ALIEN PLANT MANAGEMENT IN EVERGLADES NATIONAL PARK: AN HISTORICAL PERSPECTIVE

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ABSTRACT

Alien plants have been actively managed for the past 25 years at Everglades National Park, with primary emphasis on Australian pine (*Casuarina* spp.), cajeput (*Melaleuca quinquenervia*), and Brazilian peppertree (*Schinus terebinthifolius*). Cajeput has the highest potential for displacing native vegetation in South Florida, but the other two taxa have wide ecological tolerances. Australian pines have been controlled by chemicals (TORDON, 2,4,5-T and 2,4-D) and prescribed fire in the past, but the species continues to increase in the Park. Cajeput has been treated with the same two herbicides plus VELPAR and GARLON, but large, dense stands of the species adjacent to the Park still threaten. Brazilian peppertree has been subjected to mechanical treatment, removing altered substrate, thus increasing hydroperiod and eliminating a favorable substrate. Restoration of wetlands has proven more successful in reducing this species. GARLON 3A as a basal bark treatment is the most effective herbicide treatment. The first alien plant management plan was written in 1969 and has been revised many times. A comprehensive plan for control of some alien plant species has been prepared for Everglades, and parkwide mapping for major species is under way. The South Florida Exotic Plant Pest Council, comprised of over 50 groups, is taking a regional approach to the problem and has resulted in increased awareness and shared information. Long-term control of the target species can be achieved by continued planning and consistent and adequate funding.

INTRODUCTION

Everglades National Park is located in southern Florida at the southern terminus of the vast wetland complex known as the Everglades (Fig. 1). The park was established in 1947 to preserve the biological resources of the area and contains a variety of habitats within its 1,373,320 a (556,000 ha). The principal ecosystem types within the Park include shallow water marine habitats (558,220 a or 226,000 ha), saltwater wetland forests and marshes (449,540 a or 182,000 ha), freshwater marshes and

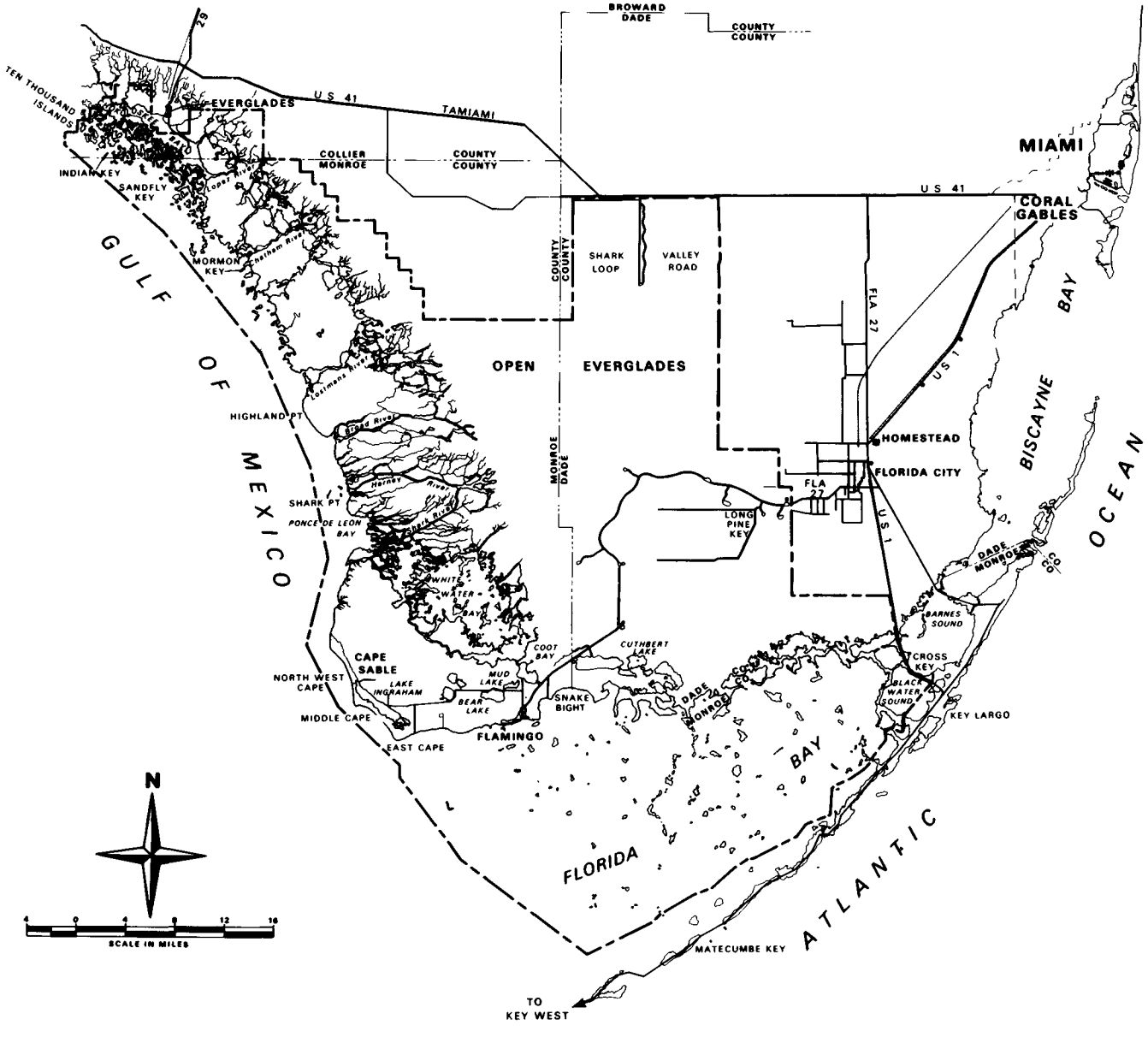

Figure 1. Everglades National Park, Florida.

prairie (370,500 a or 150,000 ha), and an upland complex of pine and hardwood forests (19,760 a or 8,000 ha).

One of the major factors controlling the distribution of the vegetation within the Everglades is the hydrologic regime, defined by the depth and duration of inundation as well as the quality and salinity of the source water. The flat topography, temporal distribution of rainfall, and proximity to the coast all interact to determine the hydrologic regime at a site. Surficial geology and overlying soil type also influence plant species composition and abundance. Natural disturbances that influence the vegetation are fires, hurricanes, freezes, and sea level changes (Craighead 1971; Alexander and Crook 1974; Olmsted and Loope 1984).

Weedy Plants in Southern Florida

The success of weedy plant species in southern Florida is due to a number of factors. Humans have accelerated the rate of species introduction, resulting in the transplanting of hundreds of thousands of plants for use as landscape ornamentals, food sources, and medicines. Southern Florida is essentially a subtropical island, surrounded on three sides by water and to the north by temperate ecosystems, which limits the natural rate of species arrival. Southern Florida is also geologically young, with the current plant communities in existence for only the past 5,000 years (Long 1974; Watts 1975). The natural disturbances that are part of the South Florida environment allow opportunities for weedy species to become established (Myers 1975; Wade *et al.* 1980; Ewel *et al.* 1982) and have been amplified by human activities. The most successful alien species (Myers 1983) are so well adapted to an altered niche that they outcompete native species (Meador 1977; Ewel *et al.* 1982).

The Exotic Pest Plant Council reported that over 400 introduced plant species have naturalized in southern Florida. In Everglades National Park, 840 plant species have been identified, of which 217 (25.8%) are nonnative in origin (Whiteaker and Doren 1989). Many of the aliens within the Park were brought in and planted by early settlers prior to park establishment. To date three taxa have been identified as the major pest aliens within the Park and are the primary objects of management actions. The targeted species are Australian pine (*Casuarina* spp.), cajeput (*Melaleuca quinquenervia*), and Brazilian peppertree or Christmas berry (*Schinus terebinthifolius*).

BIOLOGY AND DISTRIBUTION OF THE THREE WORST EXOTIC PLANTS IN EVERGLADES NATIONAL PARK

Australian Pine, *Casuarina* spp.

Two of the eight species of Australian Pine (*Casuarina*) introduced into Florida (Morton 1980) have been found in the Park: *Casuarina equisetifolia* and *C. glauca*. *Casuarina equisetifolia* was introduced into Florida in the late 1800s and was widely planted to stabilize banks, drain wetlands, and provide shade, as well as for timber

and landscaping purposes. *Casuarina equisetifolia* is currently distributed from Key West north to Tampa (Geary 1981).

Casuarina invades many of the vegetation types in South Florida but is apparently restricted by extended periods of inundation. Survival is best on well-drained sites. *Casuarina equisetifolia* is tolerant of brackish soils and sea spray and readily colonizes open sand and shell beaches and coastal prairies (Egler 1952). Scattered individuals of this species are found in higher-elevation mangrove stands and the interior of keys in Florida Bay. *Casuarina glauca* can invade sawgrass marshes and slash pine forests but is most common along roadsides, berms, and in burned tropical hardwood forests (locally referred to as hammocks).

Dense stands of *Casuarina* are generally detrimental to wildlife, especially threatened and endangered species. Nesting loggerhead and green sea turtles (*Caretta caretta caretta* and *Chelonia mydas mydas*) require gently sloping beaches with soft sand for successful nesting (Klukas 1969; Conover and McElwee 1971). Beaches dominated by *Casuarina* are rarely used by these turtles, as the trees hinder nesting. Also, trees displace native, beach-stabilizing plant species and may alter the morphology of the beach to a steeper embankment due to waves undercutting the sand adjacent to roots. Sandy beaches used as nest sites for the American crocodile (*Crocodylus acutus*) are also colonized by *Casuarina*. Mazzotti *et al.* (1981) found little or no use of *Casuarina* stands by rodents. An exception to the presumptive negative effect on wildlife is the use of *Casuarina* as migration rest sites for the endangered peregrine falcon (*Falco peregrinus*) at Fort Jefferson National Monument, Dry Tortugas.

Cajeput, *Melaleuca quinquenervia*

The potential for displacement of native vegetation by cajeput is greater than for any other introduced plant species in Florida. Introduced from Australia in 1906 as an ornamental, it has since spread rapidly into a range of habitats, assisted by intentional plantings. Cost and Craver (1981) reported that cajeput ranges from Orlando south to the tip of the Florida peninsula, occupying nearly 459,420 a (186,000 ha), of which approximately 40,260 a (16,300 ha) of this total are dense, monotypic stands. Recent studies indicated that in some areas, especially following wildfires, *Melaleuca* is able to increase numbers of trees each year by a factor of 10 (R.F. Doren *et al.*, unpub. data).

Melaleuca has many adaptations that account for its success in South Florida. This plant can flower up to five times a year (Meskimen 1962). The small seeds produced are stored in capsules along the stem and remain viable up to 10 years (Conde *et al.* 1981). Estimates of seed storage range from 2 to 20 million seeds per tree (Meskimen 1962; Alexander and Hofstetter 1975). The seeds are released following a disruption of the stem transpiration stream either slowly by natural mortality, or *en masse* following a stress such as drought, fire, or frost (Woodall 1983). The seeds germinate in moist soil, even under standing water (Meskimen 1962; Myers 1975). Young seedlings are vulnerable to drought and fire, but once established they can withstand these perturbations as well as extended

periods of inundation. *Melaleuca* is well adapted to frequent, severe fires; older individuals are well protected by thick, papery bark. A fire will release seeds onto a cleared seedbed, thereby increasing chances of regeneration (Wade 1981).

These adaptations allow cajeput to compete in native habitats but make it particularly successful in ecotones (vegetation junctions) and disturbed areas. In Australia, *Melaleuca* is found in wet, nutrient-poor savannahs with frequent fires (Coaldrake 1961). Myers (1975, 1983) has shown that the cypress prairie and the pine-cypress ecotone are similar habitats in South Florida and are the most vulnerable to cajeput invasion. Other habitats at risk include sawgrass marshes, muhly prairies, slash pine forests, hardwood hammocks, and the buttonwood-mangrove association. Large-scale alterations to the hydrologic regimes of south Florida and concomitant changes to the fire regime have also increased the distribution of this plant. In addition to the effects on native vegetation, *Melaleuca* provides poor habitat for native fauna (Schortemeyer *et al.* 1981; Mazzotti *et al.* 1981; Ostienka and Mazzotti 1988).

Brazilian Peppertree, *Schinus terebinthifolius*

Brazilian peppertree was first collected in Florida in the 1840s (Barkley 1944) but did not become a conspicuous component of natural systems until the 1960s (Alexander and Crook 1974; Craighead 1971). It was widely planted as an ornamental throughout central and southern Florida and currently ranges as far north as Jacksonville.

The success of Brazilian peppertree is due to a wide ecological tolerance, as shown by an ability to rapidly colonize disturbed areas and persist through later successional stages (Ewel *et al.* 1982; Krauss 1987; Doren and Whiteaker 1990a; Doren *et al.* 1990). As a pioneer species it grows rapidly, produces many seeds, and sprouts readily. Flowering occurs in a compressed synchronous period each October, and pollination of this dioecious species is primarily by insects. The bright red drupes mature in December and January, hence one of the common names, Christmas berry. The drupes are consumed by animals, especially robins (*Turdus migratorius*), which are the primary dispersal vectors. Seedlings can establish and survive in open, light areas as well as under dense canopies (Ewel *et al.* 1982).

Brazilian peppertree has invaded many habitats in Everglades National Park, including sawgrass marshes, muhly prairies, tropical hardwood hammocks, coastal hardwood hammocks, rockland pine forests, and at the saltmarsh/mangrove ecotone. *Schinus* rarely grows on sites flooded longer than three to six months and is not found in the deeper wetland communities. The largest populations occur on disturbed lands such as roadsides, canal banks, and abandoned farmland. The farming practices in South Florida, especially rockplowing (a method of crushing native limestone substrate), alter the substrate and allow for greater occurrence of mycorrhizae, a condition that allows *Schinus* to out-compete native species on these sites (Meador 1977) and alter successional vegetation patterns (Hilsenbeck 1976; Loope and Dunevitz 1981a; Krauss 1983, 1987; Doren and Whiteaker 1990b; Doren *et al.* 1990).

PAST ALIEN PLANT MANAGEMENT IN EVERGLADES NATIONAL PARK

The first efforts at plant eradication in Everglades National Park began prior to park establishment and were directed at a native species. In 1932, the U.S. Department of Agriculture began eradicating wild cotton, *Gossypium hirsutum*, to prevent the spread of the cotton boll weevil (*Anthonomus grandis*). The program was halted in 1972 due to unwarranted damage to park resources and lack of effects in boll weevil control.

In the early days of the Park, little attention was given to introduced species or their effects on the environment. Many plants were associated with abandoned homesites or dwellings of both native Indians and later Europeans. A memorandum by W.B. Robertson in 1956 raised the first alarm, noting that *Casuarina* spp. were found scattered throughout the Park and represented a future threat. The earliest control work focused on aquatic weeds in the Royal Palm Pond, a developed interpretive area, where some of the targeted species were actually native plants yet were being removed to improve wildlife viewing. Other control efforts were aimed at the alien water hyacinth, *Eichhornia crassipes*. Following Hurricane Donna in 1960, Park staff noticed an increase in populations of Australian pine. Initially, alien plants were located, then in 1963 the first control was attempted. This effort was a small-scale mechanical control aimed at *Casuarina* along beaches. *Casuarina* continued to expand after Hurricane Betsy in 1965.

In 1969 the first alien plant management plan was written, primarily targeting Australian pine (Klukas 1969). This report mentioned other problem plant species, including Brazilian peppertree, Australian pine, cajeput, common guava (*Psidium guajava*), and shoebutton ardisia (*Ardisia solanacea*). The first formal, comprehensive alien plant management plan for the Park was written in 1973 (Bancroft 1973) and contained information on policy, plant distributions, specific control objectives and associated costs, and research needs. Six management units were established within the Park, with specific treatment locations identified within each unit. The highest-priority actions were to control Australian pine and eradicate cajeput. Lather leaf (*Colubrina asiatica*) was added to the above-mentioned species as a problem alien plant. The potential for spread and known distribution were also included in the plan for an additional 100 plant species. The 1973 management plan was updated in 1977 (Bancroft 1977) and again targeted control efforts at *Casuarina* and *Melaleuca*. The 1977 plan also added another aquatic exotic, milfoil (*Hydrilla verticillata*), to the list of problem species. The management plan was updated in 1983 (Doren and Rochefort 1983) and again in 1988 (Whiteaker and Doren 1989). Specific programs for *Casuarina*, *Melaleuca*, and *Schinus*, which have received most of the control effort to date, will be discussed.

Australian Pine

The earliest alien plant control efforts within Everglades National Park emphasized Australian pine. Robertson (1956) reported scattered

individuals within the Park in the following locales: the southeastern corner near Card Sound, along the Ingraham Highway to the mangrove zone, on several keys in Florida Bay, and along the Gulf Coast beaches. He reported that some of the populations were spreading slowly and recommended the initiation of experimental control studies. No action was taken until 1963, when post-hurricane surveys revealed rapidly increasing populations in Cape Sable and Highland Beaches. Several small-scale programs were initiated between 1963 and 1970 and were marginally successful. These programs involved mechanical control methods -- cutting down and uprooting individuals. Chemical control began in 1966; the herbicides 2,4,5-T and 2,4-D effectively killed *Casuarina* but were banned from use in 1969. Other herbicides have since been used, with limited success. Prescribed fire effectively killed scattered trees within prairies but did not prove effective in dense stands, because the fuel structure would not carry a fire except under extremely dry conditions.

In spite of these control projects, *Casuarina* continued to spread and by 1970 covered an estimated several thousand acres. Ogden (1970) warned of a four-fold increase in area within the habitat of the endangered American crocodile. This prompted another assessment of the problem (Wodehouse 1972) and a subsequent control program, which ran from 1971 through 1978. During this period, 86,300 trees were treated in the park interior, Highland Beach, and the northern shore of Florida Bay. Due to budget reduction, only 12,000 trees were treated from 1979 through 1985. A survey in 1983 estimated that dense stands covered 18,030 a (7,300 ha) in the southeastern corner of the park, a number at or above the 1970 estimate of coverage, but the Cape Sable and Highland Beach areas remain free of *Casuarina*. Minimal monitoring for seedling control is required.

Cajeput

Cajeput was first reported in Everglades National Park in 1967, and only a dozen more had been discovered by 1969. These isolated trees were found near Park headquarters and along the eastern and northern boundaries. Treatment prior to the mid-1970s consisted of felling the trees and applying herbicide (2,4,5-T and 2,4-D) to the remnant stump. Between 1979 and 1984 8,300 individuals were treated. Most of these were seedlings, which were pulled up by hand. Larger individuals were girdled and frilled, with herbicides (VELPAR or GARLON) applied in the frill. Large, dense stands of *Melaleuca* outside and adjacent to the Park, and in areas recently proposed for acquisition and addition to the Park, still pose the greatest threat.

Brazilian Peppertree

Previous efforts at controlling *Schinus* were concentrated in the "Hole-in-the-Donut" area of the Park and adjacent pinelands. Although Craighead noted invasion of *Schinus* into the mangrove areas around Everglades City in 1961, control efforts have yet to be mounted in these areas. The "Hole-in-the-Donut" is 9,880 a or 4,000 ha of abandoned farmland located in the middle of the Park. Rockplowing, invented in the 1950s, altered the substrate in about half of this area and resulted in conditions that favored the establishment of *Schinus*.

Attempts at restoring the "Hole-in-the-Donut" were initiated in 1972. A variety of techniques was employed to arrest succession and restore native communities (Koepp 1979). Various combinations of mowing, disking, burning, rolling, chopping, and bulldozing were used to remove standing *Schinus*. Subsequent studies indicated that post-treatment succession was toward *Schinus*-dominated vegetation because of the substrate alteration. In conjunction with some of these clearing efforts, pine seedlings were planted. Very few of the pines survived; this is considered by some to be due to poor planting practices and competition from *Schinus*.

One partially successful treatment, initiated in 1976, was the creation of artificial wetlands and uplands in the "Hole-in-the-Donut." Soil was removed from one area and mounded in an adjacent area. The higher, drier area was planted with native hardwood species to simulate a tropical hammock. The lower wetlands were not planted. Recent qualitative inspections of the area revealed that native upland hardwoods are being invaded by Brazilian peppertree, with numerous seedlings in the understory. Native wetland species have colonized the lower (less than 3.5 ft mean sea level) area, and Brazilian peppertree has still not established on this site. The intermediate elevations between the two extremes, however, are dominated by peppertree.

Another management strategy in the "Hole-in-the-Donut," initiated in 1980, was the planting of saplings of native hardwood species in cleared areas. The objective was to provide a seed source to create a forest of mixed species composition, including *Schinus*. The areas around the plantings were mowed for a year to promote growth of the natives. Qualitative observations in 1987 indicate that some of the planted hardwoods have survived, but peppertree has reestablished and is the dominant regrowth.

Brazilian peppertree in the "Hole-in-the-Donut" has been used to experiment with different techniques of herbicide application. Ewel *et al.* (1982) found that basal bark spraying of *Schinus* with GARLON 3A proved to be the most effective means of killing the unwanted plant (Doren *et al.* 1991) with minimum effect on the surrounding vegetation. Ewel *et al.* (1982) also recommended that the female trees in the population be targeted for herbicide treatment, a form of matricide. The objective was to gradually remove the reproductive females from the population, with the remnant males providing a dense canopy to shade and inhibit seedling growth. The matricide approach is difficult to carry out, as the multi-stem growth form of peppertree in the forest makes it difficult to identify stems as part of a male or a female plant. Matricide was especially uneconomical with *Schinus* seedling density in the understory (Doren and Whiteaker 1990b).

The native pine forests of Everglades National Park, dominated by South Florida slash pine (*Pinus elliottii* var. *densa*), are susceptible to invasion by *Schinus* (Ewel *et al.* 1982). Many of the remnant stands of this vegetation type outside the Park are dominated by *Schinus*, but

prescribed burning at 3- to 7-year intervals has severely restricted its establishment within the Park (Loope and Dunevitz 1981b).

CURRENT ALIEN PLANT MANAGEMENT

Alien plant management is a program developed in response to several laws, general directives, and policies (National Park Service 1978; Everglades National Park 1982, 1983). National Park Service policy states that introduced species will be controlled or eradicated if park resources (native species, natural communities, and ecological processes) are threatened. This is always subject to funding availability. Management of alien plants was given a high priority in the Park's Resources Management Plan (Everglades National Park 1979, 1982). The management plan is developed by the Park Resources Management staff of the Ranger Division and articulated in the Everglades Exotic Plant Control Handbook (Doren and Rochefort 1983; Whiteaker and Doren 1989). The handbook establishes priorities, control methods, and guidelines.

Much alien plant control work is carried out by rangers in the various districts of the Park. They are guided by an annual work schedule outlined in the control handbook. Species and known locations are prioritized within each district for control. The work effort varies among districts and years, due to other work assignments and funding. For example, 35,000 trees were treated in 1984 and only 1,300 in 1985. Recent work efforts have concentrated on individuals and outliers rather than on dense stands, and primarily on *Casuarina* on the Florida Bay keys and *Melaleuca* throughout the Park.

Introduced plants are placed in five categories within the handbook for management purposes; these groupings aid in assigning priority and subsequent management action (Whiteaker and Doren 1989):

Category 1

In the first category are species that are widespread in the Park or South Florida and that have an established, documented potential to invade undisturbed native plant communities. In most cases, these species are too numerous and widespread for parkwide control with mechanical or chemical methods, given current and projected funding levels. Therefore, these species can only be controlled locally in high-value resource areas or when they occur as outlying populations or individuals that will potentially increase the distribution of the species. Examples of high-value resource areas include critical habitat for endangered animal species, such as nesting beaches for sea turtles and American crocodiles. These areas have high priority for control of *Casuarina*, which can cause severe beach erosion due to their fibrous root systems, thereby eliminating nesting habitat. *Casuarina* found on previously uncolonized keys or beaches would also have high priority for treatment. Control of outliers such as these has been statistically demonstrated to be most effective in controlling the spread of an invasive alien plant (Browder and Schroeder 1981; Moody and Mack 1988).

Category 2

The second category contains species that have localized populations in the Park but the distribution is expanding rapidly and/or the potential to invade native vegetation in other tropical or subtropical areas has been documented in the literature. These species have a high priority for treatment because they can be controlled parkwide before they become a widespread problem similar to the species in Category 1. For example, the Palay rubber vine (*Cryptostegia grandiflora*), native to Madagascar, is recorded from only one isolated site in the Park. However, in tropical Queensland, Australia, this species has invaded 11,580 mi^2 (30,000 km^2), establishing along river edges and moving into adjacent forest, covering trees up to 90 ft (30 m) tall and choking out native vegetation (McFayden 1988). Therefore, this species has a high priority for documentation of its current distribution in the Park and formulation and scheduling of control measures.

Category 3

In the third category are species able to naturalize and spread locally into undisturbed, native vegetation and form dense stands once they have been introduced to a site. Typically, these are large-fruited species that lack a long-distance dispersal mechanism. However, the distributions of these species need to be documented then monitored for rapid increases or large jumps in distribution. These species are prioritized for control relative to the value of the resources that they threaten, and they are treated as time and funding allow. The occurrence of these species is usually associated with abandoned homesites or other developed areas, where introduced landscape plants have persisted at the site and successfully reproduced, with the population gradually expanding radially from the original plant into the surrounding vegetation.

Category 4

The fourth category consists of species that are widespread in the Park and/or South Florida and form dense, monotypic populations, but primarily on disturbed sites such as roadsides, canal embankments, and agricultural lands. These species are usually identified as agricultural weeds in the literature and are a formidable problem on lands that are, or have been, intensively managed. However, large-scale invasions of undisturbed, native vegetation have never been documented for these species. Therefore, at this time these species are not considered to be threats to native plant communities. The best method for control of these species is by prevention or mitigation of disturbances that are not natural components of the Everglades environment. Included in this category are many weedy introduced grasses that form impressively dense, monotypic stands on disturbed areas just outside the Park, but have not successfully invaded adjacent native vegetation on Park land in spite of the production of copious wind-dispersed seeds.

Category 5

The fifth and largest (155 species) category contains all other nonnative species that have been listed, or observed, as occurring in Everglades National Park. These are species that persist from cultivation and landscape species that have not naturalized in the Park, or species

that are ephemeral (often annual) weeds restricted to disturbed sites and not forming dense populations even on those sites. No management action is planned or needed for these species, because they have no potential to invade undisturbed native vegetation and/or disrupt natural processes.

In late 1987, work was initiated to conduct a systematic inventory of alien plant distribution (for cajeput, Australian pine, Brazilian pepper, and lather leaf) within Everglades National Park. The work effort will produce a parkwide map of these alien plants in order to guide control work. The map will be generated from interpretation of low-level false-color infra-red aerial photographs. The map will also form a baseline inventory from which future control work can be quantitatively evaluated by following changes in spatial distribution of these plants.

Interagency Efforts

Alien plant management in southern Florida is a regional problem that transcends political boundaries. Alien plants range throughout the area, and even if complete eradication is accomplished within natural, protected areas, external populations will still pose a threat. Governmental agencies, conservation groups, and concerned individuals have held informal meetings to exchange information on aliens since the early 1970s. Following several such meetings, the Exotic Plant Pest Council was formed in 1984 at Everglades National Park. The council is a multi-member task force to meet common objectives regarding management and control of alien plants. To date, over 50 groups, including local, state, and federal agencies, conservation groups, local native plant nurseries, and universities hold active memberships. The specific functions of the Council are:

- To provide a focus for the issues and concerns regarding introduced pest plants and promote understanding of problems and possible solutions.

- To facilitate communication and exchange of information on alien plant control and management and to disseminate this information.

- To serve as an advisory panel for various interests concerned with introduced pest plants, suggest management actions and coordinate the acquisition and dispensation of funds towards mutually beneficial programs.

The Council has a number of ongoing projects, including:

- Control of *Melaleuca* and *Casuarina* on lands adjacent to the Park that are slated for acquisition. The state legislature provided $20,000 for this project in 1986 to be administered by the Council. The State and Dade County Department of Environmental Resources Management have provided an additional $180,000 for the 1987-1989 budget.

- Active support of a proposal for interagency cooperation and funding for a biological control program for *Melaleuca*. The U.S. Army Corps of Engineers allocated $160,000, and the National Park Service allocated $70,000 in 1987 and $79,000 in 1989 to this program.

- Development of a draft alien plant ordinance for counties and municipalities, which would standardize ordinances throughout South Florida and help stem the spread of unwanted alien species.

- Mitigate 60 acres (24 ha) in a pilot study for control of peppertree in the "Hole-in-the-Donut" by removing disturbed substrate and increasing hydroperiod. This has been done through an offsite mitigation program consisting of $500,000 in outside funds.

- Develop a comprehensive list of known alien species, locations, and potential threats to South Florida ecosystems.

The regional, interagency approach has greatly improved awareness of the alien plant problem in South Florida. It has brought all agencies to a common level of control knowledge, thereby saving time and money associated with development of individual programs.

FUTURE EMPHASIS AND NEEDS

Complete eradication of cajeput is the number one alien plant control priority within the Park. The currently small number of individuals can be eradicated at a relatively low cost. Eradication of *Casuarina* will require a large commitment of both human and fiscal resources in order to eliminate the large, dense stands in the southeastern corner of the Park. *Schinus* control in the mangrove areas needs to be addressed, as well as an evaluation of options for future management of the "Hole-in-the-Donut" and surrounding areas; all these programs will also require large resources. All control programs should be supplemented with ongoing monitoring for evaluation of the programs.

Initial work should be continued on biological control options for these three pest species. This type of control is expensive and will take a long time but could result in eventual elimination or significant reduction of continued manual and chemical control in the region and the Park.

Other species, primarily shoebutton ardisia and lather leaf, should be examined for their potential for invasion and techniques for control. *Ardisia* has invaded areas in and around Royal Palm Hammock and the "Hole-in-the-Donut" and appears to be spreading. *Colubrina* has invaded the mangrove areas of the park, but the current and potential distributions are unknown.

The Park should continue participation in the Exotic Plant Pest Council. The Council and its activities further interagency cooperation in solving regional control problems. Participation should also prevent duplication of control efforts and research, thereby saving each member organization time and money. Control of populations outside the Park will eventually assist control within the Park. Councils should be considered for other areas.

The development of detailed distribution maps of both problem and potential pest species should aid in future management and control. Automation of these data on a Geographical Information System would provide this information in a usable format, easily retrievable and edited. Control plans and program evaluations could effectively employ such a system.

CONCLUSIONS

Alien plants have been recognized for 30 years and actively managed for the past 25 years at Everglades National Park. Primary control efforts have been aimed at Australian pine, Brazilian peppertree, and cajeput. The program over the years has been successful in some areas but has suffered some setbacks. Current management reflects a development of effective control strategies, such as attacking outliers of dense stands of Australian pine, cajeput, and Brazilian peppertree, and using new, cooperative strategies in controlling peppertree. The Park has developed safe, effective herbicide control techniques that kill targeted species and, when properly used, are not harmful to human users or surrounding nontarget vegetation.

Many of South Florida's natural ecosystems are subjected to recurring natural disturbances that allow establishment of alien species, especially in the context of large seed sources external to the park. Solution of the alien plant problem will require a long-term commitment of fiscal and human resources in order to meet the distant goal of an alien-free Everglades National Park. The ultimate cause of future problems will be insufficient and inconsistent funds. The State of Florida successfully controls aquatic weed species in waterways by spending $17 million annually. Long-term control can be achieved by consistent and adequate funding and planning.

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