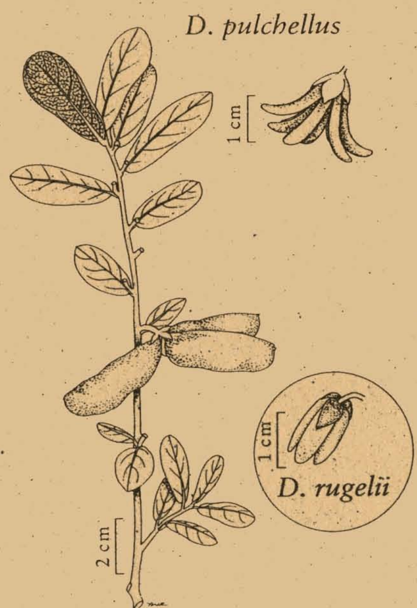
CENTER FOR PLANT CONSERVATION

AN ACTION PLAN TO CONSERVE THE NATIVE PLANTS OF FLORIDA



Southeast Environmental Research Program
Florida International University

and

Center for Plant Conservation

CENTER FOR PLANT CONSERVATION

P.O. BOX 299 ST. LOUIS, MO 63166-0299 (314) 577-9450 FAX (314) 577-9465

An Action Plan to Conserve the Native Plants of Florida

An Action Plan to Conserve the Native Plants of Florida

Southeast Environmental Research Program
Florida International University

and

Center for Plant Conservation

Center for Plant Conservation
St. Louis

Center for Plant Conservation
Missouri Botanical Garden
P.O. Box 299
St. Louis, Missouri 63166-0299

(314) 577-9450

Copies available from the Center for Plant Conservation.

Printed on 100% recycled paper. ♻

CONTENTS

ILLUSTRATIONS

FIGURES

TABLES

Cover art: Florida's endangered *Deeringothamnus pulchellus* (beautiful pawpaw or white squirrel-banana) and *D. rugelii* (Rugel's pawpaw or yellow squirrel-banana), prepared by Yevonn Wilson-Ramsey for the Flora of North America Project, Missouri Botanical Garden.

PART I: INTRODUCTION

"...It is the most wild, dream-like, enchanting sail conceivable. The river sometimes narrows so that the boat brushes under overhanging branches, and then widens into beautiful lakes dotted with wooded islands. Palmetto-hammocks, live-oak groves, cypress, pine, bay, and magnolia form an interchanging picture; vines hang festooned from tree to tree; wild flowers tempt the eye on the near banks; and one is constantly longing for the boat to delay here or there..." (Stowe 1873).

For many years, the image of Florida described above represented the mysterious, tropical element in the American natural and cultural heritage. By the boom years of the 1920s, Stowe's "dream-like" Florida had become a Paradise Lost for botanists like J.K. Small who was a crestfallen witness to the disappearance of the custard-apple forests of Lake Okeechobee and the cathedral mangroves of what had become Miami Beach (Small 1919). As the century draws to a close, the timeless natural scenes which inspired evocative prose no longer suffuse everyday life in Florida, and many people visit the state without ever recognizing the grandeur of the baldcypress or the grace of the silver palm. Today, one generally must venture far from roads, dikes, and ditches to glimpse such sites as Rawlings' Cross Creek or Douglas' "river of grass;" even here, closer scrutiny may uncover declines in the richness of flora and fauna. However, like all resources in diminishing supply, these remnants of the poets' Florida have taken on a greatly enhanced value with scarcity. If they can be preserved, restored, brought closer to our lives, the wild places and the plants and animals they shelter may continue to inspire our imaginations.

In this document, a strategy aimed at conserving the native flora of Florida is presented. The strategy is developed in a four-step sequence. Following this Introduction (Part I), The Florida Native Plant Resource (Part II) describes the resource and the threats to it. That section includes a brief description of the vegetation of Florida prior to the demographic explosion of the last century, a report on the current status of plants in the state, and discussion of some factors responsible for the evident and continuing decline in the quality and quantity of the vegetation resource. In Part III (The Florida Plant Conservation Process), an explicit goal for plant conservation in Florida is expressed, a model describing the plant conservation process is presented, and activities included with each component of the model are examined and evaluated for the state as a whole. Finally, in Part IV (Recommendations To Improve The Process), changes are presented that we believe would help create a more effective plant conservation environment in Florida.

PART II: THE FLORIDA NATIVE PLANT RESOURCE

A. Pre-settlement vegetation patterns

Within the continental United States, Florida is second only to California in the richness and level of endemism of its indigenous flora. The state has approximately 3,500 species of native and naturalized vascular plants, eight percent of which occur only within its borders (Cox et al. 1994). These species are distributed among ecosystems that range widely in geologic history, some dating to the emergence of Florida from the sea, others coming together in their current form only since humans arrived on the peninsula. The remarkable diversity of plant taxa and habitat types that is the natural heritage of Florida is the product of a complex interaction of environmental and human factors that has unfolded over many generations.

The terrestrial history of Florida began about 25 million years ago when most of the peninsula north of present-day Lake Okeechobee emerged from the sea. Florida was never again completely below water, but its length and width varied greatly over subsequent years. The most rapid and dramatic oscillations occurred during the *ca.* 2 million years of the Pleistocene epoch, as land successively emerged and was inundated during numerous glacial-interglacial cycles. At the peak of the most recent glacial advance (*ca.* 20,000 to 13,000 years B.P. [before present]), the peninsula was twice its present size. As the retreating glaciers melted, the extensive mesic forests and scrub communities that had covered the western reaches of the Floridan plateau gradually submerged beneath the rising waters of the Gulf of Mexico. It was during this post-glacial Holocene period of rising seas that most of Florida's 7,800 lakes and extensive freshwater wetland systems came into being.

Today, Florida is a long, narrow extension of the North American continent into tropical seas. It stretches 500 miles from the Georgia state line to the tip of the Keys, with no point more than 60 miles from the Gulf of Mexico or the Atlantic Ocean. Bathed by warm Gulfstream currents for much of its length, the peninsula enjoys a warm and humid climate favorable for plant growth. Florida thus provides a climatic and geographic bridge between temperate North America and the Caribbean tropics -- a bridge which has facilitated colonization by tropical plant species hundreds of miles north of the Tropic of Cancer. In the southern part of the state the intermingling of temperate and tropical plants -- many near their range limits -- has created rich and singular species assemblages (Long and Lakela 1977). In contrast, the resident south Florida fauna is relatively depauperate and of predominantly temperate origin. From an ecosystem perspective, several potential functional niches are currently unfilled by this species-poor faunal mix; feedback effects on plant community structure are possible, but have not yet been well documented.

Over Florida's Paleozoic basement rock of quartz and sandstone, marine carbonate sediments have accumulated over the course of 200-225 million years. The limestone platform that formed from these sediments may be several hundred or more meters thick. In typical upland settings, the soil capping this massive carbonate bedrock is a thin sand or clay. One exception is along the ancient central spine of the peninsula, where deep sand ridges deposited during recent interglacial periods comprise some of Florida's highest elevations -- *ca.* 100 meters above sea level. Another exception is the Miami Rock Ridge, extending into the Keys. Here extensive outcrops of limestone are rarely covered by more than a few inches of organic soil.

Most of Florida is flat and low. With the water table close to the surface, minimal differences in topography result in dramatic changes in vegetation character. Extremely xeric and hydric habitats can be juxtaposed over elevational gradients measured in centimeters. Hammocks arise from the surrounding marshes, flatwoods give way to swamps, and sandhills are dotted with bogs. In these settings, small changes in the level of the surficial aquifers -- Floridan in the north, Biscayne in the south -- may profoundly affect vegetation distribution and the fate of whole ecosystems.

The late Pleistocene pollen record illustrates Florida's landscape on the eve of its colonization by native Americans, approximately 10,000 years B.P. At that time the ecosystems of north-central Florida were like those of today -- pineland and sandhill, interlaced with temperate broadleaf forests. Further south, sand pine scrub and xeric oak woodlands cloaked the sandy central ridge of the state. In South Florida, scrub vegetation may have persisted until 5,000 B.P., when rising sea level elevated the water table to the surface, creating cypress swamps and sawgrass marshes, including the modern Everglades.

Thus, when European colonization began in the mid-16th century, interior Florida was a mixture of xeric or mesic pineland and wetlands. Mangrove swamps dominated low-wave-energy shorelines in the subtropical southern half of the state, while *Spartina* salt-marshes were predominant in the temperate northern half. High-wave-energy shorelines, most prominently on barrier islands and the Atlantic coast, were characterized by grassy sand dunes backed by scrub or maritime hammocks. The most complete description of the pre-settlement distribution of Florida vegetation is provided by Davis (1967), which we have included as Figure 1. The mapping units used by Davis are equivalent to 13 major ecosystem types still present in the state. Their descriptions are based in large part on the essays in Ecosystems of Florida (Myers and Ewel 1990).

FLORIDA ECOSYSTEM TYPES

Upland ecosystems

Pine flatwoods are characterized by a low, flat topography, sandy soils and frequent fire (Abrahamson and Hartnett 1990). Overstory composition may be any of four pine taxa either in pure or mixed stands: longleaf pine (*Pinus palustris*), pond pine (*P. serotina*), northern slash pine (*P. elliottii* var. *elliottii*) or southern slash pine (*P. elliottii* var. *densa*). The understory is usually dominated by saw palmetto (*Serenoa repens*), gallberry (*Ilex glabra*), fetterbush (*Lyonia lucida*), and wiregrass (*Aristida stricta*). **Wet prairie**, a subtype within pine flatwoods mostly found in the Panhandle, is a graminaceous, seasonally inundated community with scattered longleaf or slash pines. The dominant species include wiregrass and *Rhynchospora* spp. in wetter areas. There is a high level of endemism.

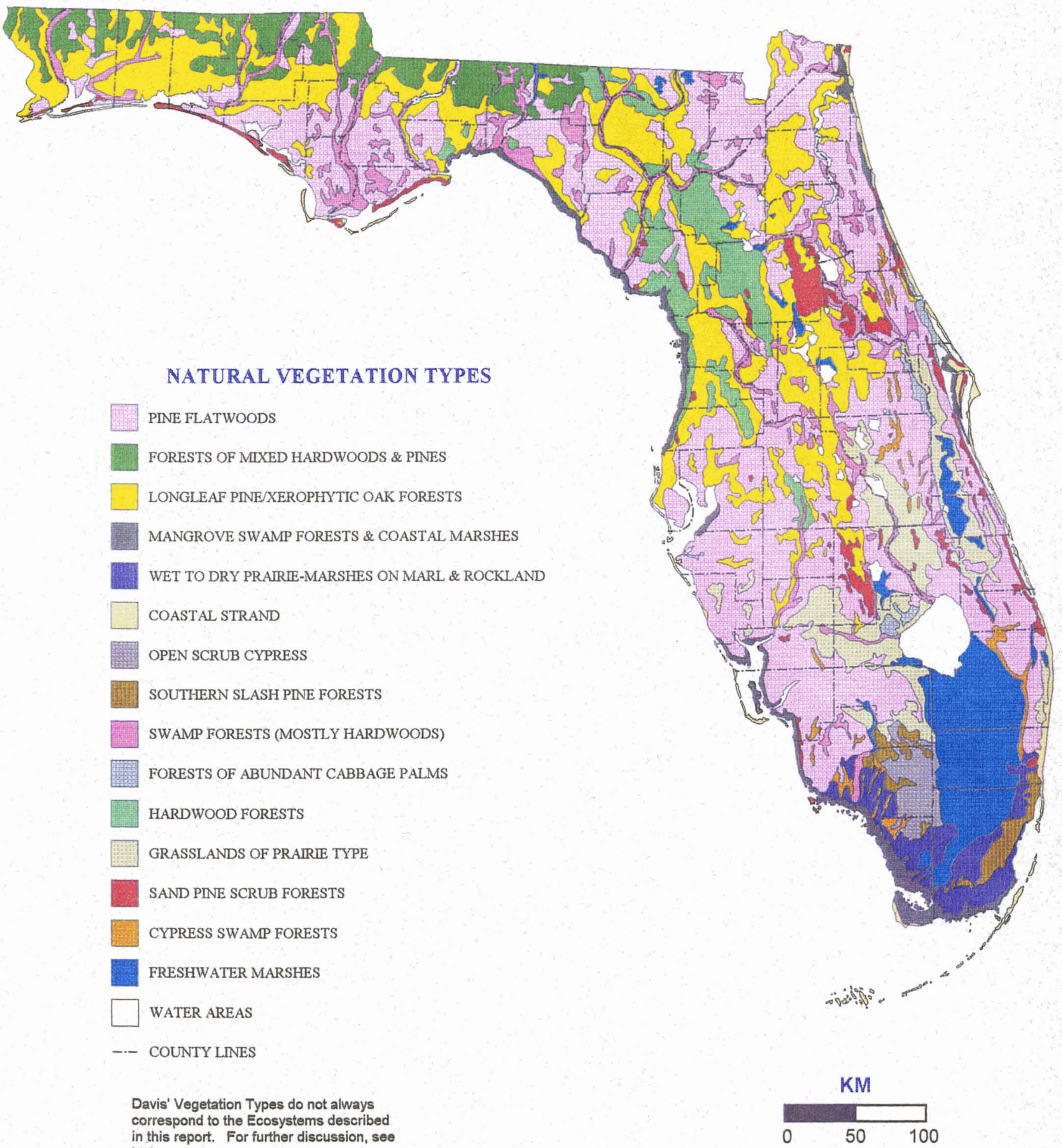
Sandhills are also known as high pine in contrast to the "low" pine of flatwoods (Myers 1990). They occupy well-drained sand ridges and are sustained by frequent low-intensity fire. Longleaf pine is the single canopy species over a continuous cover of wiregrass and occasional clumps of deciduous oaks (*Quercus* spp).

Pine rocklands are associated with outcroppings of limestone. They occur almost exclusively on the Miami Rock Ridge and on several islands in the lower Keys (Snyder et al. 1990). The sole canopy species is southern slash pine. Below the pine canopy is a diverse understory of tropical and temperate shrubs, palms and herbs, with many endemic taxa. Pine forests in the eastern third of Big Cypress National Preserve are generally classified as pine rocklands; in fact, they are intermediate in substrate and species composition between pine rocklands and pine flatwoods, and lack the characteristic endemic herbs of true pine rocklands.

Scrub is a xeric ecosystem associated with either coastal or inland sand dunes (Myers 1990). It is almost entirely endemic to Florida. Coastal scrub occurs as a backdune community landward of high-wave-energy shorelines on both the Atlantic and Gulf coasts. Inland scrub occupies the ancient (Pleistocene) sand dunes of the central ridge in Ocala National Forest and the southern third of the Lake Wales Ridge. Both coastal and inland scrub are dominated by xeric evergreen oaks and/or Florida

REDRAWN FROM

J.H. DAVIS' "GENERAL MAP OF THE NATURAL VEGETATION OF FLORIDA" (1967)



Davis' Vegetation Types do not always correspond to the Ecosystems described in this report. For further discussion, see text.

rosemary (*Ceratiola ericoides*), with or without a sand pine (*Pinus clausa*) overstory. The herb layer is typically depauperate, but characterized by many narrowly endemic species amidst a ground cover of lichens and patches of bare sand.

The environment of **dry prairies** is similar to that of pine flatwoods, but without a pine overstory (Abrahamson and Hartnett 1990). They are essentially open grasslands of wiregrass, lovegrass (*Eragrostis* spp.) and bluestem (*Andropogon* spp.), with scattered patches of low shrubs such as saw palmetto, fetterbush, and blueberry (*Vaccinium* spp.). Much of the extant dry prairie in the state shows evidence of a previous pine overstory.

Scrubby flatwoods occupy ecotones between pine flatwoods and scrub communities. They are essentially mesic flatwoods with a scrub understory, and are characterized by slash pine instead of sand pine with several species of xeric oak and other shrubs (Abrahamson and Hartnett 1990).

In addition to these six pine-associated types, there are three other major upland ecosystems in Florida:

Temperate hardwood forests occur on a variety of sites throughout the upper two-thirds of the state but are especially abundant in the northern third (Platt and Schwartz 1990). Woody plant species richness in this diverse forest type is considered to be the highest in North America, with both deciduous and evergreen species well represented. The dominant trees are species of well-known temperate genera such as oak, hickory (*Carya* spp.), beech (*Fagus* spp.), and maple (*Acer* spp.). In the Panhandle, these forests often contain a pine component and are sometimes distinguished as Mixed Hardwood/Pine Forests.

Tropical hardwood hammocks, also known as rockland hammocks, are associated with outcroppings of limestone (Snyder et al. 1990). They occur only in the southernmost counties of the state where they occupy elevated, rarely inundated and relatively fire-free sites. About 150 species of woody plants are found in these diverse forests. Most are broadleaved evergreen trees of West Indian origin.

Coastal uplands occur on high energy shorelines and on barrier islands of the Gulf and Atlantic coasts (Johnson and Barbour 1990). These communities occupy three zones: pioneer, transition, and stable. The pioneer zone extends from the high tide line to the foredune, is subjected to the greatest stress from storm tides and salt spray, and is characterized by sand-binding grasses like sea-oats (*Uniola paniculata*) and panic grass (*Panicum* spp.). The stable or backdune zone is furthest from the shoreline, is subjected to the least stress, and generally resembles the dominant plant community of the region in which it occurs. Its floristic character therefore varies from scrub to pine flatwood to maritime hammock. The transition zone is a grassy or shrubby region intermediate in location and character between the foredunes and the backdunes.

Freshwater wetlands

Swamps are forested wetlands occurring on a variety of substrates and ranging widely in hydrologic regime (Ewel 1990). Swamps may occur in river floodplains or lake margins, or may occupy more or less extensive depressions. Recognized floristic variation includes cypress (*Taxodium* spp.), bay (species of *Persea*, *Magnolia*, or *Gordonia*), hardwood, and shrub (*Cyrilla racemiflora* or *Cliftonia monophylla*) swamps.

Marshes are wetlands dominated by herbaceous plants rooted in and generally emergent from shallow water (Kushlan 1990). The Everglades, Florida's best-known marsh, is recognized as an International Biosphere Reserve. Other extensive marshes are associated with the Kissimmee and St. John's Rivers. Marshes are categorized on the basis of their dominant vegetation. These include sawgrass (*Cladium jamaicensis*), cattail (*Typha* spp.), and water lily (*Nymphaea odorata* or *Nelumbo lutea*) marshes as well as seasonally inundated prairies dominated by beakrushes (*Rhynchospora* spp.) or muhly grass (*Muhlenbergia capillaris*).

Salt water wetlands

Salt marshes are coastal ecosystems of salt-tolerant herbs occupying low-wave-energy intertidal zones (Montague and Wiegert 1990). They are at least occasionally inundated with salt water. Characteristic species include cordgrass (*Spartina* spp.), needlerush (*Juncus roemerianus*), glasswort (*Salicornia* spp.), and saltwort (*Batis maritima*).

Mangroves are low-wave-energy intertidal swamps dominated by three species of woody facultative halophytes: red (*Rhizophora mangle*), black (*Avicennia germinans*), and white (*Laguncularia racemosa*) mangrove (Odum and McIvor 1990). Buttonwood (*Conocarpus erectus*), a mangrove associate, occurs inland of the true mangroves and is transitional into upland communities.

B. Current condition of Florida ecosystems

The following discussion focuses on the current areal extent of Florida ecosystems in comparison to pre-settlement standards, with most data derived from Kautz et al. (1993). One should recognize that the areal reductions documented below express only one dimension of the problem; in many cases, ecosystem quality has also been reduced by the same factors that have affected the viability of Florida plants of conservation concern. These factors are discussed in the next section.

Overall the Florida land mass comprises some 14.1 million ha. Today 4.9 million ha (35%) of Florida are uplands, 3.3 million ha (24%) are wetlands, and 5.9 million ha (42%) represent urban, agricultural or disturbed lands. Thus, 58% of Florida, or 8.2 million ha, is still covered by some form of native vegetation (Kautz et al. 1993). About 30% of this natural area, or 2.5 million ha, is afforded some level of protection by government agencies or private organizations and constitutes Florida's Conservation Areas (CAs; see Cox et al. 1994). Table 1 provides a summary of the pre-settlement and current areal extent of the ecosystems for which information is available as well as the extent of existing CAs. Table 2 summarizes the number of imperiled plant taxa by ecosystem type.

Uplands

Prior to European settlement, pine flatwoods constituted the most extensive terrestrial ecosystem in Florida, accounting for over one-third of the land area. Today, about half of Florida's pine flatwoods are gone, and about half of what remains has been converted to commercial pine plantations. Seventeen percent of the original pine flatwoods, or about 463,000 ha, is in CAs. Thirty-one species of plants occurring in pine flatwoods, mostly forbs and graminoids, are considered by the Florida Natural Areas Inventory (FNAI) to be imperiled or critically imperiled globally (G2 and G1, respectively; see Appendix A). Of these 31 species, 17 have the wet prairie subtype as their preferred habitat.

With about 20% of the pre-settlement land cover in the state, sandhills constituted the second most extensive ecosystem. Sandhill pine forests have been reduced in area by 88%, much more than the flatwoods communities. Thirty-eight percent of remaining sandhills, or about 142,000 ha, is in CAs. FNAI lists 15 imperiled sandhill plants.

Table 1. Current and Pre-settlement Areas of 13 Florida Ecosystems (In Hectares)

Habitat	Pre-settlement[1]	Current[2]	Conservation Areas[3]
Pine flatwoods	4,846,000	2,642,000[4]	463,000[5]
Dry prairie	NA	561,000	95,000
Scrubby flatwoods	NA	NA	NA
Scrub	418,000	172,000[6]	107,000[7]
Sandhill	2,789,000	345,000	143,000
Temperate hardwood forest	1,458,000[8]	1,555,000[9]	189,000[10]
Pine rocklands	155,000	7,000[11]	6,000[12]
Tropical hammock	NA	6,000	3,500
Swamp	1,469,000[13]	1,808,000[14]	545,000[15]
Marsh	NA	1,096,000	645,000
Coastal upland[16]	81,000	36,000	20,000
Salt marsh	NA	196,000	119,000
Mangrove swamp	NA	221,000	186,000

NA = Estimates not available. Notes for Table 1: See Appendix B.

Pine rocklands have always constituted one of the least extensive Florida ecosystems, occupying about one percent of the state's land mass. The prototypic and most extensive pre-settlement pine rocklands were found on the Miami Rock Ridge. The Rock Ridge forests, which once covered approximately 70,000 ha, are now reduced by about 90%. Approximately 4,650 ha are currently protected on Long Pine Key within Everglades National Park (ENP) (Snyder 1986). Of the approximately 65,000 ha of pre-settlement pine rocklands on the Rock Ridge outside ENP, small parcels totaling perhaps 1,100 ha remain. These are beset by many problems associated with urbanization. Four hundred hectares of pine rockland are owned and managed by the Metro-Dade Parks Department, and efforts are underway to acquire and/or establish more favorable management on tracts currently in private ownership. The situation is somewhat better in the Florida Keys. Pine rocklands on Big Pine Key and adjacent islands today cover 900 ha, and most of the major tracts are protected within the National Key Deer Refuge. Compared to those on the mainland, Florida Keys pine forests are in reasonably good condition. Nevertheless, they are threatened by exotic plants, fragmentation, and salt water intrusion. The relatively pristine pine forests in the southern half of Big Cypress National Preserve are extensive (about 20,000 ha), but are floristically, hydrologically, and edaphically transitional between pine rocklands and pine flatwoods. With 24 G1 or G2 plants and a greatly diminished areal extent, pine rocklands are among the most critically threatened ecosystems in Florida.

Like pine rocklands, scrub habitats harbor many endemic taxa, including 22 plants considered to be imperiled by FNAI. Overall about 60% of Florida's scrub has been destroyed, and much of what remains is in isolated parcels. The largest remaining areas of inland scrub occur within the 84,000 ha habitat mosaic in Ocala National Forest's Big Scrub. Historically, sand pine and xeric oak scrub covered over 30,000 ha of the southernmost third of the Lake Wales Ridge. About 15% (4,500 ha) of these areas remain. With about 180 ha of true scrub (Abrahamson et al. 1984), Archbold Biological Station maintains the most extensive remaining tract of Lake Wales scrub currently under conservation management. The U.S. Fish and Wildlife Service (USFWS), The Nature Conservancy (TNC), and the State of Florida are currently attempting to procure about 8,000 ha -- with a significant proportion in scrub -- to become the Lake Wales Ridge National Wildlife Refuge. If these efforts are successful, additional *in situ* protection would be afforded to about two dozen federally listed plant species.

Table 2: Total Number of Imperiled (G1/G2) or Federally Listed (Endangered [LE] or Threatened [LT]) Plant Taxa by Habitat

Habitat	G1/G2	LE	LT	Total*
Pine flatwoods	31	5	4	31
Dry prairie	1	0	0	1
Scrubby flatwoods	2	1	0	2
Scrub	22	20	2	29
Sandhill	15	4	3	18
Temperate hardwood forest	17	4	1	17
Pine rocklands	24	4	0	25
Tropical hammock	14	2	0	14
Swamp	20	20	1	21
Marsh	5	1	0	5
Coastal upland	16	0	1	16
Salt marsh	0	0	0	0
Mangrove swamp	0	0	0	0
Totals	167	43	11	179

* Total = the number of taxa which are listed as G1/G2 and/or LE (Endangered) or LT (Threatened); some Federally Listed taxa are not listed by FNAI and some FNAI taxa are not on the Federal Endangered or Threatened List.

Estimates for the historic extent of temperate hardwood or mixed hardwood-pine forests in Florida are not available. Together, a little over 1 million ha remain, with about 190,000 ha in Conservation Areas. FNAI lists 17 species of G1 or G2 plants native to these ecosystems.

While never more than a few thousand ha, tropical hardwood hammocks were the predominant upland plant community in the Keys. They also occurred along the Miami Rock Ridge and on slightly elevated locations in the Everglades, the Ten Thousand Islands, and on Sanibel and Captiva Islands. Today about 6,000 ha of tropical hammock remain, of which 3,500 ha are in CAs. Fourteen imperiled species are listed by FNAI from this vegetation type, including four orchids and four ferns.

In pre-settlement days, more than 80,000 ha of upland habitat (both forested and non-forested) occurred on Florida's barrier islands; today, 36,000 ha remain. Mainland coastal upland habitat has also been reduced, leaving only 5,260 ha (Johnson and Muller 1993). FNAI lists 16 imperiled coastal upland species.

Figures for the pre-settlement extent of dry prairies and scrubby flatwoods are not available. These habitats are relatively extensive today and harbor only one and two imperiled species respectively. Dry prairies are important habitat for several wildlife species, including Crested caracara (*Polyborus plancus*), Sandhill crane (*Grus canadensis*), and Burrowing owl (*Athene cunicularia*).

Freshwater wetlands

Florida's freshwater wetlands are no less reduced in area than the upland ecosystems. Prior to European settlement, most of the southern third of the state -- from Lake Okeechobee to Florida Bay -- was dominated by freshwater forested or herbaceous wetlands. Together, freshwater swamps and marshes are found today on about 20% of Florida's land mass, or 3 million ha. According to Kautz (1993), more marsh has been destroyed since 1936 (1.6 million ha) than remains today (1.1 million ha). Much of this loss has occurred in the Everglades-Kissimmee marsh system, which once formed a wide, continuous flowway down the center of the peninsula. Loss of swamp habitat is more difficult to quantify because of the patchy nature of swamp distribution, but destruction has been substantial.

As a result of widespread concern expressed over the precipitous loss of wetland acreage in the state, more than 1 million ha of Florida wetland receive some level of protection today. However, it has proven to be tremendously difficult to reestablish natural hydrologic regimes on the reduced remains of this formerly continuous wetland system. Florida's freshwater wetlands are not especially species-rich communities, but they do constitute significant habitat for rare plants. FNAI considers five marsh and 20 swamp plants to be at a G2 level of endangerment or higher.

Salt water wetlands

Florida's saltwater wetlands -- tidal marshes and mangrove swamps -- have also declined in area, though not to the degree of freshwater wetlands. Reliable pre-settlement figures for the areal extent of these ecosystems are unavailable. Substantial acreage in both types has been destroyed to accommodate coastal development. Recent estimates of the extent of tidal marsh range from a low of 155,000 ha to a high of 196,500 ha (Kautz et al. 1993; Montague and Wiegert 1990). Estimates for mangrove swamp range from 200,000 to 272,000 ha. A significant part of these remaining wetlands is protected (60% for salt marsh; 81% for mangrove forest). FNAI lists no imperiled species for either habitat.

Overall, FNAI considers 167 Florida terrestrial vascular plant species to be globally imperiled; these are listed by preferred habitat in Appendix A. Forty-three of these taxa are listed as "Endangered" and 11 as "Threatened" by USFWS. According to Cox et al. (1994), more than 100 of these globally rare taxa are found in fewer than 10 Conservation Areas. Fifty-two -- nearly one-third of the total -- are not known to occur in any Conservation Area; 11 of these are federally listed as "Endangered" or "Threatened."

C. Population viability of Florida plant species

1. Extinction and endangerment. Extinction, like speciation, is a fundamental, natural process in even the most well-balanced of ecosystems. Interactions among species at various trophic levels, combined with differences in their capacity to adapt to the ceaselessly changing physical environment, guarantee that plants will continue to become locally and globally extinct. Moreover, in the young flora at the southern end of the long Florida peninsula, ecological theory suggests that species turnover will occur more rapidly than it would within the older plant communities to the north, as taxa better suited to local conditions continue to arrive, disperse, and evolve to fill southern niches more effectively than earlier immigrants (MacArthur and Wilson 1967).

2. Anthropogenic factors affecting viability. A recent catalog of plant populations of special concern (Center for Plant Conservation 1995) suggests that the extinction rate of Florida plants may be poised to accelerate rapidly over background levels, if indeed this is not already the case. The CPC findings are based on subjective assessments by leading Florida conservation biologists and ecologists. According to these experts, there is a strong likelihood that 37 Florida plant taxa may not survive another five years in the wild without immediate conservation action, while another 34 may not survive ten years (Appendix A). The imperiled condition of many of these populations is directly related to human activities. However, in most instances the cause of population decline is not one-dimensional, i.e., it is most likely a complex combination of anthropogenic change, environmental stochasticity, and the ecological idiosyncrasies of the species in question. Human activities adversely affect Florida plants in many ways, and have especially contributed to: 1) Habitat loss, 2) Habitat fragmentation, 3) Altered disturbance regimes, 4) Altered hydrology, 5) Introduction of non-indigenous plants and animals, 6) Overexploitation, and 7) Global climate change. These are addressed below in turn.

a. Habitat loss. Outright conversion of land to residential, agricultural, and commercial uses (including developed park and recreational facilities) has been the leading mechanism by which human activities have destabilized plant populations in Florida. Habitat loss on a percentage basis has been greatest for plants associated with coastal strand, sandhill, and pine rockland ecosystems, but in nearly all Florida ecosystems native plants currently have less than half the habitat originally available to complete their life cycles (Table 1). Furthermore, such figures greatly overestimate the appropriate habitat remaining for individual taxa, since the species of greatest concern are often restricted to specific sites, some of which are very limited indeed. The inseparability of species and habitat is one of the fundamental principles of ecology and natural resource management. If what appears to be an imminent wave of extinctions and extirpations within the state is to be averted, protection of the habitats of rare Florida plants must become a key consideration in the planning process for all future development at local and state levels.

b. Habitat fragmentation. The negative impact on plant populations from habitat conversion at edges of large tracts is roughly proportional to the percent of appropriate habitat affected. However, as the process continues and the area becomes divided into progressively more isolated subunits, accessory effects of fragmentation become significant. For one, the increase in structural edge begins to expose residual habitat parcels to the physical and biological influences of the converted habitat matrix, thereby altering original vegetation character. Moreover, subpopulations associated with these fragments become more isolated from neighboring population units which previously contributed genetic variability and buffering from precipitous declines. Such genetic and demographic exchanges among groups of discrete population units are termed "metapopulation" interactions, and the effects on them from anthropogenic fragmentation are in part determined by the character of the intervening land use. For some species, urban and agricultural uses interfere with metapopulation dynamics more than less intensive forestry-related uses, while other plants are equally affected by all three. In Florida, fragmentation has been more severe in upland than in wetland habitats and in the more populous southern and central portions of the state.

c. Altered disturbance regime. Periodic disturbances such as fire, flood, extreme drought, or catastrophic windstorm have also had formative influences on the evolutionary development of Florida plants. While all of these can cause significant mortality in existing plant communities, such disturbances may also accelerate nutrient cycling, open plant canopies, stimulate flowering, deposit or expose fresh seedbeds, and aid in seed dispersal. They are also capable of creating patch structure in otherwise homogeneous landscapes. Indeed, the long term survival of a species may be as dependent on the maintenance of an appropriate disturbance regime as on the preservation of its critical habitat characteristics. While it is rarely possible for resource managers in the current landscape mosaic to precisely replicate historical disturbance regimes (which include severe events that might threaten life and property), there is an emerging recognition that the disciplined use of fire and water as management tools can accomplish ecological purposes and reduce the likelihood of catastrophic events. Moreover, the elaborate protective systems that have been developed to control wildfires and floods have not succeeded in eliminating large-scale cataclysms, even while they have contributed to many less desirable human and ecological side effects. These include the eradication of riparian ecosystems from many of the state's waterways, and the gradual replacement of pine forest acreage by late-successional broad-leaved forest. Thus, as they apply to natural disturbances, measures adopted to protect public safety and property are not always compatible with ecosystem health and, thus, perhaps not even with the longer term well being of humans. On the other hand, use of fire and water as management tools increasingly appears to be more beneficial than was originally believed.

d. Altered hydrology. Artificial drainage has been the engine that propelled Florida from the steamy subtropical world pictured in Part I to its current status as a leading tourism- and agriculture-based economy. The environmental costs of this metamorphosis have been enormous: the Everglades has been subdivided and reduced to less than half its original extent, water tables have dropped by five feet or more in much of the state, water shortages are a recurrent problem, wildlife populations are a fraction of what they once were, etc. Declines in certain characteristic wetland plant populations, the result of modified water levels, have paralleled those of animals (Alexander and Crook 1973). Alterations in the timing of water delivery may also have initiated changes in the character of wetland vegetation. Hydrologic modifications may affect low-lying upland habitats as well, especially the extensive area of transitional pine forests throughout the state. However, few acres of drained wetland have become functional upland habitat, as non-indigenous plants have aggressively invaded those areas not immediately developed for residential or agricultural use. Finally, water manipulation in Florida has been accompanied by changes in water quality, which may independently induce changes in vegetation composition and structure. The best-documented example in Florida has been the replacement of native sawgrass marsh by communities dominated by cattails in areas subject to high-nutrient farm runoff south of the Everglades Agricultural Area (Davis 1994). Mitigation plans propose a system in which the polluted water is passed through filtering marshes; costs of acquisition, construction, and operation are currently estimated to exceed $400 million.

e. Non-indigenous plants. Plants continue today to be an integral part of life for Florida residents and visitors alike, though their amenity value is not always recognized as such. As the native landscapes have receded before the expanding human population centers, their beauty and utility (e.g., shade, protection from wind) have been replaced in everyday life by a wide assortment of strange and exotic plants from all over the world. Many of these introduced plants were supplied by the thriving $1 billion Florida horticultural industry. Others arrived via unintentioned human vectors, e.g., in the holds of ships, attached to clothing, etc. Set in Florida's wet, mild climate, and free from the herbivores and competitors that may have controlled them in their native environments, many of these imports have rapidly become naturalized pests. Ecosystems vary in their susceptibility to invasion, though the reasons for this are not well understood. In general, disturbed habitats are particularly susceptible (Center et al. 1991; Elton 1958; Duever et al. 1986), as are ecotonal areas between upland and wetland ecosystems (Ross n.d.). Many exotic plants have become so well established in certain habitats that native plants have been virtually excluded. This group of aggressive invaders includes trees (e.g., *Casuarina equisetifolia, Melaleuca quinquenervia, Schinus terebinthifolius*), shrubs (e.g., *Ardisia solanacea*), vines (e.g., *Jasminum* spp., *Paederia foetida*), graminoids (e.g., *Neyraudia reynaudiana, Pennisetum purpureum*), and aquatic plants (e.g., *Eichhornia crassipes, Hydrilla verticillata*). Within the U.S., probably only in Hawai`i have non-indigenous plants had a more detrimental effect on native plant communities. Unfortunately, decades may pass between the time of arrival of a plant and the time that its population growth in the wild becomes sufficiently intrusive to prompt its recognition as a problem. By then, the costs of control may be prohibitive.

f. Overexploitation. The same taste for the unusual that has brought many exotic tropical life forms into Florida has fueled the exploitation or removal of the most novel elements of the local flora, especially palms, epiphytic ferns, orchids, and bromeliads. Collectors of these plants are both amateur horticulturists and commercial enterprises. Their activities have led in some cases to the near elimination of species from habitats in which they were common earlier in this century. Harvesting of native tropical hardwoods for furniture and specialized wood products has also lead to decreases in the range and abundance of species such as lignumvitae (*Guaicum sanctum*) and mahogany (*Swietenia mahagoni*).

g. Global climate change. Sea level along the Florida coast has risen about 10 meters over the last 8,000 years. The rate of increase was very rapid at the beginning, slowing gradually to about 0.4 mm per year by about 3,000 B.P. (Lidz and Shinn 1991). Tide records at Key West and other Florida stations indicate that this rate has increased to more than 2 mm per year within the last century (Maul and Martin 1993). It is not yet known whether the latest acceleration has resulted from the recent increase in greenhouse gases associated with the combustion of fossil fuels. Regardless of the cause, a continuation of this trend will result in changes to low lying coastal plant communities over the next century. Replacement of upland species by halophytes has already been documented for isolated pine rocklands in the Florida Keys (Ross et. al. 1994). The spatial and temporal pattern of this replacement during the past century has closely paralleled the upward trend in sea level over the same period. Results consistent with this interpretation have recently been reported for cabbage palm hammocks along the west coast of the state (Williams and MacDonald 1994). Unlike sea level, the temperature records from long-term Florida weather stations are too imprecise and problematic to yet reveal much in the way of a trend. However, given a small increase in minimum winter temperatures, a northward advance of tropical species into temperate communities in central Florida may be expected. The precise distribution of vegetational change may also be affected by other, less predictable facets of global climate change, such as shifts in rainfall pattern and storm intensity.

D. Conclusion: factor interactions

For the most part, the discussion above has avoided attributing documented habitat and population declines to specific causes, primarily because of the multifactorial nature of the problems underlying plant population dynamics. The following example illustrates the point. In August, 1992 Hurricane Andrew passed over southern Dade County, as have countless previous hurricanes. Months after the storm, an outbreak of *Ips* spp. beetles decimated the dominant slash pine (*Pinus elliottii* var. *densa*) canopy. Scientists attributed the severity of the outbreak to lowered water levels (see Altered hydrology, above) and/or structural changes in the pine forest associated with frequent winter fires (see Altered disturbance regime, above). Because the pine rockland forests of the Coastal Ridge had already been reduced in extent by more than 90% (see Habitat loss, above), and because the remaining parcels were widely scattered within an urban matrix (see Habitat fragmentation, above), there was little likelihood that slash pine would be reestablished from natural seed sources outside the infested area. Furthermore, exotic tree and grass populations that had invaded the pine forests prior to the hurricane were relatively unaffected by the storm and the insect attack that followed (see Non-indigenous plants, above). The presence of these introduced species thus presented a significant barrier to reestablishment of the pine canopy, without which a fire regime critical to the many rockland herbs was impossible. One of these native herbs, *Zamia pumila*, was once abundant in these forests but had been harvested commercially as a starch source early in the century, becoming much less common today (see Overexploitation, above). In the longer term, there is a strong likelihood that the low lying rockland communities closest to the coast will be threatened by salt water intrusion caused by sea level rise (see Global climate change, above). Superimposing the complex anthropogenic background recounted above on the complexities associated with natural ecosystems -- climatic variability, species interdependencies, etc. -- one would be hard pressed to attribute a simple cause to the decline of any pine rockland plant population, despite the very considerable evidence of human involvement.

PART III: THE FLORIDA PLANT CONSERVATION PROCESS

A. The plant conservation community and its objectives

As described above, the early residents of Florida inherited a diversity of plant and habitat resources equal to any on the North American continent. The ambience that this mixture provided was an important if underappreciated element in attracting the enormous influx of people that settled in the state during this century. Ironically, accommodation of the new arrivals induced a very substantial reduction in the overall extent and quality of Florida's natural areas and in the native plant species they supported. The plant conservation community in Florida has come together in large part to halt and reverse the ongoing erosion in native plant diversity in the wild, at both the species and ecosystem levels.

The Florida plant conservation community is a heterogeneous and diffuse collection of teachers, environmental activists, native plant enthusiasts, scientists, media people, public land managers, legislators, planners, regulatory personnel, botanical garden staff, nursery managers, amateur gardeners, philanthropists, and members of the general public. However, the use of the term "community" overstates the level of integration of this set of individuals and organizations, since there is currently no formal structure or communications network connecting all of its elements.

B. The conservation process

Figure 2 presents a model of the plant conservation process in Florida, categorizes the activities of the conservation community, and summarizes the relationships among organizations, different conservation actors, the public, and the native plant resource. The model includes five conservation functions: research, education, philanthropy, government, and resource management. The Native Plant Resource is, in effect, the output of the model. It has been described in its current and historical forms in Part II above.

The position of the General Public at the top of our model of the conservation process indicates how critical public attitudes are to the overall success of the conservation effort, and this for several reasons. Through its tax contributions, the public is the origin of most of the financial resources applied to conservation functions. It is also the ultimate source of laws and regulations that provide the legal foundation for plant conservation in Florida. As one might expect of the fourth most populous state in the U.S., Florida is home to a highly diverse mix of people, and great regional cultural differences exist within the state's borders. This cultural diversity parallels that of environmental attitudes, which range from passionate advocacy to careless disdain.

Within the plant conservation process itself, the Research function provides technical information concerning the biogeography of Florida plants, their population biology, the ecological relationships affecting these populations, and their role in ecosystem function, including humanized ecosystems. Resource managers, other scientists, educators, media professionals, and decision makers all require such information in order to carry out their functions effectively. Primary information-providers include academic and museum researchers and agency biologists, but contributions are also made by scientists associated with environmental organizations, research institutes, and botanical gardens, as well as by independent consultants.

The Education function translates scientific information for diverse audiences, puts it into appropriate perspective, and transmits it to the public and to policy makers. In order to educate the greatest number of people about the importance of plant resources, accurate information must be presented in a compelling manner. Primary purveyors of the message are schools, the news media, state and federal agencies, museums, botanical gardens, environmental clubs (including garden clubs and plant societies), and activist organizations.

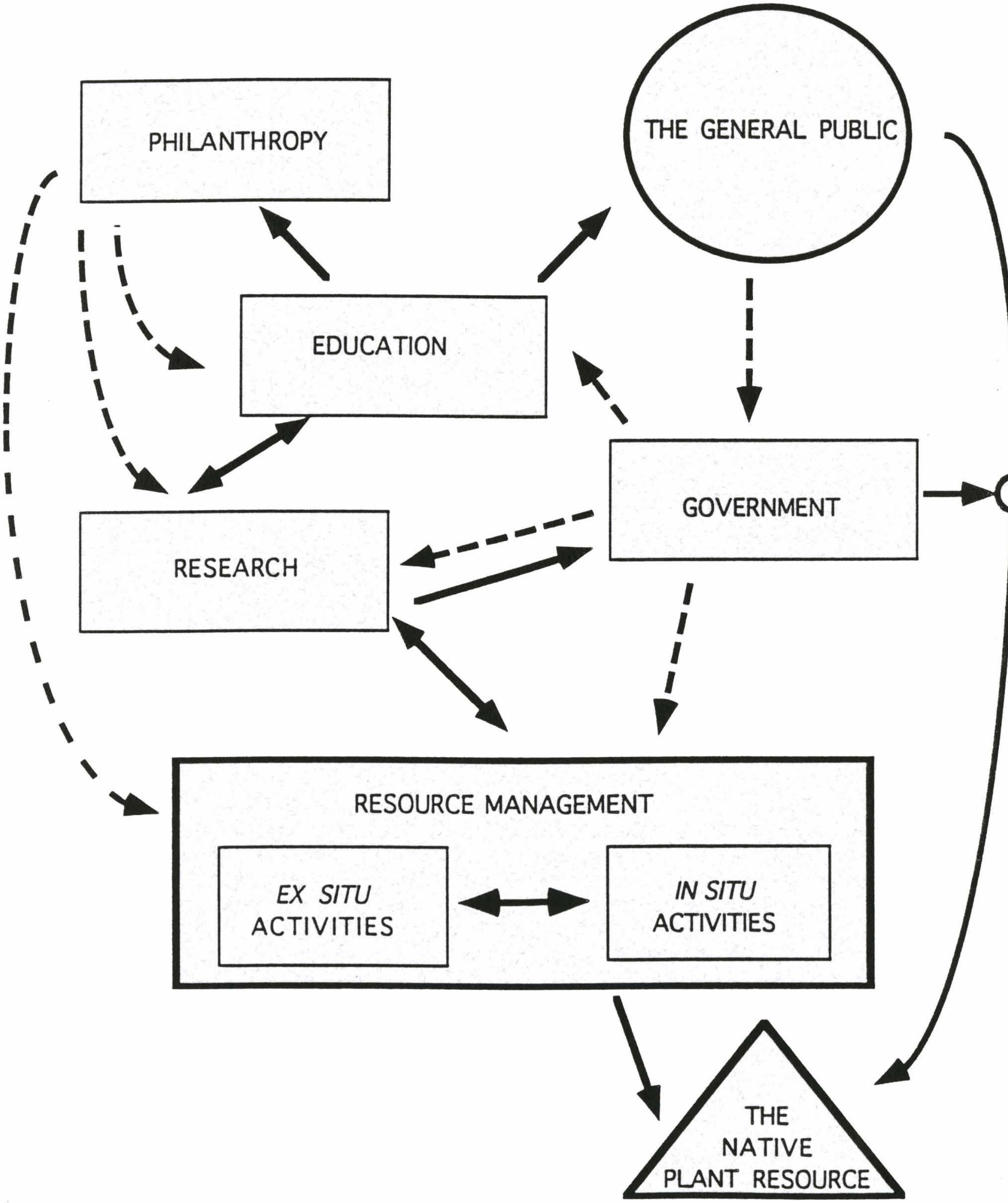


Figure 2: The plant conservation process. Functional components of the plant conservation community are enclosed by boxes. Dashed lines signify transfers of money.

By developing and enforcing policy, and providing funds, the Government function encourages research, education, and management that benefit the plant resource. This is done by increasing our understanding of the resource and its associated ecosystems, educating the public about its value and the threats to it, developing policy to manage the resource, and enforcing laws and regulation to prevent activities that may harm it. Increasingly necessitated by the failure of most economically-driven relationships to provide minimally adequate environmental protection, government has become more-and-more involved in efforts at all levels to stem the loss of plant diversity in the state.

The Philanthropy function is particularly important in filling gaps in the plant conservation process, especially those that can occur when quick action is needed. Donors may be individuals or entities such as trusts or foundations. Free of many regulations that can slow government action, philanthropy provides funds for some of the most innovative and productive plant conservation programs in Florida.

The Resource Management function involves two distinct but interdependent types of activity: those that focus on on-site (*in situ*) conservation of existing plant populations, and those that focus on the off-site (*ex situ*) protection of genetic material in order to augment existing populations, reestablish extirpated ones, or ensure against outright extinction of species. *In situ* resource management activities geared toward plant conservation are provided mostly by government agencies and non-profit environmental organizations, but also increasingly by private landowners for whom the promotion of healthy native plant communities is an important objective. Center for Plant Conservation (CPC) botanical gardens (CPC Participating Institutions) are usually the providers of *ex situ* activities for a subset of the rarest Florida plants, while commercial and government nurseries provide planting stock for some of the more common native species.

C. Conservation functions in Florida

The following section describes the conservation functions as they apply to the Florida plant conservation process. For each function, the major programs, their roles in the conservation process, and the problems and challenges they encounter are summarized.

1. Research. Given the decline in the native plant resource as described above, the long term viability, indeed in some instances, the very survival of many Florida plant species and ecosystems requires that the following questions be addressed: (1) What species or ecosystems must be protected or managed differently than is presently the case? and (2) What form should this modified protection or management take? Answers to both of these questions require research. In the first instance, detailed inventories of the native plant base are needed at intervals that will permit assessment of temporal trends, to be followed by cause-and-effect analysis. Research should be similarly employed to identify the threats to the declining resource, and to determine those threats that most seriously jeopardize existing, healthy ecosystems and plant populations, or the restoration of degraded ecosystems. Information derived from research should lead to recommendations for specific actions to reduce or eliminate the threats. However, while research can provide information in problem identification and management prioritization, thereby contributing a great deal to the design and implementation of *in situ* and *ex situ* conservation actions or recovery plans, final determinations must result from publicly supported consensus among policy makers, planners, and land managers.

The tasks of inventorying, assessing, and prioritizing "at-risk" Florida species and ecosystems have been taken on by several agencies and organizations. The Florida Natural Areas Inventory (FNAI) and the U.S. Fish and Wildlife Service (USFWS) have made substantial progress in documenting the distribution and habitat affinity of Florida's rarest plants, and state and federal agencies have initiated programs to categorize, map, and evaluate the terrestrial ecosystems of the peninsula. The Florida Endangered Plant Advisory Council now makes recommendations for modifications to the State list of threatened and endangered species. The Center for Plant Conservation has collected, adapted, and circulated expert opinions regarding species endangerment status via one statewide and two regional Task Forces composed of plant biologists and ecologists.

However, as important as many of these various inventory and conservation prioritization data are to helping preserve plant biodiversity in Florida, they have thus far been developed and used in only a handful of rare plant conservation efforts. Similarly, the ecology and population biology of very few rare Florida plants have been studied in the depth and detail needed to identify key bottlenecks in their life cycles. Moreover, gradual population declines among species not yet recognized as threatened may ultimately be a more pervasive problem, and this has hardly been addressed. Indeed, given this continued lack of thorough understanding of plant life histories and population trends, the attribution of causes for short term declines and the determination of corrective measures remain today, in most instances, educated guesses.

Florida is a large and ecologically complex state, with great interregional and seasonal variability (see Part II). In developing research, conservation, and restoration programs, this natural complexity can be further complicated by jurisdiction sharing and institutional squabbling among government agencies involved in development and water issues (see Part III, Sections 3 and 5b(3) above). While the best guarantee of a research base in Florida capable of determining species- and ecosystem-level conservation priorities is the maintenance of experienced plant biologists pursuing long term monitoring programs across a range of habitat types, a substantial investment of time is also required to maneuver through the bureaucratic environment and to integrate one's research into the larger conservation process, hopefully ensuring its application. Among the successful research programs that have maintained a focus on plant conservation issues over several decades are those of several state universities, the Institute of Food and Agriculture Sciences, Everglades National Park, Fairchild Botanical Garden, Archbold and Tall Timbers Biological Stations, and National Audubon Society's Corkscrew Swamp Sanctuary.

These institutions undertake programs at sites that are actively managed for products and services, including natural area values. Such programs encourage the exchange of information between researchers and land or resource managers. This interchange provides a key mechanism for the scientist to continually refine research goals and for the manager to adapt vegetation management practices to the most current and best scientific evidence. Though the benefits of such interaction are unquestionable, interaction frequently fails to occur for many reasons. The newly-created Florida Department of Environmental Protection (DEP) recognizes this need for exchange among its own staff, and is developing a separate unit to provide liaison between scientists and managers of state parks and natural areas.

Unfortunately, not all Florida habitats house experiment stations or ongoing research programs that employ plant conservation scientists with knowledge of the flora and easy access to long term data sets. With approximately two percent of Endangered Species Act funding devoted to plants nationally, there are few opportunities for federally-funded, applied rare plant research in Florida. The very limited availability of financial support, and year-to-year fluctuations even when funds are present, are preventing scientists from dealing with many important, integrative problems that require multi-year observations. Moreover, little research attention has been given to the societal dimensions of native plant issues: i.e., the comparative use of water by native versus exotic plants, the potential buffering effects of forest canopies on winds that can cause extensive property damage, the psychological benefits of maintaining significant green spaces, and so on. Florida boasts many plant scientists doing exceptional work, but their numbers are dwarfed by the enormity and the rate of loss within the native plant resource.

Florida plant researchers, as elsewhere, communicate effectively among themselves through technical journals. Florida Scientist provides a much-needed outlet for technical, conservation-related information of statewide or regional interest. The Palmetto, magazine of the Florida Native Plant Society, publishes short, informative articles in a more popular format. While peer-reviewed journal articles are the proper venue for a full airing of scientific issues, the pace of such interchange is slow. There is currently a need for a regular, well-organized statewide forum in which the leading Florida plant researchers can engage in public debate on issues of immediate plant conservation significance (e.g., fire and water management prescriptions, protocols for *ex situ* resource management, guidelines for reintroduction and restoration projects, etc.). By strengthening emerging scientific consensus on important applied research topics, such symposia would be exceedingly useful for resource managers as well as researchers.

In the important related area of data access, exchange, and compatibility there have been some important successes. For instance, FNAI has succeeded in inducing plant scientists to contribute to and utilize its Element Occurrence data base. On the other hand, the many attempts to achieve a common habitat classification in the state have yet to lead to that result. In the first case, FNAI presented researchers with a fully-developed system that met most of their needs. In the second instance, federal and state organizations (USEPA, USFWS, FNAI) independently developed classification systems to meet limited agency objectives in such areas as vegetation mapping and assessment, gap analysis, and documentation of species-habitat relationships (Scott et al. 1993). Widespread use of one or the other of these systems will only occur after they are integrated into a more general framework that combines broad applicability with sufficient regional detail to satisfy the requirements of diverse users. On this and other computerization and data exchange issues, a statewide coordinating committee would be very helpful in resolving conflicts between the needs of the individual organizations and the requirement for a common classification of statewide plant resource management and conservation applicability and acceptability.

Within the last decade, the traditional reticence of scientists to enter non-technical forums has been dissolving in the face of a public hungry for hard information and a news media eager to feed that appetite, and this is to be applauded and encouraged. With the increasing environmental regulations that have resulted from the deterioration of our natural world (see Section II), environmental issues have touched the lives of many people, creating a large, involved audience for a range of plant and habitat-related issues. The demand on plant scientists to provide basic and applied research results for land and resource managers and decision makers can only grow as the causes for biodiversity decline remain unchecked. Also likely to increase, and rightly so, is the involvement of researchers in enhancing public awareness of species and habitat conservation, toward the goal of improving the quality of the public policy debate.

2. Education. The role of education in the plant conservation process is to inform the general public, their legislative representatives, and private donors about the vulnerability of Florida's native plants and habitats, and the importance of their conservation. For the most part, information about native plant problems has been embedded in a more comprehensive message promoting a diffuse environmental ethic. While this broader message has been expressed in many imaginative ways, it has not induced its audience to take strong action on native plant issues.

Public education is a multi-faceted function performed in many ways, at several levels, and by numerous players. Government agencies and private organizations that manage natural areas typically provide users with materials and programs varying from labeled trees, to interpretive signage and brochures, to education/interpretive centers. Organizations such as the Florida Native Plant Society, The Nature Conservancy and other environmental organizations, garden clubs, and botanical gardens and museums publish magazines and newsletters, sponsor speakers, and conduct field trips. Many newspapers now have regular columns devoted to environmental issues, including the problems of habitat loss and plant rarity. Schools often include environmental education within their curricula, and many colleges and universities offer Environmental Studies programs. Legislators are in close touch with government agencies responsible for environmental matters as well as with lobbyists representing national and local environmental organizations.

As a rule, environmental education programs sponsored by state and local government agencies are broadly focused. Within the Department of Environmental Protection (DEP), the Office of Ecosystem Management (OEM) is responsible for Florida's environmental education efforts. The OEM develops educational materials, operates DEP's Environmental Education computer bulletin board, maintains an extensive collection of educational and public informational publications, and coordinates the agency's speakers bureau which provides speakers on environmental issues at schools and other venues.

Another state-sponsored environmental education program is "Project Wild" which is offered by the Florida Game and Fresh Water Fish Commission. "Project Wild" trains teachers from all grade levels in the presentation of environmental materials, and provides them with hundreds of short lesson plans relevant to Florida's environment. Notably, while broad ecosystem concepts are included prominently among these many lessons, topics specific to native plant conservation or threats to rare native plants are absent.

Schools are especially important to the development of a conservation ethic among the younger members of society. But in Florida there is no state-wide mandate for environmental education in the classroom. Local school boards that believe this to be an important educational item are left to design environmental education programs of their own. Several counties have developed outstanding programs that include material on native plants. For example, Dade County has developed a program addressing a variety of environmental issues. One resource used in the program is The Dade County

Environmental Story, a compilation of essays on the natural history of the county, written by local biologists, naturalists and educators, and targeted at school children from kindergarten through high school. Perhaps an even more effective means of teaching children about their natural environment is to involve them in it directly, e.g., through the restoration of natural areas near schoolyards or the creation of artificial habitats, such as native plant gardens, on school grounds. Butterfly gardens are currently a popular way of conveying to primary school children the interdependency of our natural flora and fauna.

In general, the educational programs that focus most directly on native plant issues are extra-governmental. With 23 local chapters and 3,000 members, the Florida Native Plant Society (FNPS) plays a major role in Florida plant conservation and associated education. The membership of FNPS ranges from homeowners looking for environmentally-responsible ways of landscaping their yards, to university professors. The Society publishes The Palmetto, a newsletter that includes informative articles on native plants and ecosystems, provides tips on landscaping with natives, and serves as a forum for native plant conservation advocacy. FNPS also publishes pamphlets and books on native plants and is planning state-wide efforts to provide local chapters with Fact Sheets on local native plants to be distributed to the public at large.

A recent survey conducted by FNPS indicates that a majority of members initially joined the Society in hopes of resolving practical landscaping problems that they faced as homeowners, and only later did they become interested in plant conservation. This suggests that programs with goals of broadening public awareness in native plant conservation issues must first focus on items of immediate relevance to people's everyday lives. Such problems as exotic weeds in the garden, the voracious appetite of non-indigenous ornamentals for water and fertilizer, the beneficial effects of native shade trees and landscapes on electric bills, the success of native plant canopies in buffering nearby dwellings from hurricane winds, are all good examples. Having achieved a greater appreciation of the role of native plants in one's own backyard, the average citizen is much more likely to see personal and societal benefit in applying the same concepts to the Florida environment as a whole.

By using volunteerism as an educational tool, The Nature Conservancy (TNC) has played a major role in increasing public awareness of Florida native plant issues. TNC conducts many volunteer programs at regional levels that involve hundreds of participants. Volunteers staff TNC offices, are involved in exotic plant removal and control, monitor populations of endangered species, and so on. These innovative programs not only contribute to the work of TNC in managing its own properties, they also provide direct hands-on experience for the volunteers and instill in them a sense of pride and ownership in Florida's native plant communities. The involvement of committed volunteers also presumably filters out to friends and families, increasing the overall support for species and ecosystem conservation. While TNC volunteers are generally young urban professionals, Florida's large population of retirees is becoming more-and-more active in plant conservation efforts, and this should be encouraged and developed.

According to the latest polls, Floridians are aware of and are concerned about environmental issues. But all too often this awareness and concern lack focus and practical outlets. It is the responsibility of educators and conservation biologists to develop and then provide compelling and accessible programs that explain clearly and without condescension why biodiversity matters and, more specifically, why the preservation of Florida's natural habitats and species is so important.

3. Government. Federal, state, and local governments play major roles in the conservation of species and ecosystems through their ability to acquire and manage the large tracts of land necessary to preserve functioning ecosystems. Furthermore, government is uniquely mandated to make and enforce conservation-related laws and regulations.

Including all three levels of government (national, state, local) and private land trusts, Florida has the largest environmentally-sensitive land acquisition program in the U.S. The biggest of these are sponsored by the state. Through three state programs -- Preservation-2000, Conservation and Recreation Lands (CARL), and the Land Acquisition Trust Fund -- the Division of State Lands in the Department of Environmental Protection has allocated in recent years on average $300 million annually for land purchases. Under Preservation-2000, this level of funding may be available through the year 2000. At the federal level, current highlights are the additions to National Park Service holdings in the Big Cypress National Preserve, and the U.S. Fish and Wildlife Service's planned acquisition (in cooperation with the state, TNC, and Archbold Biological Station) of some 8,000 ha of Lake Wales Ridge scrub habitat. Several county and municipal governments also have dynamic land acquisition programs. One of these is Dade County's Environmentally Endangered Lands (EEL) program, with acquisitions supported by a $90 million bond issue. Many smaller tracts are being acquired and preserved by land trusts, the largest being The Nature Conservancy.

Federal, state, and local governments also share responsibility for regulating the use of native plants and their habitats. In comparison to the relatively straightforward business of acquiring land, the array of laws, regulations, and enforcement mechanisms created to govern use of the native plant resource is exceedingly complex and difficult to implement.

The federal Endangered Species Act (ESA) is one of the cornerstones of American environmental law. It regulates the "taking" of animal or plant species considered at risk of extinction, provides a procedure for determining which species are critically threatened, and establishes a mechanism to provide for their recovery. ESA has been amended a number of times since its passage in 1973. The current version has several weaknesses with respect to plant protection, including the lack of prohibition for "takings" of endangered plants on non-federal lands, and for indirect "takings" of rare plants through such actions as habitat destruction on private property. Because habitat loss is the primary threat to Florida native plant populations (see Part II, Section C2b, above), providing endangered plants with a higher degree of habitat protection appears to be necessary if declines in their populations are to be slowed and then reversed.

Under Section 6 of the ESA, federal funds are available for cooperative efforts with state agencies for implementation of "Recovery Plans." The Florida Plant Conservation Program, under the direction of the State Division of Forestry, was created to utilize these funds. For example, several research projects on rare native plants are now being funded in Florida with Section 6 monies, as is the hiring of a population biologist at Lake Arbuckle State Forest to monitor endangered plant populations there.

The U.S. Fish and Wildlife Service (USFWS) is the lead agency in the implementation of the Endangered Species Act. USFWS has long been a committed advocate of rare plant protection in Florida. However, over the last decade or so, USFWS has administered a process that has been slow to add new listings in Florida despite strong evidence of endangerment. Of the 54 Florida plant taxa currently listed as Endangered or Threatened, final or draft Recovery Plans have been developed for 39. But until recently these have been formulaic documents that provided little guidance for resource managers. Monies for the implementation of the Plans have been particularly difficult to identify.

The Protection of Native Flora of Florida Act (1978) is the analog of the Endangered Species Act at the state level. To some extent the former compensates for the limitations of the latter with regard to plants. The state law is based on broader definitions of "endangered" and "threatened" than those adopted by the ESA. For example, its inclusion of "commercially exploited" as a category has lead to regulation of some plants that are not yet threatened but which might become so in the future. Most importantly, the Florida law affords wider plant protection generally by extending its purview to plants growing on non-federal lands. For example, the law prohibits destruction or harvesting of any state-listed endangered plant from any private or public lands without permission of the landowner and a permit from the state.

While the intent of the Protection of Native Flora of Florida Act was to prevent the destruction or overexploitation of native plant populations, it does not specifically address conservation of habitat. Instead, it regulates the movement of plant materials for commercial purposes (e.g., through nursery inspections). Thus, despite the useful features of the Act described above, it provides no mechanisms for the recovery of plant species that have seriously declined or are near extirpation or extinction. The Division of Plant Industry is the lead state agency for enforcement of the Act.

Thus, much of the frustration surrounding rare plant legislation as it is applied in Florida relates to the unevenness of the protection as it moves from federal to local. Federal law, which defines "endangered" as vulnerable to imminent extinction worldwide, does not prohibit the destruction of endangered plants on non-federal lands, and it does not take into account plant rarity within the specific Florida context *per se*. On the other hand, state law provides a greater measure of overall protection by extending its purview to all lands public and private. Because it focuses on rarity in Florida, it doubles the list of endangered species by defining endangerment as the likelihood of extirpation within the state. However, state law does not restrict the prerogatives of individual property owners to destroy rare plants on their own lands for non-commercial purposes. In some instances, local ordinances provide more comprehensive protection by limiting the rights of landowners to use property in ways detrimental to endangered plants, or by prohibiting removal of certain native species, endangered or not.

Many local ordinances that affect plant and habitat conservation were developed under the impetus of a state law (Florida Administrative Code Sec. 9J-5) that requires counties and municipalities to prepare Comprehensive Growth Management Plans every five years, and to include in these plans prescriptions for management of natural resources. As a result, local ordinances frequently provide additional protection for native plants, especially state-listed endangered or threatened species, and this is to be applauded and encouraged. For instance, Monroe County has adopted a policy whereby the buildable portion of a previously undeveloped lot is determined by the character and condition of the existing vegetation. A smaller percentage of the lot can be developed when endangered or threatened plants are present in intact native plant communities. Conversely, when exotic plants are a prominent component of the vegetation, a larger part of the lot is deemed to be buildable. When native vegetation is present on the undeveloped portion of the lot, the law further requires that it be maintained as such.

While the adoption of such local regulations can be contentious and emotional, the resulting compromises often enhance community pride among people on both sides of the issue and foster much greater citizen involvement in government.

4. Philanthropy. Total donations toward plant conservation efforts in Florida from private sources such as foundations and individuals are difficult to quantify, but unquestionably they are substantial. For instance, in 1994 alone, contributions from corporations, foundations, and citizens toward the habitat conservation activities of The Nature Conservancy in Florida exceeded $2 million. In addition to supporting TNC's highly effective program (see below), private funds have maintained the Archbold and Tall Timbers Biological Stations, and National Audubon Society's Corkscrew Swamp Sanctuary. The focus of these facilities varies from basic ecological research, to applied research, to education, each built upon a strong conservation background. Thus, all are multi-functional programs that study, preserve, and showcase ecologically-significant remnants of diverse habitats, providing models for good management of similar lands elsewhere. Private funds similarly support plant conservation, research, and education functions at botanical gardens and museums in Florida, lobbying efforts on behalf of habitat preservation by groups like National Audubon Society, Florida Audubon, and the Wilderness Society, and the coordination and facilitation efforts of the Center for Plant Conservation.

Foundations have focused their attention on especially beleaguered ecosystems. The MacArthur Foundation's recent program in the Florida Keys is an outstanding example. When the program began in 1988, the terrestrial ecosystems of the Keys were not well understood and were protected by a disconnected series of small state and federal refuges. There was relatively little public appreciation of the Keys as an important natural area within the state. A $3 million grant from the Foundation was divided equally among The Nature Conservancy, the Florida Keys Land and Sea Trust, and National Audubon Society. In its Keys program, TNC focused on lobbying for government land acquisition and improved public land management. The Land Trust's efforts turned to land acquisition and public education. Audubon contributed through an enhanced Keys research program. By the time the MacArthur Foundation reduced its involvement in 1991, acreage in conservation management had increased dramatically, the scientific basis for decision making and management was much improved, and greater statewide support for habitat conservation in the Keys was evident. By focusing its resources on a mixture of ecosystems within a well-defined region, and by supporting organizations with complementary programs, the MacArthur Foundation employed a model that might be very effectively reproduced in other parts of Florida.

5. Resource management. The integrated management of native plant resources can be divided into *in situ* and *ex situ* activities. The former focus on the immediate protection and restoration of natural populations and ecosystems, while the latter look toward the development of off-site genetic storage capabilities in order to protect plant species from outright extinction, and to supplement or restore natural populations when and if this is required and becomes possible. Since the aim of both agendas is the conservation of healthy populations and communities in the wild through an integrated plant conservation model, their separation below is to a considerable extent a false dichotomy. Nevertheless, the distinction is retained here to facilitate and clarify the discussion that follows.

a. *Ex situ* activities

Ex situ resource management activities involve the maintenance of living, rare plant collections in gardens or greenhouses and the storage of seed and tissue culture material as insurance against extinction and for use in rare plant augmentation and restoration projects. Bok Tower Gardens (BTG) in Lake Wales and Fairchild Tropical Garden (FTG) in Miami are Participating Institutions (PIs) of the Center for Plant Conservation in Florida. BTG and FTG presently house important collections of rare native Florida plants. Bok holds 35 taxa as part of the Center's National Collection of Endangered Plants, while Fairchild holds 33. The Center's program is based on a threefold approach to U. S. plant conservation with the following objectives: 1) to build and maintain genetically diverse collections of rare native plant taxa as insurance against extinction and genetic erosion; 2) to contribute to the reestablishment of self-sustaining native plant populations in protected and monitored natural areas; and, 3) to provide rare U.S. plants for research purposes and to educate the public about the plant endangerment problem in this country.

In order for such activities to be carried out effectively, *ex situ* plant specialists in Florida should, and often do, share in the responsibility for *in situ* activities associated with the management and restoration of rare plants in native habitats. This involves such activities as genetic assessments of natural populations, identification of appropriate reintroduction sites, and monitoring and management of reintroduced populations.

As in other parts of the U.S. and the world with similar conditions, the development of genetically diverse *ex situ* collections in Florida is made difficult by several factors:

1) Very small population sizes or sporadic seed set in some taxa of special concern;

2) The high cost and time associated with establishing adequate propagation and cultivation protocols for tropical and subtropical species. Once these protocols are well-formulated, costs for maintenance of a taxon in the live collection remain significant (estimated to be about $1200 per year at BTG);

3) Seed recalcitrance, often found in tropical species, is the characteristic of seeds to germinate immediately at maturity and to lose viability as a result of desiccation and exposure to cold. Recalcitrance makes seed storage by standard means impossible. Most long term seed storage for the Florida CPC Participating Institutions is currently being handled by the USDA National Seed Storage Laboratory (NSSL) at Fort Collins, CO, with an emphasis on rare Florida plants that produce orthodox seeds (those seeds that tolerate desiccation and cold storage). Development of specialized seed storage methods for Florida's recalcitrant seed-producing rare plants would require a greatly enhanced research effort into the long term storage capacity of recalcitrant seeds generally. This would be most appropriately undertaken at NSSL. Tissue culture is a high-tech alternative to seed storage that needs to be seriously considered for Florida's rare tropical plants. While it can be expensive, requires specialized training, and is not presently practiced on a significant scale in Florida native plant conservation, very successful rare plant tissue culture programs are now being operated fairly inexpensively in Hawai`i (Center for Plant Conservation 1994);

4) Little is known about the genetic variability present in Florida rare plant species. Plant conservationists increasingly view such information as data crucial to both *in situ* and *ex situ* management programs for rare plants. Descriptions of genetic variation that result from protein electrophoretic work and other recently-developed techniques have been made at Fairchild Tropical Gardens and at a number of universities within the state. However, such studies have been applied to few rare Florida plants and need to be expanded with an emphasis on management applications.

Because the biology of so many rare Florida plants is unknown, conservation horticulturists are faced with the difficult tasks of determining soil, water, light, and fertilizer requirements for rare plants while attempting to learn about their reproductive phenology, pollinators, and natural enemies. In this respect, conservation horticulture involves a very significant research component. If they do not have adequate research facilities or staff in-house, the *ex situ* plant conservation organizations are strongly encouraged to develop or enhance partnerships with research institutions possessing those capabilities.

The long term goal of *ex situ* management is the reintroduction of rare plant taxa into appropriate wild settings. The Nature Conservancy and the Department of Environmental Protection recently and independently proposed guidelines for reintroduction projects (Gordon 1994; Younker 1994). In considering the important question of where it is appropriate to try to reestablish rare taxa, the consensus was that a species should not be introduced outside of its historic range (some would argue for an exception to this rule if no protected, ecologically-suitable sites now exist within the documented historic range of the taxon). In Florida, the few reintroductions that have occurred (see below) have been carefully designed to avoid the introduction of native plants into inappropriate locations. However, as reintroductions become more frequently employed in the state, ecologically- and genetically-based protocols for plant augmentation and restoration must be formulated by scientists and managers representing all concerned parties.

Reintroductions invariably require intensive monitoring in order to determine, at a minimum, the conditions that will best assure the success of future restoration efforts. At the 1993 CPC-sponsored conference "Restoring Diversity: Strategies for Rare Plant Reintroductions," national experts agreed that little was known about how to restore most rare plants to natural habitats and, as a result, reintroductions should be considered to be experimental until proven otherwise. The costs and the expertise necessary to design and carry out restoration research and monitoring are substantial for any credible reintroduction effort. Allocation of charges and responsibilities for such activities must be negotiated among the relevant organizations during initial planning, and is, again, an area in which general statewide protocols and guidelines are needed.

Ex situ plant conservation activities in Florida fall largely within the purview of the state's two CPC Participating Institutions. Those activities are outlined briefly below.

Fairchild Tropical Garden

FTG's Endangered Species Program currently maintains *ex situ* collections of 11 CPC-approved (and some 30 additional) rare South Florida plant taxa. FTG's collection protocols generally follow CPC standards found in the CPC Handbook and in the Appendix to Genetics and Conservation of Rare Plants (Falk and Holsinger 1991). A routine horticultural maintenance and biological monitoring program has been established, and there is an ongoing effort to identify and codify propagation protocols for rare species. Careful computerized documentation of collection and curation procedures at FTG is done through BG-BASE, a conservation-oriented database management program designed for botanical gardens.

In collaboration with DEP biologists, FTG has developed and implemented a reintroduction plan for the buccaneer palm (*Pseudophoenix sargentii*) on the coastal berm at Long Key State Recreation Area. FTG/DEP's apparent success in reestablishing this species at one of the sites where it was described earlier in the century may provide a model for other reintroductions planned in the near future. These may include *Amorpha crenulata* (a pine rockland species) and *Jacquemontia reclinata* (a coastal strand species).

Bok Tower Gardens

BTG has 35 CPC-approved rare taxa in its *ex situ* collection. These are held as living plants and/or in long term seed storage. Thirty-four of these are Florida endemics. All of these taxa were collected as seeds or cuttings from wild populations according to CPC standards. The program at BTG has emphasized the development and documentation of propagation, maintenance, and field introduction methods. BTG has been a partner in establishing or augmenting populations of three rare plants into protected natural areas. For example, a population of an undescribed species of *Dicerandra*, known from only two sites on the Lake Wales Ridge, was established in a natural buffer area at the Gardens. The Nature Conservancy and BTG reintroduced *Conradina glabra* to TNC's Apalachicola Bluffs and Ravines Preserve. Another BTG introduction, funded by the U.S. Fish and Wildlife Service, involved the establishment of the endangered mint *Dicerandra immaculata* beyond its known historic range because no protected sites within its historic range could be found. This case illustrates not only the acuteness of the plant endangerment problem in some parts of Florida, but also the dilemma which often faces resource managers committed to the reestablishment of rare plants in the wild. Finally, a BTG reintroduction of *Ziziphus celata* into native scrub is planned.

Altogether, about 45% (approximately 80 out of 179) of Florida's imperiled plant taxa are represented in *ex situ* collections at these two CPC affiliates. Nevertheless, in the interest of preserving the genetic diversity of Florida's rare plants -- as a backup against extinction, and for eventual augmentation or reestablishment into natural settings -- a goal of 100% should be set. A realistic time frame for achieving such a "full insurance policy" standard needs to be established.

b. *In situ* activities

In situ resource management activities in Florida primarily concern the administration of terrestrial habitat in the nearly 3 million ha of Conservation Areas (Cox et al. 1994). Most of this land is in public ownership. 1.85 million ha are under federal jurisdiction, slightly under one million ha are in state management, and approximately 15,000 ha are managed by county or municipal governments. Extremely valuable habitat is also included in the extensive tracts under U.S. Department of Defense control, which total more than one-quarter million ha. While conservation objectives are now being given serious attention by the military, they remain secondary priorities on these lands. A number of relatively small but ecologically significant parcels are owned and managed by private, not-for-profit conservation organizations.

The National Park Service is responsible for the largest parcels of protected lands, including adjacent tracts in Everglades National Park and Big Cypress National Preserve, and for the largest total amount of land, about 1 million ha. The U.S. Fish and Wildlife Service has jurisdiction over 27 National Wildlife Refuges statewide, totaling some 375,000 ha. The U.S. Forest Service manages three National Forests with about 430,000 ha. Most state lands in conservation management are under the jurisdiction of the Division of Recreation and Parks, part of the Department of Environmental Protection. Smaller agencies manage the rest of the state-owned CAs. Diverse local agencies manage the many small parcels controlled by counties and municipalities.

The prevailing philosophy of these federal and state land-managing agencies is "ecosystem management." Depending on the practitioner, this concept includes a number of economic, ecological, and institutional components. Among these is the idea that by eliminating interference from non-native species, and by restoring natural regulatory processes over physiographically- and biologically-defined (*viz.* administratively-defined) areas, healthy, functional ecosystems can be maintained or reestablished. Maintenance of ecosystem functionality, in turn, is the best assurance of sustained well-being within the systems' biotic components, including the rare plant taxa. Thus, native habitats are maintained by removing exotic species, by reestablishing historical hydrologic regimes, and by utilizing prescribed burns within ecosystems once regulated by periodic fires. When an ecosystem has been so modified that its natural functionality is seriously disrupted or altogether replaced by non-native species, habitat restoration may be necessary.

While the amount of land managed by private conservation organizations is not large, it includes some of the best-preserved examples of rare native habitat in Florida. The Nature Conservancy is the largest private owner of Conservation Areas, managing 42 sites totaling over 15,000 ha. The three largest TNC sites are: Apalachicola Bluffs and Ravines (2,600 ha), notable for the presence of several of Florida's rarest species; Tiger Creek (1,900 ha), encompassing many endangered Lake Wales Ridge scrub species; and Disney Wilderness Preserve (4,500 ha). The National Audubon Society owns and manages the 10,000 ha Corkscrew Swamp Sanctuary, which includes one of the largest remnants (about 250 ha) of virgin baldcypress forest in the United States. Archbold Biological Station, established by eco-philanthropist Richard Archbold, and funded by an Archbold Expeditions endowment, is a 2,000 ha property on the Lake Wales Ridge consisting of pine flatwoods, sandhills, and scrub. Tall Timbers Experiment Station manages a 1,600 ha property north of Tallahassee composed mostly of sandhill vegetation.

Private-land managers have sometimes been more innovative than their public counterparts, presumably because of the simpler administrative structures and more homogeneous constituencies to which they are accountable. While natural area values are important to the four private conservation organizations described above, their resource management objectives range from pure habitat preservation (Archbold) to more traditional "multiple use" objectives such as wildlife habitat, timber, and agricultural production (Tall Timbers). As on the public lands, prescribed fire, exotic plant removal, and/or hydrologic management are important practices within privately-owned Conservation Areas. These are described in somewhat more detail below:

(1) Exotic plant removal. Conserved lands have not been immune to invasion by the hundreds of exotic plants that have been introduced into Florida by humans. Some of these introductions have become aggressive, invasive pests that are doing enormous and costly damage to native ecosystems. For example, thousands of acres of Everglades National Park are now overrun by Brazilian pepper (*Schinus terebinthifolius*), melaleuca (*Melaleuca quinquenervia*), and Australian pine (*Casuarina equisetifolia*). Such trees not only dominate disturbed sites, but are capable of supplanting native communities and outcompeting native species. The key factor in their success is believed to be the absence of coevolved biological controls which would presumably limit their invasive spread within their natural ranges. Especially in the southern portions of the state, managers of most protected lands are now forced to devote large parts of their budgets and staff resources to what has become repetitive removal of exotic pest plants. Costs of melaleuca control alone in Everglades National Park and nearby Big Cypress National Preserve total nearly two million dollars since the mid-1980s. In Big Cypress, current plans call for exotic plant pest removal at the rate of $200,000 a year. Similar exotic plant control projects have been promoted and facilitated in recent years by the Exotic Pest Plant Council (EPPC). EPPC is a non-profit organization of agency biologists and private individuals that has accomplished much by assisting municipalities and agencies in the development and implementation of exotic pest plant control programs, by publicizing the magnitude and seriousness of the exotic plant problem in Florida, and by listing and prioritizing invasive species for control. A statewide plan to deal with exotic species issues is needed, and EPPC's recent work on the subject (Department of Environmental Protection 1994) will aid in its development.

(2) Prescribed fire. Florida's prairie vegetation and several pineland habitats are fire-maintained communities. Prior to the arrival of humans, fires were lightning-caused, but Native Americans and, more recently, society as a whole, have very substantially modified the natural fire regime. Today, Florida has one of the largest prescribed burn programs in the U.S., and both federal and state agencies use fire as an ecosystem management tool. Given that 80-85% of the federally-listed plant species in Florida are fire-adapted (D. Hardin, pers. comm.), many undoubtedly depend on these prescribed burns for their continued existence.

In recent years, upwards of 500,000 ha of state- and privately-owned land (mostly pinelands) have been burned annually. Most of these burns are carried out by timber companies for wildfire suppression or by private individuals to enhance wildlife habitat. The state Division of Forestry burns between 32,000 and 48,000 ha annually for ecosystem management. In rural, lightly-populated areas of the state, the activity is relatively non-controversial. However, in and adjacent to urban areas, such programs have been limited by smoke and safety concerns expressed by citizenries not well-informed about the ecological and hazard-reduction benefits of controlled burns in ecosystems that were once maintained naturally by fire.

(3) Hydrologic management. Water is unlike any other Florida resource because its immediate control is not in the hands of the land managers themselves. Instead, management of water in Florida is centralized in the hands of five Water Management Districts. These districts distribute water through a massive plumbing system, i.e., a series of interconnected canals, pumps, and control structures built by the U.S. Army Corps of Engineers. The Districts are semi-autonomous authorities, with independent taxation powers, nominally under the purview of the Department of Environmental Protection. In providing for the needs of wetland plant species and habitats, Water Management District managers must also consider impacts on other users, for example, urban and agricultural interests. Thus, managers of Conservation Areas that include wetland ecosystems must not only know how much water they need and when, they must contend for it in a highly politicized, competitive environment. For example, the publicly-supported decision to allocate limited water supplies to the maintenance of the native ecosystem in the Payne's Prairie State Preserve south of Gainesville has recently resulted in a legal challenge by nearby lakeshore owners who have requested compensation.

Florida's extensive canal and delivery systems were designed for drainage and flood control, not for ecological values. The structure and size of the existing network now limit the ability of the Water Management Districts to meet many of the objectives of ecosystem management. Because of the magnitude of the environmental changes that resulted from water control, structural modifications are currently being planned that will require large capital outlays and years of construction. In South Florida for instance, releases of water into Everglades National Park are governed by a complex set of rules driven by precipitation, canal levels, and seasonality, but not by the condition of the marsh itself. These rules have been modified many times in the last few decades, partly at the urging of Park scientists, but rule changes have not yet reversed a long time decline in wildlife populations. Large-scale vegetation changes resulting from unnatural hydrology in the Everglades marsh have not been unequivocally documented, but changes north of the Park, in the Water Conservation Areas, have been very substantial indeed, provoking great concern within a range of observer organizations. Here, the replacement of native sawgrass marsh by cattails (*Typha* spp.) has resulted from the delivery of phosphorus-enriched water from adjacent agricultural lands. While some may view this as the substitution of one monospecific plant community by another, the tall, dense cattail stands tear at the fabric of the natural Everglades landscape, and utterly transform the resident fauna. In the wake of a long period of litigation and negotiation over the issue, a major redesign of the water delivery system is being planned. The new design is intended to benefit the ecological health of the Water Conservation Areas and restore the characteristic biotic assemblages there and in adjacent wetlands.

(4) Restoration and reclamation. Restoration usually involves some combination of the management tools described above, with or without replanting native vegetation. Reclamation is by definition a more arduous and drastic procedure because it occurs on lands where little of the original ecosystems and vegetation remain (Younker 1994). Due to the scope and complexity of the tasks involved, many reclamation projects become large-scale interagency ventures. These include mega-projects such as those intended to reclaim marshes in the Everglades and along the Kissimmee River. Three smaller examples are described below:

Longleaf pine restoration. The State Division of Forestry is currently restoring longleaf pine (*Pinus palustris*) habitat on approximately 8,000 ha under its jurisdiction. The areas in question had been converted to sand pine (*Pinus clausa*) and/or slash pine (*Pinus eliottii*) plantations, largely because of the lower economic returns of longleaf pine which passes through an extended juvenile "grass-like" stage before commencing rapid growth. This project signifies the Division's increasing recognition of natural ecosystem values, and is to be commended and supported. In conjunction with Tall Timbers Experiment Station, the Division is also investigating methods of re-establishing native ground cover within several forests. Wiregrass (*Aristida stricta*), one of the dominant understory plants of this habitat, is now being grown in state nurseries, and mycorrhizal relationships are being studied. Prescribed fire is also being studied as an important element of longleaf pine ecosystem management.

Blowing Rocks reclamation. Blowing Rocks Preserve is a small tract (about 30 ha) of diverse habitats on Jupiter Island owned and managed by The Nature Conservancy. The Preserve includes degraded beach dune, coastal strand, tropical hammock, and mangrove swamp communities, all of which are becoming rare in southeastern Florida as a result of coastal development. Reclamation efforts involve replanting with regionally native plant materials that were grown in an on-site nursery. With initial reclamation now completed, TNC nevertheless believes that periodic removal of exotic vegetation will continue indefinitely.

The "Hole-in-the-Donut" reclamation project. The "Hole-in-the-Donut" is a 2,000 ha wetland within the bounds of Everglades National Park which was farmed prior to Park creation. After farming was abandoned, the "Hole-in-the-Donut" was invaded by Brazilian pepper (*Schinus terebinthifolius*). Scheduled to begin this year, reclamation will involve removal of the rubbly materials that formed the planting rows when the area was plowed. This is expected to increase the period of time during the year that the area is inundated with water, thereby favoring native wetland plants over the pepper. A smaller wetland in an eastern portion of the Everglades was reclaimed in the late 1980s by similarly removing the rock-plowed planting rows which was then followed by grading. Native wetland species recolonized the area and no replanting was needed (Dalrymple et al. 1993). If such experimental restoration projects can be successfully applied on a wider scale, the ability to restore large portions of the Everglades ecosystem will be very substantially enhanced. Unfortunately, the removal of the planting rows is difficult and expensive, and the acreage needing this treatment is large. At current rates, restoring the entire "Hole-in-the-Donut" will take several decades and many millions of dollars. As the project moves forward, the Technical Review Board (the project oversight body) must continuously reassess the balance between realized ecological benefits and their costs in terms of worthy projects deferred. The Board should continue to educate itself about less expensive alternative technologies and apply these as appropriate.

6. Integration and planning. Lack of coordination across ownership boundaries can frustrate species and habitat protection efforts, even when they are important management priorities. For example, the benefits of controlling or removing exotic plants in one conservation area may be confounded by an untreated seed source in an adjacent unit under the jurisdiction of another agency that is following a different management regime. Therefore, organizations managing common vegetation resources within a watershed or other geographic subunit will achieve best results by coordinating management schedules, biological resource monitoring, vandalism control, personnel training, and so on. The benefits of interagency planning and cooperation similarly extend to land acquisition, research, and education. But as elsewhere, such collaboration doesn't always occur in Florida for many reasons. In order to facilitate cooperation, within the last few years the Greater Arbuckle Ecosystem and the Wekiva River Basin Ecosystem have formed Working Groups to exchange information and to explore opportunities for collaboration. Such interactions and cooperative management efforts should be explicitly stated as goals of ecosystem management throughout Florida.

At the state level, cross-organizational planning to improve the condition of Florida native plants has focused on single conservation themes or on specific conservation problems. Examples are land acquisition programs by the state under Preservation-2000 (Section IIIC3, above), the listing activities of the Endangered Plant Advisory

Council (Section IIIC1, above), and the education and restoration activities of the Exotic Plant Pest Council (Section III5b(1), above). All have brought an element of statewide planning to native plant problems in Florida. Organizations headquartered outside of the state have also attempted to foster plant conservation agendas within Florida. For example, the Center for Plant Conservation organized an Endangered Plant Task Force meeting in 1992 to promote and facilitate the Florida plant conservation planning process. One of the objectives of this meeting was to identify and establish recovery teams for regions and for specific taxa. Another was to assign priority conservation rankings to species of special concern. A 1995 Task Force meeting expanded on these efforts to focus and to intensify native plant conservation collaborative efforts throughout the state.

PART IV: RECOMMENDATIONS TO IMPROVE THE PROCESS

Recommendation One: Develop or strengthen feedback loops between biologists, ecologists, and resource managers.

While a significant body of information is now available on the abundance, distribution, and taxonomic affinities of Florida's rare plants, much less is known about the specific factors that are causing their decline or limiting their expansion, or what might improve their condition. Furthermore, what little is known often takes a long time to become generally available and then translated into applied management contexts. Similarly, what are now serious management problems have usually taken a long time to develop, and it is characteristic of our response time for long periods to pass again before these problems become themes for applied research. Limited understanding and inadequate communication within the research and the applied sides of the Florida plant conservation equation have contributed to the superficiality of some Recovery Plans now being produced (Schemske et al. 1994). Without fundamental ecological knowledge of the plants, efforts to rehabilitate failing species rely on guesswork or on restoration models developed for different species or conditions.

The incomplete or fragmentary nature of rare plant knowledge in Florida is a result, in part, of the limited funding allocated to it. An exceedingly small portion of the operating budgets of state and federal land and resource managing agencies is allocated to research activities. Similarly, research programs in conservation biology comprise a minute fraction of overall government funding for science. However, the problem is not entirely a financial one. Institutional factors also hamper applied plant science, the most significant perhaps being the compartmentalization of research personnel and management staff. Because scientists and managers are generally housed in separate administrative units, efforts are needed to promote and facilitate greater exchange between those people generating research results and those people applying this knowledge in management contexts. When scientists lose touch with the application of their results, the vitality and practicality of their work suffers. When managers become less mindful of the need for their activities to be based on the best and the latest research, the plant resource itself suffers. In working together to develop, implement, and assess the results of resource management techniques, researchers and managers must focus on the ultimate goal of maintaining, augmenting, or restoring good habitat, and on increasing the abundance of rare plants within healthy ecosystems. In situations where good cooperation has developed, gaps in information flow can close rapidly as scientifically-based management is practiced, and management lessons and problems are fed back to the researchers for study and, hopefully, solution.

Recommendation Two: Develop and implement innovative programs to educate a wider public about the practical importance of native plants, the threats to them, and the ramifications associated with their loss.

Organizations specializing in habitat conservation in Florida have been quite successful in establishing a system of preserves in remote locations throughout the state. However, for rare plants, these successes have been more than matched by the losses of important natural areas to residential and agricultural development and by a general decline in the biological quality of the preserves themselves. The condition of the native plant resource in Florida can be improved through the growth of a broader, better informed plant and habitat conservation constituency.

While the educational activities of state agencies and school systems and, indirectly, the traditional news media have resulted in greater public awareness of environmental issues than a decade ago, much remains to be done to build support for plant conservation. Perhaps the central need is to convert a mostly unfocused public sympathy for environmental issues into active support for plant and habitat conservation. We believe this must begin by involving people personally. Several successful programs known to encourage hands-on involvement in plant conservation were described above: the Florida Native Plant Society programs that appealed to the economic and aesthetic concerns of homeowners; the TNC volunteer programs; the various school programs that encouraged student contact with native habitats and ecological relationships; etc. If personal involvement is a crucial first step in creating plant conservationists, then environmental educators must develop or enhance programs to bring this experience to individuals or groups not presently being reached. Perhaps as important, the message conveyed by the Florida native plant conservation community needs to become more focused, especially so that it can be distinguished from the many other, sometimes conflicting, environmental messages. One subject toward which the native plant message might be directed is the state's exotic plant problem. While many solutions are being developed and tried, individual involvement in eliminating invasive exotics, and planting natives, is gaining interest and ascendancy. But spreading such a message to large audiences usually involves mass media, and associated costs are beyond the means of most conservation organizations. State agencies charged with the stewardship of Florida's natural areas and rare species must assume a greater leadership role in educating the public on this and on other plant conservation issues.

Recommendation Three: Provisions of existing federal, state, and local laws pertaining to rare plants and habitats should be maintained and enhanced and, preferentially, made collectively more coherent. Public funding for plant and habitat conservation should be increased.

Existing federal, state, and local laws involving conservation and/or recovery of plant taxa vulnerable to extinction or extirpation have many weaknesses, some of which have been discussed above. Since the federal Endangered Species Act is the cornerstone law and model, improving environmental legislation at all levels must begin with maintaining or even strengthening the Act. Indeed, plant species should be afforded the same level of protection as animal species, so that the "taking" of rare plants on non-federal lands and the destruction of "critical habitat" of rare plants can be more appropriately regulated. Similarly, the criteria for listing in the original version of the Act, based solely on biological considerations, should be restored; subsequent amendments to include consideration of economic factors have very substantially weakened the listing process as it now stands. While provisions for initiation of the listing procedure by private petition are available, the establishment of an impartial nongovernmental panel of experts to participate in the listing process (comparable to the role of the state's Endangered Plant Advisory Council) might expedite the process and reduce some of the recent pressures that have been applied to the Secretary of the Interior, U.S. Fish and Wildlife Service officials, and associated political appointees.

State laws should be similarly rationalized to provide protection for the habitat of state-listed endangered and threatened species, and to aid the recovery of rare plants. State legislation should be enacted to address, minimally, the following four items:

1) State agencies that manage the majority of state conservation areas, such as the Division of Recreation and Parks (in the Department of Environmental Protection) and the Division of Forestry (in the Department of Agriculture and Consumer Services), should formulate statewide plans and policies to enhance the survivorship of state-listed plant species;

2) State agencies, such as the Department of Transportation, should be required to produce listed-species impact statements prior to implementation of projects and to provide for mitigation. Where feasible and practical, state agencies should use a significant proportion of native plants in their landscaping;

3) All state agencies should directly or indirectly work to conserve state-listed species and use their authorities to further the well-being of native plants and their habitats (as must federal agencies under the Endangered Species Act);

4) Non-indigenous plant species listed as invasive by the Exotic Plant Pest Council should be prohibited from use on public lands and in commercial trade or transport within the state.

Changes to legislation at all levels must occur within the widest possible context of information availability and public debate.

Recommendation Four: *In situ* and *ex situ* plant conservation activities should be informed by integrated conservation plans. These should be based upon research-based protocols for maintenance of genetic diversity, horticultural treatments, reduction or elimination of threat, and selection and monitoring of restoration sites and methods.

In situ and *ex situ* plant conservation activities have sometimes been characterized as having distinct agendas, but they are in fact complementary sides of the same plant conservation coin. While *ex situ* collections are important genetic libraries for rare plant taxa and exceptional resources for research and public education, their highest value is realized when they serve to restore rare plants to natural evolutionary settings. Moreover, when native plant populations are reduced to points where they approach extirpation or even extinction, *ex situ* conservation and rare plant horticulture become critical to species survival itself. As desirable as *in situ* conservation is to the long term viability of native species and ecosystems, the reality is that parks, preserves, and other Conservation Areas simply cannot provide complete protection for the full range of Florida's rare plants. Initiated by the U.S. Forest Service, the tenets of "ecosystem management" have been widely adopted by resource management agencies in Florida. Ecosystem management elevates the health of the ecosystem above single-species considerations in determining the management strategies applied to public lands.

While it promises to be of great benefit to Florida native plants, and we support the implementation of ecosystem management in Florida's Conservation Areas, instances can and do arise in which ecosystem-level considerations cannot ensure the preservation of individual taxa. When such situations occur, *in situ* management *and* the availability of an *ex situ* capability have proven to be exceedingly useful, when combined, in assuring the continued viability of the population involved.

Because safeguarding our native plant resources today usually involves multiple tasks, diverse types of expertise, and constant cooperation within the *in situ* and *ex situ* plant conservation communities, it is fundamentally important that integrated conservation plans be developed for all Florida plants of conservation concern. Such plans need to consider the full range of research-based conservation-related data including, if possible, detailed information on biogeography and population numbers, reproductive biology, threats to native populations and threat mitigation, adequacy of genetic representation in both on-site and off-site settings, selection of sites and monitoring protocols in reintroduction projects, etc.

As emphasized in the reintroduction guidelines produced both by the TNC and the DEP (described above), the existence of such plans, and a history of *in situ* and *ex situ* collaboration become especially important during the planning, design, implementation, and monitoring of reintroduction projects. Indeed, it is here that *in situ* and *ex situ* concepts, methods, and personnel will interact most closely. Reintroductions occurring within such contexts should involve *in situ* and *ex situ* scientists and managers as full partners, and be based upon a well-defined and understood division of labor.

Recommendation Five: Form plant conservation working groups at regional and state levels and initiate a regular Interdisciplinary Conference on the Management of Native Florida Plants.

As described in our plant conservation model (Figure 2), plant conservation in Florida occurs within at least five separate functions and through the general support of the public at large. Even the most comprehensive resource management institutions in Florida are incapable of carrying out more than a few of the specialized functions effectively. Moreover, most species and habitats cross ownership boundaries, complicating the conservation efforts of single entities, all of which have distinct institutional cultures, management mandates, and conservation methodologies. For these reasons, successful plant conservation requires cooperation among a diverse group of specialists and land managers.

Except in rare instances, cross-agency and cross-functional collaboration have been left to develop on *ad hoc* bases in Florida. Better organization is needed to coordinate the diverse activities and points-of-view of the many plant conservation players. Organizational emphasis should be placed initially at the local level where parties representing different positions nevertheless share a common concern for the plant resource. The Greater Arbuckle and the Wekiva River Basin working groups might represent models for such organizations, though the form that cooperation might take can vary depending on local situations. Well-organized local groups can facilitate the flow of information, help enormously in generating consensus, and thus ease decision making among resource managers who may or may not be local people. Indeed, novel and innovative collaborative efforts are more likely at this level, and such groups can become very effective in widening the base of support for natural areas and rare plants within their regions.

There is also a fundamental need for leadership at the state level on the larger, conceptual, plant conservation issues. Whereas EPAC and EPPC provide direction on rare plant listings and exotic plant problems, respectively, there is not a single group within the plant conservation community that brings a non-partisan, expert, plant advocacy voice to issues such as land acquisition priorities, plant collection and reintroduction protocols, impacts of potential legislation on native plants, park management policies, or the structure and content of environmental education efforts. Formation of a Florida Native Plant Council is therefore recommended as the mechanism to provide direction on these and other issues relevant to native plants in the state, as well as to explore ways to implement the recommendations outlined above. The Council would consist of 20 to 30 members: native plant researchers, managers, and advocates, representing a broad range of institutions, disciplines, and geographic regions. Agencies, institutions, and groups that should be invited to participate include the following:

National Park Service
National Biological Service
U. S. Fish and Wildlife Service
U. S. Forest Service
Department of Defense
Native American Tribes
Florida Department of Environmental Protection
Florida Division of Forestry
Florida Department of Plant Industry
Florida Fish and Game Commission
State Water Management Districts
County governments
Primary and secondary public schools
Florida Natural Areas Inventory
The Nature Conservancy
Florida Native Plant Society
National Audubon Society
Native plant nurseries
Exotic Pest Plant Council
Endangered Plant Advisory Council
CPC Florida Participating Institutions
Universities
Other research institutions

In order for the Florida Native Plant Council to be most effective, a source of funding must be identified to support its activities. The Council would meet annually. Individual members could meet more frequently in smaller working groups to address specific or pressing issues.

The need for enhanced communication and interaction among the diverse participants and supporters of Florida plant conservation is a theme that has been repeated throughout this document. Researchers, managers, advocates, and educators must develop more opportunities to share experiences, points-of-view, and news. The convening of an annual meeting of native plant conservationists is therefore recommended. We might call this the Interdisciplinary Conference on Management of Florida Native Plants. This conference might be arranged to coincide in time and place with the annual convention of the Florida Native Plant Society, the Florida Native Plant Council, or some similar gathering. The objectives of such a conference might be the presentation of research results or management findings regarding rare native plants of Florida, debate on the implications of management alternatives, or exposure of primary and secondary school teachers and others to up-to-date information on Florida native plant issues. By orienting the conference to the exploration of interfaces among research, management, advocacy, and education, we can achieve these objectives and more.

PART V. ACKNOWLEDGEMENTS

Funding to produce this Action Plan was provided by the Elizabeth Ordway Dunn Foundation through a grant to the Center for Plant Conservation, for which we are exceedingly grateful. Special thanks go to D. Garvue, D. Gordon, A. Johnson, G. Knight, J. Shaw, and T. Race for extensive reviews and comments on earlier drafts of this text. Input from the Florida Rare Plant Task Force, convened on May 15 and 16, 1995 at Bok Tower Gardens (Lake Wales, FL), and from many other agency and NGO biologists and managers, was instrumental in completing this document.

PART VI. LITERATURE CITED

Abrahamson, W.G., A.F. Johnson, J.N. Layne, and P.A. Peroni. 1984. Vegetation of the Archbold Biological Station, Florida: An example of the Southern Lake Wales Ridge. Florida Scientist 47(4):209-250.

Abrahamson, W.G. and D.C. Hartnett. 1990. Pine flatwoods and dry prairies. Pages 103-149 *in* Ecosystems of Florida. R.L. Myers and J.J. Ewel (eds.), University of Central Florida Press, Orlando, FL.

Alexander, T.R. and A.G. Crook. 1973. Recent and long-term vegetation changes and patterns in South Florida. Part 1 of Report to National Park Service (EVER-N-51).

Center for Plant Conservation. 1994. An action plan for conserving Hawaiian plant diversity. CPC report, St. Louis, MO.

----. 1995. Summary of 1995 Florida rare plant task force meeting. CPC report, St. Louis, MO.

Center, T.D., R.F. Doren, R.L. Hofstetter, R.L. Myers, and L.D. Whiteaker. 1991. Proceedings of the symposium on exotic plants. Tech. Report NPS/NREVER/NRTR-91/06. 387 pages.

Cox, J., R. Kautz, M. MacLaughlin, and T. Gilbert. 1994. Closing the Gaps in Florida's Wildlife Conservation System. Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Dalrymple, N.K., G.H. Dalrymple, and K.A. Fanning. 1993. Vegetation of restored rock-plowed wetlands of the East Everglades. Restoration Ecology Dec. 1993:220-225.

Davis, J.H. 1967. General map of natural vegetation of Florida. Institute of Food and Agricultural Sciences. University of Florida, Gainesville, FL.

Davis, S.M. 1994. Phosphorus inputs and vegetation sensitivity in the Everglades. Pages 357-378 *in* Everglades: The Ecosystem and its Restoration. S.M. Davis and J.C. Ogden (eds.), St. Lucie, Delray Beach. 826 pages.

Department of Environmental Protection. 1994. An assessment of invasive non-indigenous species in Florida's public lands. Technical Report No. TSS-94-100. Tallahassee, FL.

Duever, M.J., J.E. Carlson, J.F. Meeder, L.C. Duever, L.H. Gunderson, L.A. Riopelle, T.R. Alexander, R.L. Myers, and D.P. Spangler. 1986. The Big Cypress National Preserve. National Audubon Society, New York, NY. 444 pages.

Elton, C.S. 1958. The ecology of invasions by animals and plants. John Wiley, New York. 199 pages.

Ewel, K.C. 1990. Swamps. Pages 281-323 *in* Ecosystems of Florida, R.L. Myers and J.J. Ewel (eds.). University of Central Florida Press, Orlando, FL.

Falk, D. and K. Holsinger (eds.). 1991. Genetics and Conservation of Rare Plants. Oxford University Press, New York, NY.

Gordon, D.R. 1994. Translocation of species into conservation areas: a key for natural resource managers. Nat. Areas Journal 14:31-37.

Hardin, D. n.d. Personal communication.

Johnson, A.F. and M.G. Barbour. 1990. Dunes and maritime forests. Pages 429-480 *in* Ecosystems of Florida, R.L. Myers and J.J. Ewel (eds.). University of Central Florida Press, Orlando, FL.

Johnson, A.F. and J. Muller. 1993. An assessment of Florida's remaining coastal upland natural communities: final summary report. Florida Natural Areas Inventory, Tallahassee, FL.

Kautz, R.S. 1993. Trends in Florida wildlife habitat 1936-1987. Florida Scientist 56:7-24.

Kautz, R.S., D.T. Gilbert, and G.M. Mauldin. 1993. Vegetative cover in Florida based on 1985-1989 Landsat Thematic Mapper imagery. Florida Scientist 56:135-154.

Kushlan, J.A. 1990. Freshwater marshes. Pages 324-363 *in* Ecosystems of Florida, R.L. Myers and J.J. Ewel (eds.), University of Central Florida Press, Orlando, FL.

Lidz, B.H. and E.A. Shinn. 1991. Paleoshorelines, reefs, and a rising sea: South Florida, U.S.A. Journal of Coastal Research 7:203-229.

Long, R.W. and O. Lakela. 1976. A Flora of Tropical Florida. Banyan Books, Miami, FL.

MacArthur, R.H. and E.O. Wilson. 1967. The Theory of Island Biogeography. Princeton University Press, Princeton, NJ.

Maul, G.A. and D.M. Martin. 1993. Sea level rise at Key West, Florida, 1846-1992: America's longest instrument record. Geophysical Research Letters 20(18):1955-1958.

Montague, C.L. and R.G. Wiegert. 1990. Salt marshes. Pages 481-516 *in* Ecosystems of Florida, R.L. Myers and J.J. Ewel (eds.). University of Central Florida Press, Orlando, FL.

Myers, R.L. 1990. Scrub and high pine. Pages 150-193 *in* Ecosystems of Florida, R.L. Myers and J.J. Ewel (eds.). University of Central Florida Press, Orlando, FL.

----. and J.J. Ewel (eds.). 1990. Ecosystems of Florida. University of Central Florida Press, Orlando, FL.

Odum, W.E. and C.C. McIvor. 1990. Mangroves. Pages 517-548 *in* Ecosystems of Florida, R.L. Myers and J.J. Ewel (eds.). University of Central Florida Press, Orlando, FL.

Platt, W.J. and M.W. Schwartz. 1990. Temperate hardwood forests. Pages 194-229 *in* Ecosystems of Florida, R.L. Myers and J.J. Ewel (eds.). University of Central Florida Press, Orlando, FL.

Ross, M.S. n.d. Unpublished data.

----., J.J. O'Brien, and L. Sternberg. 1994. Sea-level rise and the reduction in pine forests in the Florida Keys. Ecological Applications 4(1):144-156.

Schemske, D.W., B.C. Husband, M.H. Ruckelshaus, C. Goodwillie, I.M. Parker, and J.G. Bishop. 1994. Evaluating approaches to the conservation of rare and endangered plants. Ecology 75:584-606.

Scott, J.M., F. Davis, B. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'Erichia, T. Edwards, Jr., J. Allman, and R. Wright. 1993. Gap analysis: a geographic approach to protection of biological diversity. Wildlife Monographs 123.

Small, J.K. 1919. Eden to Sahara. Science Press, Lancaster, PA.

Snyder, J.R. 1986. The impact of wet season and dry season prescribed fires on Miami Rock Ridge pineland, Everglades National Park. Report SFRC-86/06, Everglades National Park, Homestead, FL.

----., A. Herndon, and W.B. Robertson, Jr. 1990. South Florida rockland. Pages 230-280 *in* Ecosystems of Florida, R.L. Myers and J.J. Ewel (eds.). University of Central Florida Press, Orlando, FL.

Stowe, H.B. 1873. Palmetto-Leaves. Boston, Osgood.

Williams, K. and M.R. MacDonald. 1994. Immediate and projected long-term effects of a large storm-surge, an infrequent episodic event, on the rate of coastal forest decline on the Gulf Coast of Florida. Bull. Ecol. Soc. Am. 75(2).

Younker, D. 1994. A proposal: Native plant translocations for natural community restoration or artificial community reclamation on managed areas. Restoration and Management Notes 6(4):26-29.

APPENDIX A: 179 RARE AND\OR FEDERALLY LISTED PLANT TAXA IN FLORIDA

TAXON	HABITAT	FNAI STATUS	FEDERAL STATUS	CPC STATUS
Amorpha crenulata	pine rockland	G1	LE	A
Anemia wrightii	trop hammock	G2G3	N	N
Argythamnia blodgettii	trop hammock	G2	C2	C
Aristida rhizomophora	pine flatwood (wet prairie)	G2	N	N
Aristolochia pentandra	trop hammock	G2G4	N	N
Arnoglossum diversifolium	swamp	G2	C2	N
Asclepias virdula	pine flatwood	G2	C1	N
Asimina tetramera	scrub	G1	LE	B
Asplenium curtissii	temp hw forest	G1	N	N
Asplenium x biscayneanum	trop hammock	G1	N	N
Asplenium x heteroresiliens	temp hw forest	G2	C2	N
Asplenium x plenem	trop hammock	G1	C2	N
Aster spinulosus	scrubby flatwd	G1	C2	C
Balduina atropurpurea	pine flatwood	G2G3	3C	N
Baptisia calycosa var. calycosa	pine flatwood	G2T1T2	C2	N
Baptisia calycosa	sandhill	G2T1T2	C2	N
Basiphyllaea corallicola	pine rockland	G2	N	C
Bonamia grandiflora	scrub	G3	LT	C
Bourreria radula	trop hammock	G2	N	N
Brickellia cordifolia	temp hw forest	G2G3	C2	N
Brickellia mosieri	pine rockland	G1	C2	A
Calamovilfa curtissii	pine flatwood	G2	C2	C

Calystegia catesbeiana	sandhill	G1	N	N
Campanula robinsiae	marsh	G1	LE	A
Carex baltzellii	temp hw forest	G2	C2	N
Carex chapmanii	temp hw forest	G2G3	C2	N
Cassia keyensis	pine rockland	G2	3C	C
Catesbaea parviflora	coast upland	G2G3	N	N
Catopsis nutans	swamp	G2G3	N	N
Cereus eriophorus var. fragrans	scrubby flatwd	G2G3T1	LE	B
Cereus gracilis var. arborigum	coast upland	G2G3T2	C2	A
Cereus gracilis var. simpsonii	coast upland	G2G3T2	C2	X
Cereus robinii var. deeringii	trop hammock	G1T1	LE	N
Cereus robinii var. robinii	trop hammock	G1T1	LE	N
Chamaesyce cumulicola	coast upland	G2	C2	A
Chamaesyce deltoidea var. adherens	pine rockland	G2T2	N	A
Chamaesyce deltoidea ssp. deltoidea	pine rockland	G2T1	LE	B
Chamaesyce deltoidea ssp. pinetorum	pine rockland	G2T1	N	N
Chamaesyce deltoidea ssp. serpyllum	pine rockland	G2T1	3C	C
Chamaesyce garberi	coast upland	G1	LT	C
Chamaesyce porteriana var. keyensis	coast upland	G2T1	C2	C
Chamaesyce porteriana var. porteriana	pine rockland	G2T2	C2	C
Chamaesyce porteriana var. scoparia	pine rockland	G2T2	C2	C

Chionanthus pygmaeus	scrub	G3	LE	C
Chrysopsis floridana	scrub	G1	LE	B
Chrysopsis godfreyi	coast upland	G2	C2	C
Clitoria fragrans	sandhill	G3	LT	B
Conradina brevifolia	scrub	G2Q	LE	N
Conradina etonia	scrub	G1	LE	N
Conradina glabra	sandhill	G1	LE	B
Coreopsis integrifolia	swamp	G1G2	N	N
Crotalaria avonensis	scrub	G1	LE	N
Croton elliottii	sandhill	G2G3	3C	N
Ctenium floridanum	pine flatwood (wet prairie)	G2	3C	N
Cucurbita okeechobeensis ssp. okeechobeensis	swamp	G3T1	LE	A
Deeringothamnus pulchellus	pine flatwood	G1	LE	A
Deeringothamnus rugelii	pine flatwood	G1	LE	A
Dicerandra christmanii	scrub	G1	LE	A
Dicerandra cornutissima	scrub	G1	LE	B
Dicerandra frutescens	scrub	G1	LE	B
Dicerandra immaculata	scrub	G1	LE	A
Digitaria floridana	sandhill	G1	C2	B
Digitaria gracillima	scrub	G1	C2	B
Digitaria pauciflora	pine rockland	G1	N	A
Eragrostis tracyi	coast upland	G2	C2	N
Eriogonum longifolium var. gnaphafolium	sandhill	G4T3	LT	N
Eryngium cuneifolium	scrub	G1	LE	B

Euphorbia telephioides	pine flatwood	G1	LT	B
Forestiera segregata var. pinetorum	pine rockland	G2T2	C2	C
Galactia smallii	pine rockland	G1Q	LE	A
Glandularia maritima	coast upland	G2	C2	A/C
Glandularia tampensis	swamp	G1	C2	A
Gymnopogon chapmanianus	sandhill	G2	N	N
Harperocallis flava	pine flatwood (wet prairie)	G1	LE	A
Hartwrightia floridana	pine flatwood	G2	C2	N
Hedeoma graveolens	pine flatwood	G2	C2	N
Helianthus carnosus	marsh	G1G2	C2	N
Huperzia dichotoma	swamp	G2	N	N
Hymenocallis henryae	swamp	G1	C2	N
Hypelate trifoliata	trop hammock	G2	N	N
Hypericum cumulicola	scrub	G2	LE	C
Hypericum edisonianum	marsh	G2	C2	N
Hypericum lissophloeus	sandhill	G2	C2	N
Illicium parviflorum	swamp	G1G2	C2	C
Jacquemontia curtissii	pine rockland	G2	C2	C
Jacquemontia havenensis	coast upland	G2G3	N	N
Jacquemontia reclinata	coast upland	G1	PE	A
Juncus gymnocarpus	swamp	G2G3	3C	N
Justicia angusta	pine flatwood	G2	N	N
Justicia cooleyi	temp hw forest	G1G2	LE	B
Justicia crassifolia	pine flatwood	G2	C2	N
Lantana depressa var. depressa	pine rockland	G2T1	C2	N

Lantana depressa var. floridana	coast upland	G2T2	C2	N
Lantana depressa var. sanibelensis	coast upland	G2T1	C2	N
Lechea divaricata	scrub	G2	C2	N
Lechea lakelae	scrub	G1	C2	A
Lepanthopsis melanantha	swamp	G1G3	C2	N
Liatris ohlingerae	scrub	G3	LE	N
Liatris provincialis	scrub	G2	C2	N
Lilium iridollae	swamp	G1G2	C2	B
Lindera melissifolia	swamp	G2	LE	C
Lindera subcoriaceae	swamp	G2	C2	C
Linum arenicola	pine rockland	G1G2	C2	C
Linum carteri var. carteri	pine rockland	G2T1	C2	A
Linum carteri var. smallii	dry prairie	G2T2	C2	A
Linum westii	pine flatwood (wet prairie)	G2	C2	N
Lupinus aridorum	scrub	G1	LE	A
Lupinus westianus	coast upland	G2	C2	N
Lythrum curtissii	swamp	G1	C2	B
Lythrum flagellare	swamp	G2G3	C2	B
Macbridea alba	pine flatwood	G1	LT	B
Macradenia lutescens	trop hammock	G2G3	N	N
Marshallia ramosa	sandhill	G1	C2	C
Matelea alabamensis	temp hw forest	G1	C2	B
Matelea baldwyniana	temp hw forest	G2G3	C2	N
Matelea floridana	temp hw forest	G2	C2	N

Minuartia godfreyi	pine flatwood (wet prairie)	G1	C2	B
Nemastylis floridana	pine flatwood	G2	C2	N
Nolina brittoniana	scrub	G2	LE	C
Oncidium floridanum	trop hammock	G2	N	N
Ophioglossum palmatum	swamp	G2	3C	N
Opuntia spinosissima	coast upland	G1	C2	A
Opuntia triacantha	coast upland	G1G2	3C	A
Panicum abscissum	pine flatwood (wet prairie)	G2	C2	C
Parnassia caroliniana	pine flatwood (wet prairie)	G2	C2	C
Parnassia grandifolia	pine flatwood (wet prairie)	G2G3	N	N
Paronychia chartacea ssp. chartacea	scrub	G3T3	LT	N
Paronychia chartacea ssp. minima	sandhill	G3T3	LT	N
Pinguicula ionantha	pine flatwood (wet prairie)	G2	LT	N
Poinsettia pinetorum	pine rockland	G2	N	C
Polygala lewtonii	sandhill	G2	LE	B
Polygala smallii	pine rockland	G1	LE	A
Polygonella basiramia	scrub	G3	LE	N
Polygonella macrophylla	scrub	G2	C2	N
Polygonella myriophylla	scrub	G3	LE	C
Polymnia laevigata	temp hw forest	G2G3	3C	N
Ponthieva brittoniae var. brittoniae	pine rockland	G2T2	N	N
Potamogeton floridanus	marsh	G1G3	N	A

Prunus geniculata	scrub	G2G3	LE	C
Rhexia parvflora	swamp	G2	C2	B
Rhexia salicifolia	sandhill	G2	N	N
Rhododendron chapmanii	pine flatwood (wet prairie)	G1G2	LE	B
Rhynchospora crinipes	swamp	G1	C2	N
Rhynchospora culixa	swamp	G1	3C	N
Rhynchospora stenophylla	pine flatwood (wet prairie)	G2	N	N
Ribes echinellum	temp hw forest	G1	LT	B
Sachsia polycephala	pine rockland	G2	N	N
Salix floridana	swamp	G2	C2	C
Salpingostylis coelestina	pine flatwood (wet prairie)	G2	3C	N
Schizachyrium niveum	scrub	G1	C2	C
Schwalbea americana	sandhill	G2	LE	C
Scutellaria floridana	pine flatwood	G1	LT	A
Silene polypetala	temp hw forest	G2	LE	N
Spigelia gentianoides	temp hw forest	G1	LE	A
Spigelia loganioides	swamp	G1G2	C2	B
Spiranthes polyantha	trop hammock	G1G3	C2	N
Stylisma abdita	scrub	G2G4	N	N
Stylosanthes calcicola	pine flatwood (wet prairie)	G2	N	N
Taxus floridana	temp hw forest	G2	C2	N
Tectaria lobata	trop hammock	G2G4	N	N
Tephrosia corallicola	pine rockland	G2	N	N
Tephrosia mohrii	sandhill	G2G3	C2	N

Thalictrum cooleyi	pine flatwood (wet prairie)	G1	LE	B
Torreya taxifolia	temp hw forest	G1	LE	A
Tragia saxicola	pine rockland	G2	C2	C
Triphora craigheadii	temp hw forest	G1	C2	C
Triphora rickettii	temp hw forest	G2	N	C
Tripsacum floridanum	pine rockland	G2	C2	B
Vanilla mexicana	trop hammock	G1G3	N	N
Verbesina chapmanii	pine flatwood (wet prairie)	G2G3	C2	N
Verbesina heterophylla	sandhill	G2	C2	N
Vernonia blodgettii	pine rockland	G2	N	N
Vicia ocalensis	marsh	G1	C2	B
Warea amplexifolia	sandhill	G1	LE	B
Warea carteri	scrub	G1G2	LE	B
Xyris chapmanii	pine flatwood (wet prairie)	G2	N	N
Xyris longisepala	sandhill	G2	C2	A
Xyris scabrifolia	pine flatwood (wet prairie)	G2G3	C2	N
Ziziphus celata	scrub	G1	LE	A

1. Key to Appendix A abbreviations

FNAI STATUS:

G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurances or less than 1000 individuals) or because of extreme vulnerability to extinction due to some natural or man-made factor.

G2 = Imperiled globally because of rarity (6 to 20 occurances of less than 3000 individuals) or because of vulnerability to extinction due to some biological or man-made event.

G3 = Either very rare and local throughout its range (21-100 occurances or less than 10,000 individuals) or found locally in a restricted range or vulnerable to extinction because of other factors.

G4 = Apparently secure globally (may be rare in parts of its range).

G#/G# = Range of rank; insufficient data to assign specific global rank (e.g., G2G3); such compound ranks are categorized according to their higher rank (i.e., lower number).

G#T# = Rank of taxonomic subgroup such as subspecies or variety.

FEDERAL STATUS (U.S. Fish and Wildlife Service)

LE = Listed as Endangered Species under provisions of the Endangered Species Act; a species which is in danger of extinction throughout all or a significant portion of its range.

PE = Proposed for addition as an Endangered Species.

LT = Listed as a Threatened Species; a species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

PT = Proposed for listing as Threatened Species.

C1 = Category 1 Candidate: substantial information is available to support listing of the species as endangered or threatened.

C2 = Category 2 Candidate: listing is possibly appropriate but conclusive information is not available.

3A = Taxon no longer being considered for listing because of pursuasive evidence of extinction.

3B = Taxon no longer being considered for listing because it does not meet the Endangered Species Act's definition of "species."

3C = Taxon no longer being considered for listing because it appears to be more widespread or abundant than previously thought.

N = Not currently listed nor being considered for listing.

CPC STATUS (Center for Plant Conservation)

A = Taxa that could possibly go extinct in the wild within the next five years without conservation measures.

B = Taxa that could possibly go extinct in the wild within the next ten years without conservation measures.

C = Taxa that will probably remain extant in the wild for the next ten years.

X = Taxa that were once proposed as Priority A, B, or C, but that have since been removed from the list by one or more Regional Task Forces.

N = Not listed.

APPENDIX B: NOTES FOR TABLE 1

1. Pre-settlement figures, unless otherwise noted, are based on estimates by Kautz et al. (1993) from Davis' 1967 General Map of the Natural Vegetation of Florida. Figures are rounded off to three significant digits.

2. Current estimates, unless otherwise noted, are based on Kautz et al. (1993). Figures are rounded off to three significant digits.

3. Unless otherwise noted, estimates for Conservation Areas are taken from Cox et al. (1994), and are rounded off to three significant digits.

4. This figure was obtained by subtracting an independent estimate of 7,000 ha for the current extent of Pine rocklands (see note 12 below) from the figure given by Kautz et al. (1993). These authors apparently included Pine rockland under their Pine flatwoods category.

5. This figure was obtained by subtracting an independent estimate of 6,000 ha for the amount of Pine Rockland now protected in Conservation Areas from Cox et al. (1994). These authors apparently included Pine rocklands under their Pine flatwoods category.

6. This figure was obtained by combining "Sand Pine Scrub" and "Xeric Oak Scrub" estimates in Kautz et al. (1993).

7. This figure was obtained by combining "Sand Pine" and "Oak Scrub" estimates in Cox et al. (1994).

8. This figure was obtained by combining Davis' "Mixed Pine-Hardwood" and "Hardwood Forest" categories as estimated by Kautz et al. (1993).

9. This figure was obtained by combining "Upland Hardwood Forests" and "Mixed Hardwood-Pine Forests" estimates in Kautz et al. (1993).

10. This figure was obtained by combining "Upland Hardwood Forest" and "Mixed Hardwood-Pine Forest" estimates in Cox et al. (1994).

11. This estimate comes from Snyder (1986).

12. This estimate is based on data from Snyder (1986) and J. O'Brien (pers. comm.).

13. This figure was obtained by combining Davis' "Hardwood Swamp," "Scrub Cypress," and "Cypress Swamp" categories as estimated by Kautz et al. (1993).

14. This figure was obtained by combining "Mixed Hardwood Swamp," "Cypress Swamp," "Shrub Swamp," "Bay Swamp," and "Bottomland Hardwood Forest" estimates in Kautz et al. (1993).

15. This figure was obtained by combining "Mixed Hardwood Swamp," "Cypress Swamp," "Shrub Swamp," "Bay Swamp," and "Bottomland Hardwood Forest" estimates in Cox et al. (1994). The apparent anamoly of an increase in the land area of swamps is an artifact of the different scales used by Davis and by Kautz et al. (1993). Davis' map does not show the thousands of small isolated cypress domes, depression swamps, etc., that were mapped by Kautz et al.

16. Figures for coastal uplands were taken from Johnson and Muller (1993). The Pre-settlement figure includes only coastal uplands on barrier islands, while the current figure includes both barrier island and mainland coastal uplands. The Conservation Areas figure excludes publicly held areas under military jurisdiction.

CENTER FOR PLANT CONSERVATION

P.O. BOX 299 ST. LOUIS, MO 63166-0299 (314) 577-9450 FAX (314) 577-9465

Participating Institutions

The Arnold Arboretum of Harvard University
125 Arborway
Jamaica Plain, MA 02130
Robert E. Cook, Director

The Berry Botanic Garden
11505 SW Summerville Avenue
Portland, OR 97219
Linda R. McMahan, Executive Director

Bok Tower Gardens
1151 Tower Boulevard
Lake Wales, FL 33853-3412
Jonathan Shaw, President

Denver Botanic Gardens
909 York Street
Denver, CO 80206
Richard H. Daley, Director

Desert Botanical Garden
1201 N. Galvin Parkway
Papago Park
Phoenix, AZ 85008
Carolyn O'Malley, Acting Director

Fairchild Tropical Garden
10901 Old Cutler Road
Miami, FL 33156
Brinsley Burbidge, Executive Director

The Arboretum at Flagstaff
Transition Zone Horticultural Institute
P. O. Box 670
Flagstaff, AZ 86002
Wayne A. Hite, Executive Director

Garden in the Woods
180 Hemenway Road
Framingham, MA 01701
David DeKing, Director

Amy B. H. Greenwell Ethnobotanical Garden
P. O. Box 1053
Captain Cook, HI 96704
Peter Van Dyke, Acting Manager

The Holden Arboretum
9500 Sperry Road
Kirtland, OH 44094-5172
Richard Munson, Executive Director

Honolulu Botanical Gardens
50 North Vineyard Boulevard
Honolulu, HI 96817
Michael Kristiansen, Executive Director

Harold L. Lyon Arboretum
University of Hawaii at Manoa
3860 Manoa Road
Honolulu, HI 96822
Charles Lamoureux, Director

Mercer Arboretum
22306 Aldine Westfield
Humble, TX 77338
Douglas Williams, Director

Missouri Botanical Garden
P. O. Box 299
St. Louis, MO 63166
Peter H. Raven, Director

National Tropical Botanical Garden
Box 340
Lawai, Kauai, HI 96765
William McK. Klein Jr., Director

The Nebraska Statewide Arboretum
C. Y. Thompson Library
University of Nebraska
Lincoln, NE 68583-0175
James Locklear, Director

The New York Botanical Garden
Bronx Park
Bronx, NY 10458
Gregory R. Long, President

The North Carolina Arboretum
P. O. Box 6617
Asheville, NC 28806
George Briggs, Director

The North Carolina Botanical Garden
Box 3375 Totten Center
University of North Carolina
Chapel Hill, NC 27599-3375
Peter S. White, Director

Rancho Santa Ana Botanic Garden
1500 N. College Avenue
Claremont, CA 91711-3157
Roy L. Taylor, Executive Director

Red Butte Gardens and Arboretum
18A DeTrobriand Street
Salt Lake City, UT 84113-5044
Mary Pat Matheson, Director

Regional Parks Botanic Garden
East Bay Regional Parks Disrtict
P.O. Box 5381
Oakland, CA 94605-5369
Stephen W. Edwards, Director

San Antonio Botanical Garden
555 Funston
San Antonio, TX 78209
Eric Lautzenheiser, Director

University of California Botanical Garden
Centennial Drive
Berkeley, CA 94720
Philip Spieth, Interim Director

Waimea Arboretum and Botanical Garden
59-864 Kamehameha Highway
Haleiwa, HI 96712
Keith R. Woolliams, Director