fire patterns (a result of both natural and human ignitions) in the BICY are conducive to the expansion of melaleuca. Hunters and cattlemen have altered the timing and, perhaps, frequency of fires (Duever et al. 1979, Taylor and Doren 1982). Burning is largely confined to the dry season as Taylor and Doren (1982) reported that 96 percent of all fires in the 1979-80 season occurred from October through May. Many fires are started in the fall just prior to hunting season and are relatively benign. March through May fires are the most severe, both in terms of size and impacts. Hunters and cattlemen usually don't burn in the peak of the dry season, but burn in the fall when water levels are high, and the fires are confined to the pinelands. As these user groups are interested in the fresh vegetation sprouts after a fire, they probably burn as frequently as sufficient fuel loadings exist. Arsonists are responsible for lighting the severe fires in the dry season.

In the BICY, three vegetation types are regularly burned: pinelands, muhly prairie, and cypress prairie (Taylor and Rochefort 1981). These three vegetation types are being actively invaded by melaleuca, and except for disturbed areas (such as borrow mounds) account for all of the native vegetation types being invaded. Fire undoubtedly is a major factor in the expansion process, indeed, age classes (as evidenced by height) can be traced to recent fire history. The young age classes around older individuals in the prairies around Monroe Station seem to correspond with the occurrence of recent fires in this area.

Hurricanes: Hurricanes or severe tropical storms may spread melaleuca seed, but seem to have variable effects on the tree. Meskimen (1962) observed melaleuca after Hurricane Donna in 1960. He relates that large trees rooted in sand were not toppled, but that trees in shallow soil (such as those in BICY) are readily downed. The high winds also break branches and may blow their stems for hundreds of meters. The species readily resprouts following branch breakage, so the hurricanes may help result in multistem morphology. Saplings and seedlings are apparently unaffected by high winds (Meskimen 1962).

Frosts: Severe frosts may defoliate melaleuca, but they readily refoliate. The frost damaged tree may also release seed. Frosts definitely do not kill melaleuca, and even rarely affect it. The freezes of 1977, 1981, and 1982, were severe in terms of record low temperatures. No foliage damage was even noticed on melaleuca in BICY following these events (Duever, et al. 1979, Gunderson 1981).

Water consumption by Melaleuca

Many arguments have been made on the consumptive use of water by melaleuca. Many people think that the species actually has a greater evapotranspiration (ET) rate than native species and therefore will dry up a wetland area. A few studies have been made to answer this question and their results will be presented.

Meador (1977) conducted a greenhouse study comparing water loss from potted cypress and melaleuca seedlings. He found that melaleuca transpired slightly less on a per-seedling basis and even less on a per-leaf-area basis, because the leaf area of melaleuca was approximately twice that of cypress. He stated however, the yearly transpiration of water by melaleuca may be larger because it is evergreen, whereas cypress is annually deciduous.

Alexander et al. (1977) compared melaleuca and sawgrass transpiration from pots placed in field conditions. On a per-leaf-area basis, no difference in transpiration was measured, but they presumed leaf-area differences between sawgrass and melaleuca sites would result in more water transpired from the melaleuca areas.

Olmsted (1978) studied the stomatal resistance of melaleuca, and compared differences among leaf sides, leaf ages, leaves on different age trees, various species, and environmental factors. Her data indicate that melaleuca probably does not transpire more than native species. Much variability exists in the measurements from various types of leaves, and under various environmental conditions, so that meaningful comparisons among species are difficult.

Woodall (1980b) reviewed methods of estimating water loss, as well as, reported on a few experiments on his own. He concluded that reliable evapotranspiration estimates for south Florida vegetation types (native and exotic) do not exist. He states, however, that the replacement of gramineous wetlands by melaleuca forests would probably result in increased water loss from the system.

Schinus terebinthifolius

Distribution

Schinus, also called Brazilian pepper, Florida holly, or christmas berry, is perhaps the second-most widespread exotic tree in the BICY. The highest concentration of schinus stands is located in the Ochopee area (Duever et al. 1979, and enclosed map). The schinus stands in this area are found on former prairie, cypress, and pineland sites with histories of clearing and farming during the 1930's, 40's, and 50's. Alexander and Crook (1975) found schinus to be a component of a mixed hardwood association with native species; Persea borbonia, Magnolia virginiana, Acer rubrum, Ilex cassine, and Cornus foemina. This analysis agrees with the description of Duever et al. (1979) who added Salix caroliniana, Myrica cerifera, and Baccharis halimifolia to the list of native associates. Except for some roadside stands, most of the schinus in the Ochopee area occupy sites with native species, and do not form the characteristic monospecific stands found in other areas, such as "Hole-in-the-Donut" region of Everglades National Park (EVER). The significance of this association is that the native hardwoods are emergent from the schinus canopy and are present as seedlings and saplings. This indicates regeneration of native species and not succession towards a schinus-dominated, monospecific stand. Alexander and Crook (1975) state the Ochopee area is drained by canals put in for agriculture. Restoration of natural water flow to this area, as proposed by Rosendahl and Sikkema (1981), may help native hardwoods outcompete schinus.

Schinus is also found in single-tree-wide stands on the berms along Turner River, Birdon, Wagon Wheel, and Loop Roads. The trees are still restricted to this berm and are not spreading into the nearby Muhlenbergia prairies.

Schinus is also a component in the upland hammocks. Duever et al. (1979) report schinus occurring in hammocks in the saline marshes and mangrove area in the southern area of the preserve which borders Everglades National Park. Usually the schinus is found where a camp or former camp exists. These areas were cleared and schinus invaded the opened areas. Disturbed hammocks in the Ochopee area also show signs of schinus invasion. Most of these hammocks are surrounded by undisturbed vegetation, usually cypress-mixed hardwood forest. Schinus occupies elevated sites adjacent to the Turner River (Gunderson et al. 1982). Other stands were found on edges of hammocks located in Deep Lake Strand (Gunderson and Loope 1982d). Schinus has not been found in undisturbed hammocks. Proximity of a seed source and degree of disturbance to a hammock probably determine the amount of schinus likely to invade pristine hammocks.

Pinelands peripheral to the Ochopee area have schinus as an understory component (Gunderson et al. 1982). The nearby old-field stands probably served as seed source to these areas. Usually, a 5 year or greater absence of fire in pinelands allows schinus to become established (Loope and Dunevitz 1981), and these pinelands probably have a similar history. Currently, frequent fires burn these areas (Duever et al. 1979) and topkill the schinus. Subsequent root-sprouting allows schinus to quickly recover and persist.

Ewel et al. (1982) compared the susceptability of pineland sawgrass-glade and hammocks in EVER to schinus invasion by sowing seed and transplanting seedlings into these communities. Although some environmental conditions are different between EVER communities and BICY communities, many of the factors important to schinus survival, such as light, competition, and hydrology are similar. They determined that pinelands were most susceptible, since seed germination as well as seedling survival and growth were highest on these sites. Both the sawgrass glade and hammock had less germination, seedling survival and growth, and appear to be more resistant to schinus establishment than pinelands.

Factors affecting establishment

Ewel et al. (1982) studied schinus phenology for 2 years in EVER. They found that flowering peaked in February and the seed ripened on the trees between December and February. Taylor (1981) correlated the fire patterns in BICY with schinus fruiting patterns to show that burning occurs the same time of year as schinus fruit are ripe. Perhaps this fire pattern may give schinus a competitive edge by having viable seed on freshly burned ground, at a time when few native shrubs are fruiting.

Schinus seed dispersal is mainly by animals, especially raccoons, opossums, catbirds, and robins (Ewel et al. 1982). Germination is improved by dilute acid scarification, a process analagous to passing through the intestine of an animal (Ewel et al. 1982). Since these animals traverse many vegetation boundaries, schinus is likely to become established any place favorable conditions exist. This may be on a cypress knee, or fork in a cypress tree, or the middle of a hammock, but survival is usually limited at these sites. In addition to the work by Ewel et al. (1982) on the resistance exerted by native communities to successful schinus germination and growth, other authors have documented aspects of inhibition exerted by native vegetation. For example, Dunevitz and Ewel (1980) found Myrica cerifera (wax myrtle) to be allelopathic to schinus, that is wax myrtle exudes a chemical that inhibits schinus growth.

Natural disturbances

Hurricanes: Little is known about the effect of hurricanes on schinus. Isolated individuals may be uprooted by the strong winds, but the degree of uprooting is probably related to the severity of the winds. The root systems are shallow and probably not tenacious. With the shrub stature the species exhibit, it is probably no more susceptible to windthrow than other native species, such as pine or cypress. The danger with hurricanes is the denuding of native vegetation in hammocks or pinelands leaving the area open to schinus colonization. Hurricanes usually occur in late summer, allowing little time for recovery of the native vegetation on these denuded sites before schinus seed ripen. (This scenario is hypothetical, as no documentation could be found on these effects.) However, schinus is an aggressive colonizer, with prolific amounts of readily dispersed seed and rapid growth rates on open or disturbed sites. So it is conceivable that schinus could colonize areas denuded by hurricanes, especially given the current distribution and abundance of schinus seed .

Fire: Fire may be an effective means of precluding schinus invasion, but becomes ineffective once a thicket developes. Loope and Dunevitz (1981) felt that fire exclusion is the important reason for schinus domination on many Miami-rock ridge pineland sites. They showed that a burn frequency of less than once every 5 years effectively excluded schinus establishment from pinelands in EVER, even though a nearby copious seed source exists.

Once an established seedling is greater than 1 meter tall, a burned, top-killed plant can readily resprout (Ewel et al. 1982) and persist at a site. Further development without fire can result in a well-developed thicket. Once a thicket of schinus is formed, the sparse standing fuels and moist litter make the site not conducive to fire, so the site rarely burns and schinus is perpetuated (Wade et al. 1980).

The current fire regime in BICY pinelands may be acting to exclude schinus. Although the time of the year of fires coincides with schinus seed ripening, the fire frequency appears to be such that schinus establishment and growth are hindered. Frequent fires in the pinelands, muhly prairies, and cypress prairies may be helping to exclude schinus from these vegetation types.

Just as frequent fires may exclude schinus, infrequent severe fires are conducive to its establishment (Wade et al. 1980). Severe fires, which kill overstory pines and hardwood shrubs, remove existing, native vegetation leaving the site susceptible to schinus establishment.

Casuarina sp.

Distribution

Casuarina is a genus of plants commonly called Australian Pines. At least eight species of the genus were introduced in Florida before 1924 (Morton 1980). Three of the species are prevalent in south Florida, but only two are common in the BICY. Duever et al. (1979) found *C. glauca* and *C. cunninghamiana* in the preserve. Most of the species along US 41 fit Morton's (1980) description of *C. glauca*. Casuarina was planted along US 41 from Trail Center (Dade county line) to Forty-Mile Bend. Planting was done as a WPA project during the 1930's (Duever et al. 1979). Most of the other stands within the preserve are a result of intentional planting near homesites. Only one place in the BICY does there appear to be direct seeding of casuarina. This spot is on the south side of US 41, in Section 8 (T54S, R35E). These trees were identified as *C. glauca.* Morton (1980) relates stray reports of cones on this species, but she believes they actually may be hybrids of *C. glauca* and *C. equisetifolia.* Whatever the species, these trees do appear to have originated from seed, unlike the remainder of the stands in the preserve where only vegetative regeneration from root sprouts is observed.

Natural disturbances

Severe Storms: As Morton (1980) points out, casuarina is extremely susceptible to windthrow, a result of severe storms. Old large limbs become brittle and are easily blown down by strong winds. The shallow, flattened root system gives little stability and allows entire trees to be readily uprooted by hurricanes. Morton (1980) related the dramatic ease of uprooting following the 1945 hurricane. The writer remembers casuarina as a commonly downed species after hurricane Donna (1960) blew through the Ft. Myers area.

Fire: Casuarina will burn, but the species found in the preserve will readily resprout. *C. equisetifolia* will not resprout after a fire, but the *C. glauca* and *C. cunninghamiana* will. The dense litter layer characteristic of casuarina stands will burn (usually smoldering, rather than a roaring fire) under dry conditions and will topkill the standing trees, but root sprouts will rapidly recover the site (Wade et al. 1980).

Other Woody Exotic Species

Three other species of exotic trees were located within the BICY, but do not now appear to be actively colonizing surrounding areas.

Rosewood, Dalbergia sissoo, was planted at a homesite (now an NPS maintained homesite) on Birdon Road. Seedlings and saplings were found growing on the filled area around the house. No expansion into surrounding areas was noticed, however, the potential for regeneration may be high.

Java plum, Syziguim sp. A single stand of java plum is located on the Loop Road 2 miles south of US 41. No regeneration was noticed at this site. However, this species has regenerated into natural areas in the Naples area.

Bottlebrush, Callistemon sp., is naturalizing from intentional plantings at Trail Center and homesites near Burns Lake. Only limited regeneration has been noticed and now, no more than a dozen trees are found at either site.

CONCLUSIONS

A. Melaleuca quinquenervia

1. The current distribution of melaleuca populations is now largely restricted to roadside stands, but many isolated trees and small stands are located in the interior pinelands, especially in the eastern portion known as Raccoon Point. Most developed stands can be traced to intentional plantings, but have expanded copiously from these original points.

2. During the last 20 years, melaleuca has colonized and displaced vegetation types of Muhlenbergia prairies, cypress prairies, and pinelands. Current site conditions and patterns of recurring fires and severe storms will result in continued expansion of existing melaleuca populations. ORV's may be conveying viable seed, thereby increasing the areal extent of potential colonization.

3. Areas of concern are presented. These areas have the largest populations, and from stand structure, are steadily expanding in size.

B. Schinus terebinthifolius

1. Schinus is generally restricted to the disturbed areas around Ochopee and should be expected to continue to dominate these areas.

2. Roadside stands are found on elevated berms along Turner River, Wagon Wheel and Birdon Roads. These stands are restricted to the berms and show little sign of expanding into surrounding prairie and cypress prairie vegetation types. These two types appear fairly resistent to schinus invasion.

3. Disturbed hammocks now support schinus stands. These stands will probably remain stable, unless a disturbance opens these areas to further colonization.

4. Pinelands, especially near Ochopee, have a schinus component in the understory shrubs. Frequent fires probably help to maintain schinus in a low abundance in all pinelands.

C. Casuarina spp.

1. Casuarina is fairly restricted in its distribution in BICY. Most casuarina stands are a result of direct planting. Only one stand of casuarina appears to be expanding as a result of direct seeding. All other stands of casuarina in BICY are slowly expanding by vegetative regeneration.

D. Other Species

1. Rosewood (*Dalbergia sissoo*) is colonizing the immediate, artificial area around a NPS homesite on Birdon Road.

2. Java plum (*Syzigium* sp.) Trees of this species are found in the preserve. It has not been observed to regenerate in the preserve, but has been found to seed in similar vegetation types nearby the preserve.

3. Bottlebrush (*Callistemon* sp.) is naturalizing in some areas, but is very restricted in range.

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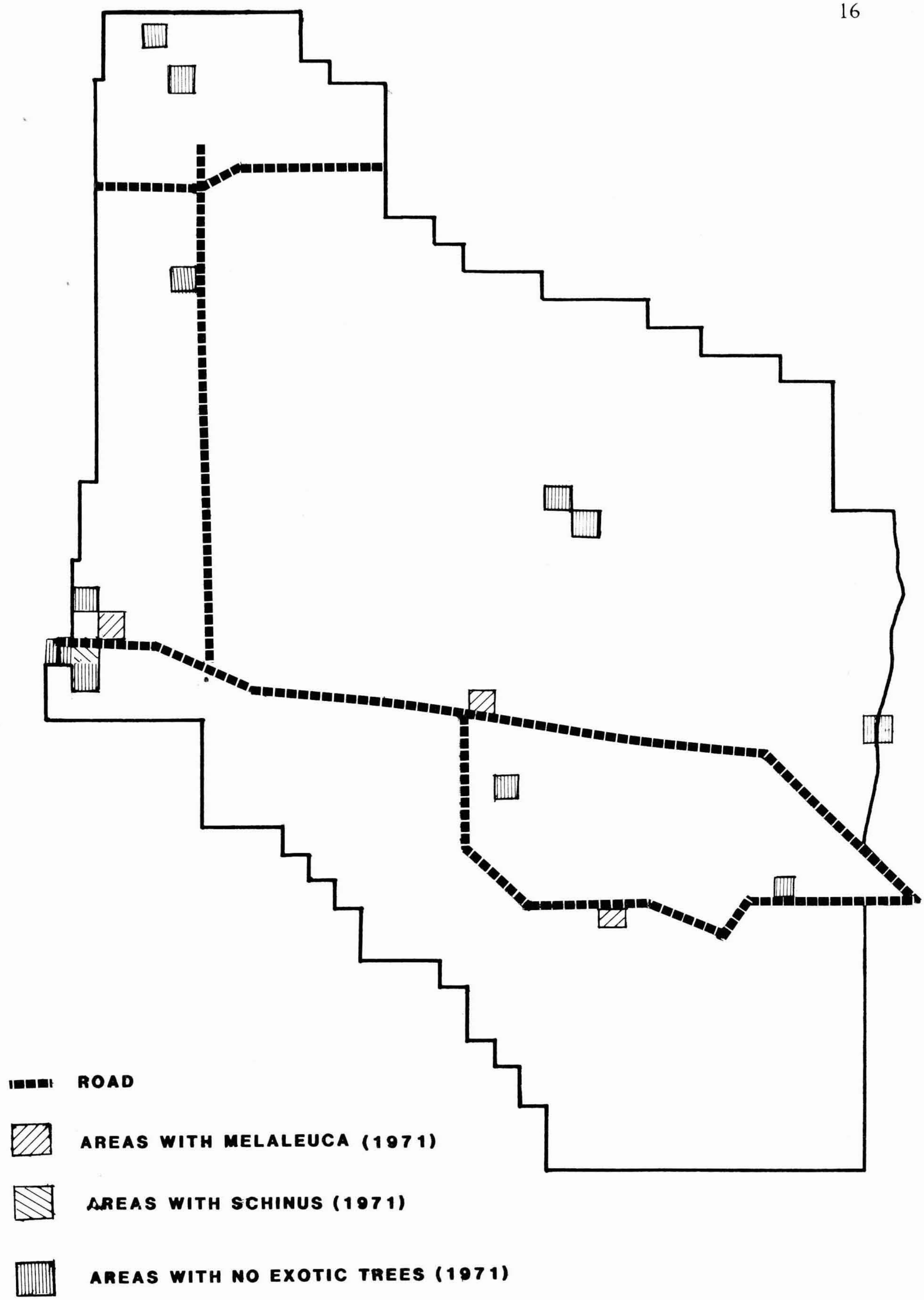

Figure 1. Location of fifteen, 1 mi^2 quadrats within Big Cypress National Preserve surveyed by Alexander and Crook (1975). No exotic plants were found in any quadrat during their review of the 1940 aerial photographs. Quadrats with exotic species present in 1971 are noted.

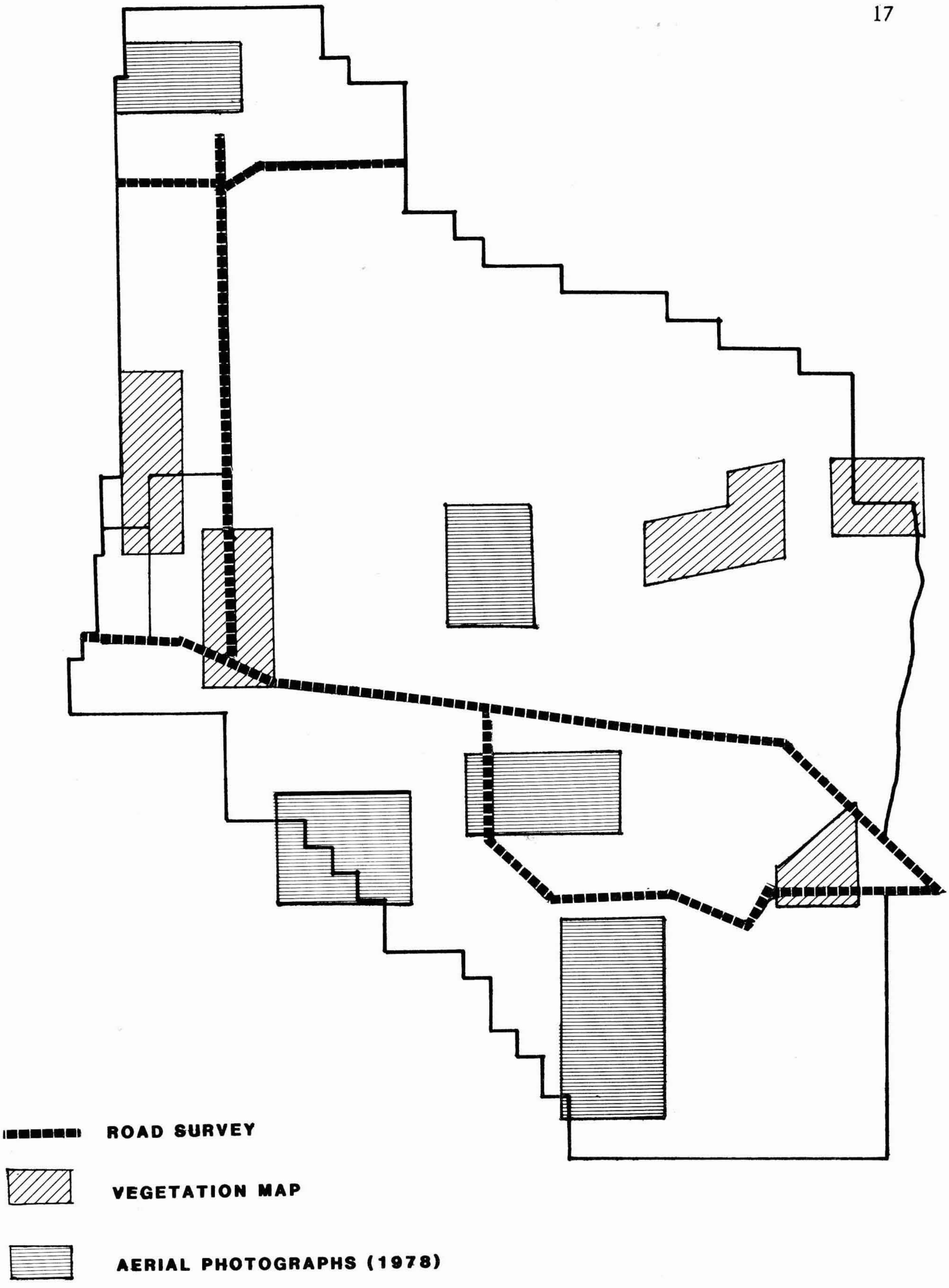

Figure 2. Areas surveyed by various methods to map distribution of woody exotic species in Big Cypress National Preserve.

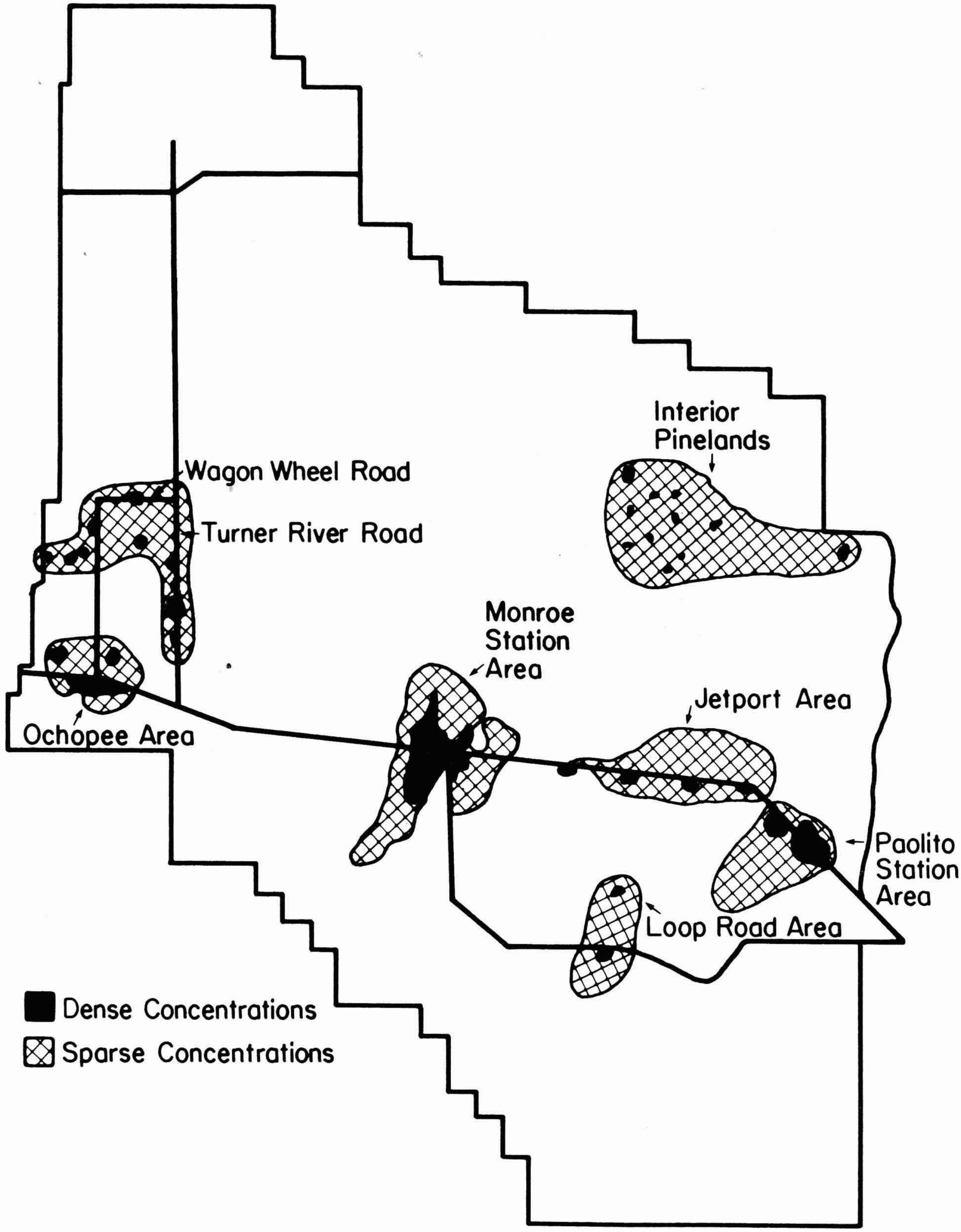

Figure 3. Current (1982) distribution of Melaleuca in Big Cypress National Preserve. Dense concentrations indicate dense, well-developed stands. Sparse concentrations indicate outliers or individuals.

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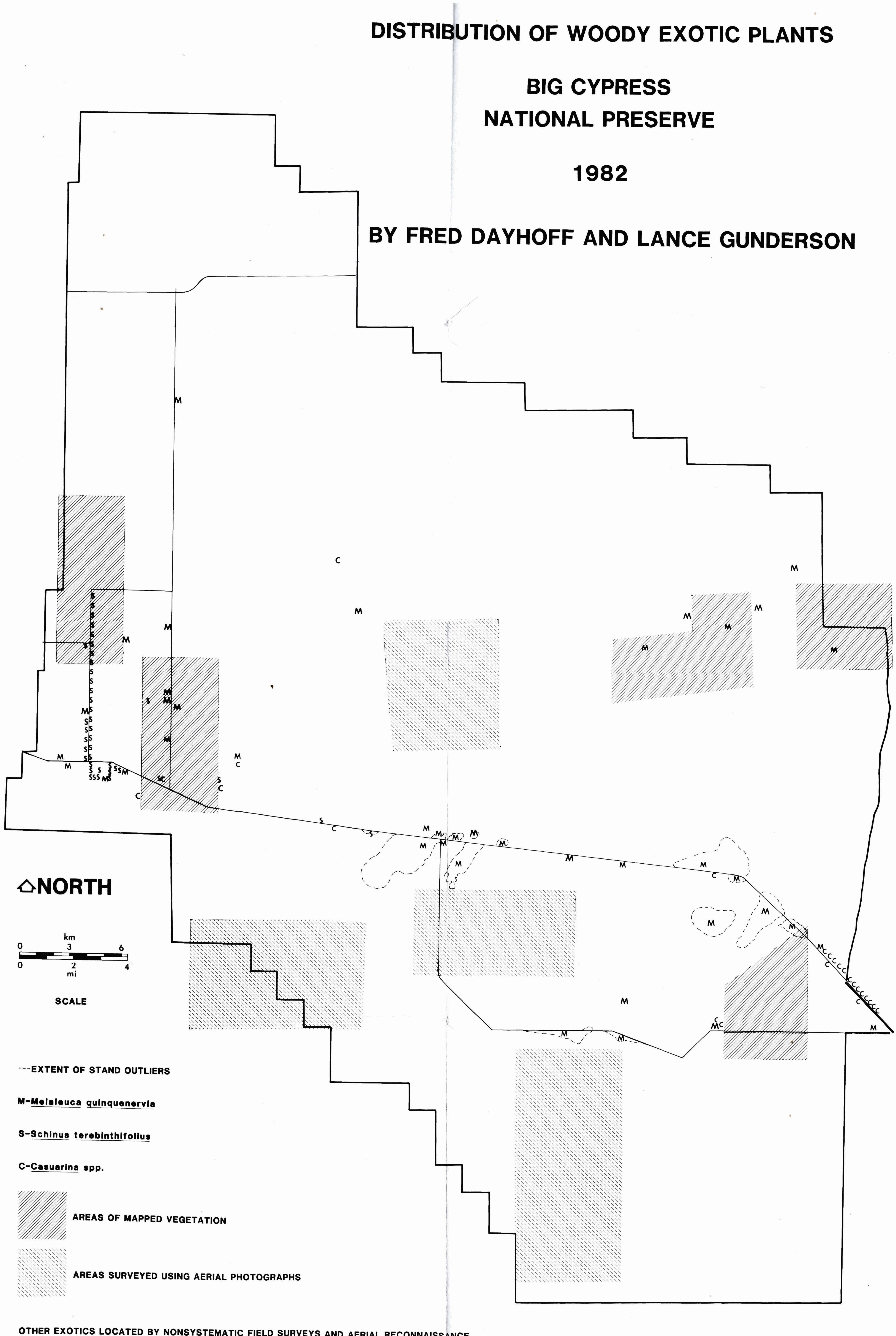
DISTRIBUTION OF WOODY EXOTIC PLANTS
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BY FRED DAYHOFF AND LANCE GUNDERSON
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SCALE
---EXTENT OF STAND OUTLIERS
M-Melaleuca quinquenervia
S-Schinus terebinthifolius
C-Casuarina spp.
AREAS OF MAPPED VEGETATION
AREAS SURVEYED USING AERIAL PHOTOGRAPHS
OTHER EXOTICS LOCATED BY NONSYSTEMATIC FIELD SURVEYS AND AERIAL RECONNAISSANCE