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The Rate of Expansion of Melaleuca in South Florida

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ABSTRACT

Melaleuca (*Melaleuca quinquenervia* (Cav.) Blake) is widely distributed in South Florida and becoming the dominant plant in many areas. The uncontrolled expansion of melaleuca constitutes one of the most serious threats to the existing biological integrity of many ecosystems of south Florida. Aerial photo interpretation and ground truthing surveys were used to determine boundaries of melaleuca infestations at several locations. These boundaries were then digitized from aerial section sheets using AutoCad and Arc/Info GIS software to determine total area of infestation for expansion rate calculations over a 25 year period. The pattern of melaleuca expansion indicated three differential rates of expansion which were characterized as three phases of a sigmoid growth function. The data indicated that when melaleuca infestation had reached approximately two to five percent of the sampled land, it took about 25 years for 95% infestation to occur.

Key words: exotic woody plant, infestation rate, invasion, Everglades, wetlands.

INTRODUCTION

Melaleuca is an evergreen subtropical tree belonging to the Myrtaceae family and is native to Australia, New Caledonia, and New Guinea (Ewel 1986). It was intentionally introduced into South Florida around the turn of the century to afforest the Everglades (Austin 1978). The general belief was that the increased evapotranspiration rate of melaleuca forests would dry up vast areas of wetlands and enable development (Hofstetter 1988).

As a result of both artificial introduction and natural dispersal, melaleuca is now widely established and rapidly expanding in South Florida (Meskimen 1962). Melaleuca is capable of tolerating a broad range of site conditions. It can survive on almost any soil type, tolerates extended periods of flooding, moderate droughts, and tolerates fire and moderate salinity, all conditions characteristic of the wetlands in South Florida (Woodall 1981). These factors, in conjunction with a lack of natural competition, insect feeding and diseases, allow melaleuca to grow more densely in South Florida than in its native range (Thayer and Bodle 1990). Mature melaleuca trees in South Florida commonly form dense canopies which compete with native vegetation and reduce species diversity (Austin 1978).

A single tree may contain millions of seeds stored in capsules on its branches and a single branch may contain seed capsules of different ages. The seeds may remain viable within the seed capsule for several years (Vandiver 1981). Seed release is often related to stress events such as the cutting or breaking off of stems, herbicide treatment, fire or frost damage, as well as natural death (Thayer and Bodle 1990). Because its seeds are encapsulated, melaleuca seedlings can germinate throughout the year (Ewel 1986). Seedfall range is generally restricted to one to one-and-one-half total tree heights (Meskimen 1962). Germinative capacities vary with the length of time that seeds have been retained on a tree: usually 10 to 20% of seeds released germinate (Meskimen 1962).

According to Myers (1975), regardless of the availability of seeds, a certain set of environmental factors must be met before invasion will occur. One very important factor which influences melaleuca colonization is disturbance in the form of an altered hydroperiod. Disturbed sites may

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provide the most favorable conditions for many wetland exotic infestations, and once established in a disturbed area, these populations tend to expand into adjacent areas (Myers 1975). Disturbed areas may also act as staging areas from which an invasive species may disperse its seeds into surrounding landscape (Ewel 1986). It is not clear, however, whether the invasion of melaleuca requires an initial disturbance to create an environment for its establishment. The largest stands of melaleuca in South Florida are concentrated in areas of initial introduction and the expansion patterns seem to lie within an area altered by man (Myers 1975). It has been speculated that these changes are significant enough to cause existing ecosystems to enter into a new successional stage where native vegetation can no longer remain dominant (Sedlik 1976).

The actual geographic distribution of melaleuca in South Florida is, as of this date, unclear. Capehart et al. (1977) attempted to use LANDSAT imagery to determine the distribution of the species. This method was not useful in monitoring the spread of melaleuca because discerning melaleuca trees from other vegetation was difficult. This was, in part, due to resolution levels which were too low to allow for a highly accurate map. Ewel and Myers[2] attempted to evaluate the current and future geographic significance of melaleuca in South Florida. Methods included field observations, as well as low-level aerial reconnaissance. One result of this study was a generalized thematic map of South Florida in which they attempted to categorize the area according to potential future melaleuca invasion if all current environmental conditions continued.

The uncontrolled expansion of melaleuca constitutes one of the most serious threats to the existing biological integrity of many ecosystems in south Florida (Thayer and Bodle 1990). The potential range of melaleuca in Florida includes the majority of the peninsula south of Lake Okeechobee, excluding the saline zone (Woodall 1978). If left unchecked, melaleuca may eventually degrade much of the wetlands in South Florida. Resource managers can use expansion rate estimates as a useful tool for predictions of control cost.

METHODS AND MATERIALS

A total of eight study sites, each one square mile in size were selected within two locations, Dade and Broward county, Florida. As a requirement to be selected, the majority of each site had to be heavily infested prior to 1990. After site selections were made, aerial section photographs, each encompassing one square mile at a scale of 1:3600, were obtained for each site. The dates of these photos were from 1965 to 1990, with an average interval of approximately five years. Aerial photos were purchased from either Broward County Engineering or Dade County Public Works.

Aerial photo interpretation as well as ground truthing surveys were utilized to determine boundaries of melaleuca infestation at each site. These boundaries were then digitized from the section sheets using AutoCad software and later imported into Arc/Info GIS software for further analysis. The State Plane Coordinate system was used to geo-register each aerial section. The total area of each section was adjusted to exclude areas previously cleared for farming or development to obtain consistent expansion rates. The adjusted area was then used to calculate the percentage of melaleuca infestation within each site for each year.

The data obtained were then analyzed using Statistical Analysis Systems software (SAS Institute 1985). A completely randomized design was used to determine differences between the two locations, and study sites within these locations were used as replicates. Since no significant differences were found between the two locations, the data from all study areas were pooled and the scatter diagram technique (Gomez and Gomez 1983) was used to determine the relationship between melaleuca infestation and time. Regression analysis was performed on the data using the sigmoid form of non-linear correlation:

$$\text{melaleuca infestation} = \frac{a}{(1 + \rho b^{year})} \quad \text{where } \rho \text{ autocorrelation coefficient where } 0 < \rho < 1,\ a = \text{intercept, and } b = \text{slope.}$$

RESULTS AND DISCUSSION

The quantitative changes of melaleuca infestation as a function of time are shown in Figure 1. The data indicates that once the infestation reached a level of approximately two to five percent, it took about 25 years for 95 percent infestation to occur within the sampled areas. However the following assumptions must be taken into consideration: no human intervention, no geological structure changes, and ideal site conditions for melaleuca growth.

The pattern of melaleuca expansion can be characterized by a logistic function which is referred to as the

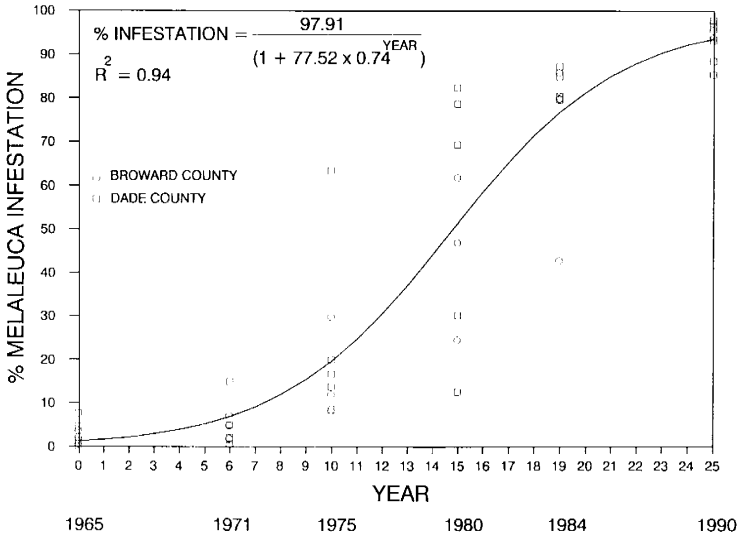

Figure 1. Infestation trend of melaleuca within selected sections, each encompassing one square mile, in Broward and Dade County, Florida.

[2]Unpublished manuscript. Ewel, J., et al. 1976. Studies of vegetation changes in South Florida, Department of Botany, University of Florida, Gainesville, FL.

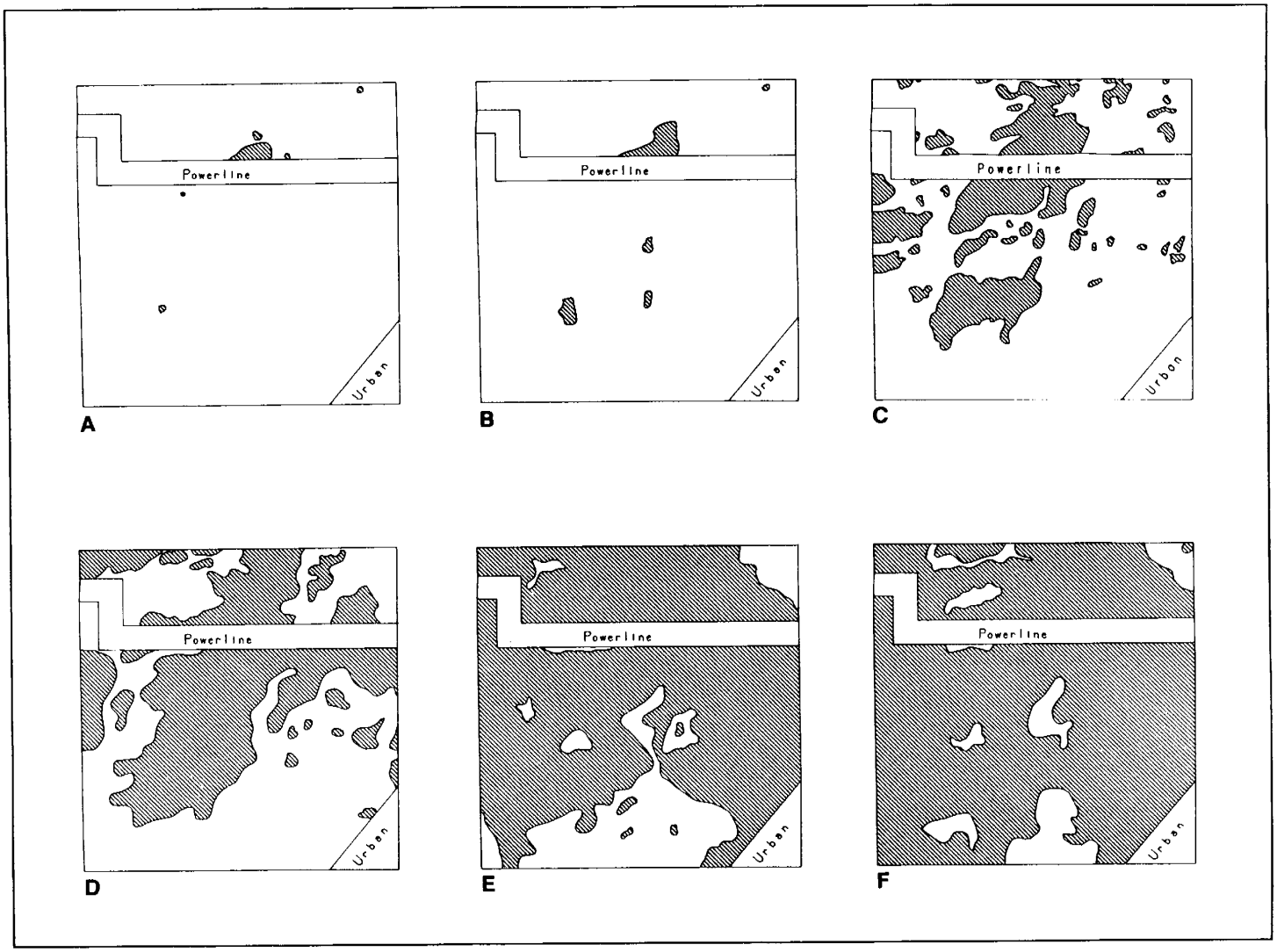

Figure 2 A-F. Shaded areas indicate the development of melaleuca invasion within an area encompassing one square mile in Dade County, Florida. Melaleuca coverage in 1965 (A), 1971 (B), 1975 (C), 1980 (D), 1984 (E), 1990 (F).

sigmoid growth curve. Three phases of growth can usually be detected in this type of curve: a logarithmic phase, a linear phase, and a phase of declining rate of increase (Salisbury and Ross 1978). These phases describe the three differential rates of expansion which occurred during the invasion of melaleuca in all the sampled areas. In the logarithmic phase, or initial rate of expansion, melaleuca occurred in a few isolated locales (Figure 2A), slowly expanded and rate of expansion continually increased as more plants were produced. The logarithmic phase is analogous to the growth of money invested to draw compound interest, with the accumulated interest also drawing interest. (Leopold and Kriedemann 1975). In the following linear phase, expansion continued at a more constant maximum rate between 1972 and 1984. The linear phase was followed by a phase of declining rate of expansion where the increase in expansion became progressively less until a steady state of invasion was reached due to space limitation.

Melaleuca infestation development within one of the sampled areas is presented in Figure 2, A through F. The spatial spread of melaleuca occurred from several points of introduction or "foci" and expanded to its final limits which were determined by the boundaries of the sampled area (Figure 2F). There have been several foci from which melaleuca expanded within Florida. Melaleuca was planted in the early 1900s in at least two coastal locations: Dade County near Coral Gables and in Lee County near Estero (Meskimen 1962). Melaleuca seeds were released from an airplane over western Broward County in the 1930s, and in the 1940s trees were planted on the rim canal along the southern levees of Lake Okeechobee and at Monroe Station in the Big Cypress National Preserve (Thayer and Bodle 1990). As melaleuca expands new foci are created by natural seed dispersal. Hurricane force winds could theoretically transport viable melaleuca seeds a maximum distance of 7.1 kilometers (Browder and Shroeder 1981). According to Mack (1985), each additional "focus" acceler-

ates the invasion of an exotic plant. Spread is also enhanced by foci that are far apart because more area can be covered before population ranges coalesce. The importance of each "focus" illustrates the virtual impossibility of total eradication of an exotic plant. Current melaleuca management programs include manual removal, mechanical removal, physical controls and herbicides, alone or in combination (Langeland 1990). Biological control for melaleuca is currently under study and should be implemented in the near future. Several insects are being evaluated in Australia by USDA personnel (Balciunas 1990). However, unless melaleuca control practices are maintained, a few remnant populations will always become the foci for reinvasion.

Melaleuca spreads readily throughout South Florida. Its potential range includes the majority of the peninsula south of Lake Okeechobee (Woodall 1978). The geographical range of melaleuca in Florida has the potential to expand until it has colonized all land suitable for its establishment. Once established, the areal distribution of melaleuca infestation will remain unchanged, unless the plants are eliminated by ecological or physical factors such as disease, insect damage, climatic or hydrogeological change or until a new more vigorous competitor arises or man clears the land. According to Thayer and Bodle (1990), the melaleuca population as a whole now covers ten percent of its potential range in Florida. As shown in Figure 1, this level of invasion falls within the initial (logarithmic) rate of expansion. No significant decrease in the rate of expansion would be expected until about sixty percent infestation is reached.

Costs and benefits of melaleuca control can be difficult to quantify but the increase in control cost will undoubtedly be proportional to the increase in infestation. This study emphasizes the importance of melaleuca management at early stages of invasion. Additionally, continued uncontrolled expansion of melaleuca may eventually eliminate natural environmental functions of areas vital to the Everglades ecosystems.

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